



# Insights about Smart Cities in Brazil for policy makers and public managers

**Leveraging technologies for sustainable development**

**March - 2023**

This study was commissioned by NEC from Deloitte and aims to provide an updated figure of the Smart Cities scenario in Brazil, comparing local initiatives with global references and consolidating suggestions to address barriers and enable opportunities in this area. The concrete cases of organizations cited throughout this report are based on information made public.

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# Executive Summary

The world is going through a transformation journey and so are the cities. As centers of innovation and shared prosperity, cities are where the future first happens, so imagining the Future of Cities is anticipating the future of human life.

Today, more than half of the world's population lives in urban areas, and it is expected to increase to 68 percent by 2050, when 2.5 billion people will inhabit the world's cities.<sup>1</sup> In Latin America, 81 percent of the population already live in urban areas<sup>2</sup> and, in Brazil, there are more than 210 million people, of which 84 percent living in urban areas of 5570 cities.<sup>3</sup>

Cities and their urban areas are a major attractor because they constitute a platform for potential opportunities, prosperity, and wellbeing for residents, and play a central role in improving lives and livelihoods. Today they account for about 80 percent of global GDP (Gross Development Product) and in some regions large cities produce up to 12 percent of national GDP.<sup>4</sup>

The population growth is increasingly concentrated in large metropolitan areas. Metropolitan areas with more than one million inhabitants grew half a percentage point faster per year than smaller ones. By 2030, there will be more than 43 megacities.<sup>5</sup> The metropolitization and densification of cities bring great challenges in the use and management of their resources. Bringing technologies for optimization and disciplines for sustainable use of these resources is a major challenge for public managers.

Smart cities use information and communication technologies to achieve long-term economic development, efficient resource management, and provide greater quality of life for their residents. A smart city can use its advanced infrastructure to help local businesses, environment, transportation and mobility, healthcare, lifestyle and governance. The adoption of smart city solutions is being driven by increased urbanization trends around the world and the desire for a higher quality of life.

Globally, governments have stepped up enablement and projects for smart cities through their regulations and initiatives focused on deploying smart services as an important part of their infrastructure. The size of the global smart cities market is estimated to be valued at US\$1025.9 billion in 2021 and is projected to reach US\$7162.5 billion by 2030, growing at a CAGR of 24.1 percent from 2021 to 2030.<sup>6</sup>

Deloitte recently published a report on 12 key trends that will affect our urban life in the near future.<sup>7</sup> These trends cover: the need to deal with the climate emergency – both through mitigation (low-carbon cities) and adaptation strategies (resilient cities); the data and technological environment that supports and strengthens the capacity of cities (smart cities); and the human-centered approach, unavoidable for attaining Sustainable Development Goals and nurturing strong communities (inclusive cities). These trends play with Environmental, Social and Governance (ESG), which is one of the most significant agenda of the decade for businesses and investors.

ESG is becoming a major strategic imperative, especially for large, public organizations and especially in cities. Cities are responsible for great part of carbon emissions, consuming roughly 2/3 of the world's energy and produce approximately 70 percent of greenhouse gas emissions.<sup>8</sup>

However, according to a study by the Coalition for Urban Transitions,<sup>9</sup> there is the potential to reduce carbon emissions by 90 percent by 2050 by making infrastructure more efficient, incorporating renewable energy into buildings, using different materials to build infrastructure, and improving transportation. The study also makes an investment case for Smart City initiatives, estimating that achieving target carbon emissions would require an investment of \$1.8 trillion per year but would generate expected returns of \$2.8 trillion per year starting in 2030. Smart Cities address ESG goals in managing physical assets, community services and resources, public transportation and traffic management, optimized energy consumption, water supply, waste management, and public safety.

Technologies such as: Smart Connectivity (IoT), Smart Infrastructure, Smart Buildings, Smart Homes, Smart Safety & Security, Smart Mobility, Smart Waste and Water Management, Smart Energy and Grids will play important role for sustainability, carbon emission reduction, safety, governance and for social welfare. The figures below bring successful technology use cases in Latin America.

Example of Successful Use Cases for Smart Cities

## Smart traffic success case: Buenos Aires city, Argentina



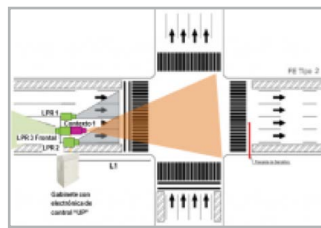
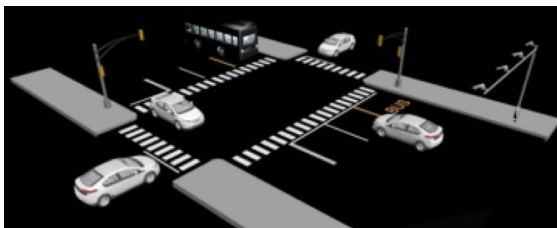
Deployment of LPR and context cameras with Machine Learning models to detect inappropriate behaviors from drivers (red light crossing, stopping over pedestrian crosswalk, seat belts use, among others).

**The challenge:**

- Reduce the rate of accidents in the city.
- Improve the flow of traffic in the city by complying with traffic regulations.
- Reduction of system operating and maintenance costs.
- Optimize the allocation of resources.
- Provide performance indicators that help measure and improve policies.

**Solution:**

- LPR cameras and Context Cameras were installed at intersections in order to automatically detect driver violations by minimizing the amount of hardware.
- A PC was installed where the analytics run and the presumptions of violations are set up at each intersection in order to reduce the cost of sending data.
- Machine learning models will be in the backend in order to reduce the number of false positives presented to agent-operators.
- All the license plates captured/processed by the cameras will be analyzed to create KPIs for the city. (number of vehicles that circulate daily, flow, average times, congestion detection, etc.)
- Detection and classification of bicycles and scooters will be implemented to obtain information on the circulation of low-emission vehicles.



256 LPR video cameras

240 Inspection points

122 Process Units

11 Detected behaviors

90 Evidence cameras

CitySensAI - Integrated Platform for centralized management

Example of Successful Use Cases for Smart Cities

## Safe city success case: Tigre city, Argentina



Improve Surveillance Efficiency by detecting human and traffic related abnormal behaviors in specific context /scenarios: Railway stations, Banking areas, Access roads, Streets, parks & open places.

**The challenge:**

The large number of events, alarms and incidents received daily by the Command and Management Centers for citizen security requires the implementation of specialized tools to organize and analyze the information promptly and efficiently.

- To expedite the handling of events and incidents from sources such as anti-panic buttons, social networks, mobile applications, sensors and video analytics, among others by means of Standard of Operations or SOPs, according to the incident type & nature.

- To improve the decision-making process by providing reliable information in real time to the Command-and-Control Center.



**+2000** Video cameras      **42** Seats Command and Control Room

**LPR** Systems      **Facial** recognition systems

**Behavior** detection      **Incidents** Management Systems

**Results: About 80% reduction of vehicle theft rate and 20%-year growth of tourists**

Example of Successful Use Cases for Smart Cities

## Smart public lighting success case: La Reina, Santiago city, Chile



Benefiting a neighbourhood of 96,762 inhabitants.

### The challenge:

- Replace the public lighting infrastructure with LED, optimize the consumption and monitor the luminaires in real time.



**Smart City Platform**

10,973 Lights replaced with LEDs

13,082 Monitored lights

10-year contract

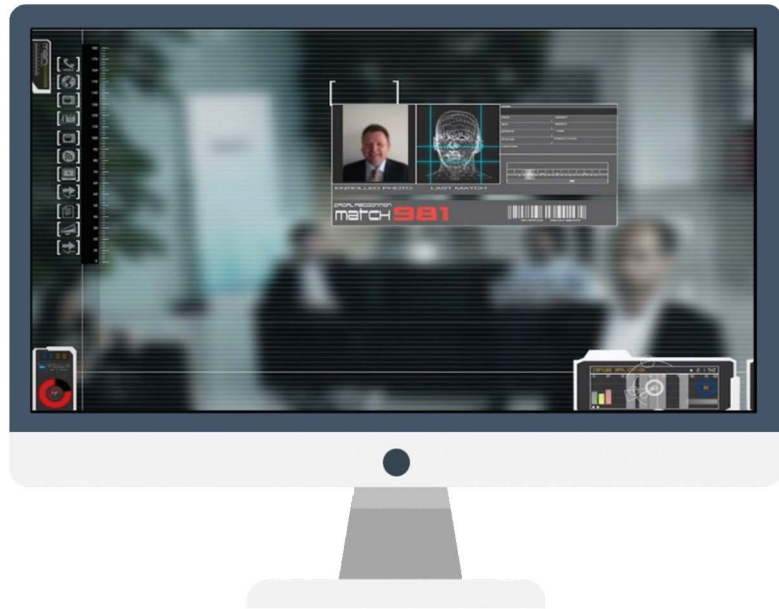
Integrated Platform for Smart City Operations

## Example of Successful Use Cases for Smart Cities

### Safety and Efficiency for 14 International Airports



- Used to enhance efficiency and effectiveness of customs operations in 14 international airports in Brazil.
- Facilitate the identification of passengers who have been registered for suspect activity by the agency, contributing to the improvement of the country's border controls.
- Contributing to prevent traffic and smuggling activities.



#### Challenge:

Increase the efficiency and rigour of customs control in airports

#### Solution:

NeoFace Watch real-time face recognition system

#### How:

Detection of pre-registered individuals who have been registered for suspicious activities

#### Results:

ROI = 2 months; Drug Dealers arrested in International Airports in 2017 = +50% (compared with 2016) registered for suspicious activities

**Preventing illegal activities at airport customs control.**



In Social of ESG, Public Safety is the central part of this discussion, bringing a lot of benefits in quality-of-life improvements. From third edition of the IMD-SUTD Smart City report (2021),<sup>10</sup> in a survey involving ranked Smart Cities worldwide, a list of 15 indicators was used, and respondents were asked to select five that they perceived as the most urgent for their city. In Latin America pointed out as the main problem to be solved: Safety and Health Services with more than 70 percent score of interviewed cities.

According to data from the Brazilian Yearbook of Public Security 2022,<sup>11</sup> Brazil represents 5 percent of the global population, but with 20 percent of all lethal crimes worldwide. However, the Public

Safety investments and projects are very incipient comparing to Public Lighting. Currently, there are more than 450 Public-Private Partnerships for public lighting,<sup>12</sup> but a few initiatives of public safety Smart City projects.

The discussions to make cities more efficient in Brazil remits to the beginning of 2000 when the City Statute (Law 10257/01) was approved, and since then several important public policies have been introduced, such as: PPPs Law (Law 11079/04); Digital City Program; Antenna's Law (13116/15); National IoT Plan (Decree 9854/19); Brazilian Charter of Smart Cities (2020); Regulatory Framework for Artificial Intelligence (PL 21/20) and Principles for the Use of AI in Brazil (Bill 5051/19 and 872/21); Startups Legal

Framework (Law 182/21); National Smart Cities Policy (Bill 976/21) among others.

### Main barriers

Even with many advances in public policies for Smart Cities in Brazil, this study still identified some barriers and opportunities based on analysis and interviews with several specialists who represent the main actors: public administration (federal, state and municipal governments), industry (manufacturers, suppliers, service providers and associations), and academy (universities). They have been grouped into 5 areas: Political & Administrative; Economics, Knowledge and Training, Legal and Regulatory Order and Technology. Below, the main barriers are listed:

**Table 1: Sample of Existing Barriers**

Political – Administrative	Economic	Competence & Knowledge	Legal-regulatory Framework	Techniques and Technologies
<ul style="list-style-type: none"> <li>• Lack of long-term planning</li> <li>• There is no post-term continuity</li> <li>• Lack of focus on the problem instead on technology or political exposure</li> <li>• Multiplicity of entities (departments) operating in independent silos.</li> <li>• Lack of ownership or empowerment to guarantee the success of the project.</li> </ul>	<ul style="list-style-type: none"> <li>• Availability of financial resources for investment in innovation</li> <li>• Dependence on federal government resources</li> <li>• Private investment and ROI guarantees - such as long-term contracts.</li> <li>• Predominance of small cities that lack scale and less attractive for investments by private sector</li> </ul>	<ul style="list-style-type: none"> <li>• In public administration:</li> <li>• Shortage of human resources with knowledge and technical training</li> <li>• Training heterogeneity and attribution distortion</li> <li>• Lack of knowledge about Smart City</li> <li>• Politically biased decision making rather than being based on data and insights</li> <li>• Lack knowledge of the mechanisms and legal provisions available to support the development of initiatives and projects</li> </ul>	<ul style="list-style-type: none"> <li>• Outdated laws that prevent committing resources from available funds</li> <li>• Restrictive new laws and legal frameworks that make innovation that obstacles new business models</li> <li>• The regulatory discussion takes a long time and leaves many dubious points. The technology timing is lost.</li> </ul>	<ul style="list-style-type: none"> <li>• Legacy and proprietary solutions</li> <li>• Data spread across vertical silos</li> <li>• Lack of standardization to ensure interoperability and integration</li> <li>• Lack of communication infrastructure</li> <li>• Data access, integration &amp; handling (privacy &amp; GDPR)</li> </ul>
	<ul style="list-style-type: none"> <li>• Lack of advocacy by the industry</li> </ul>			

**Summary of the recommendations**

Based on the above areas to be improved, recommendations from the CBCI (*Carta Brasileira para Cidades Inteligentes*) and captured insights from experts interviewed, this study selected a set of suggestions for public policy to be enhanced or focused

in order to unlock opportunities for Smart Cities development – table below.

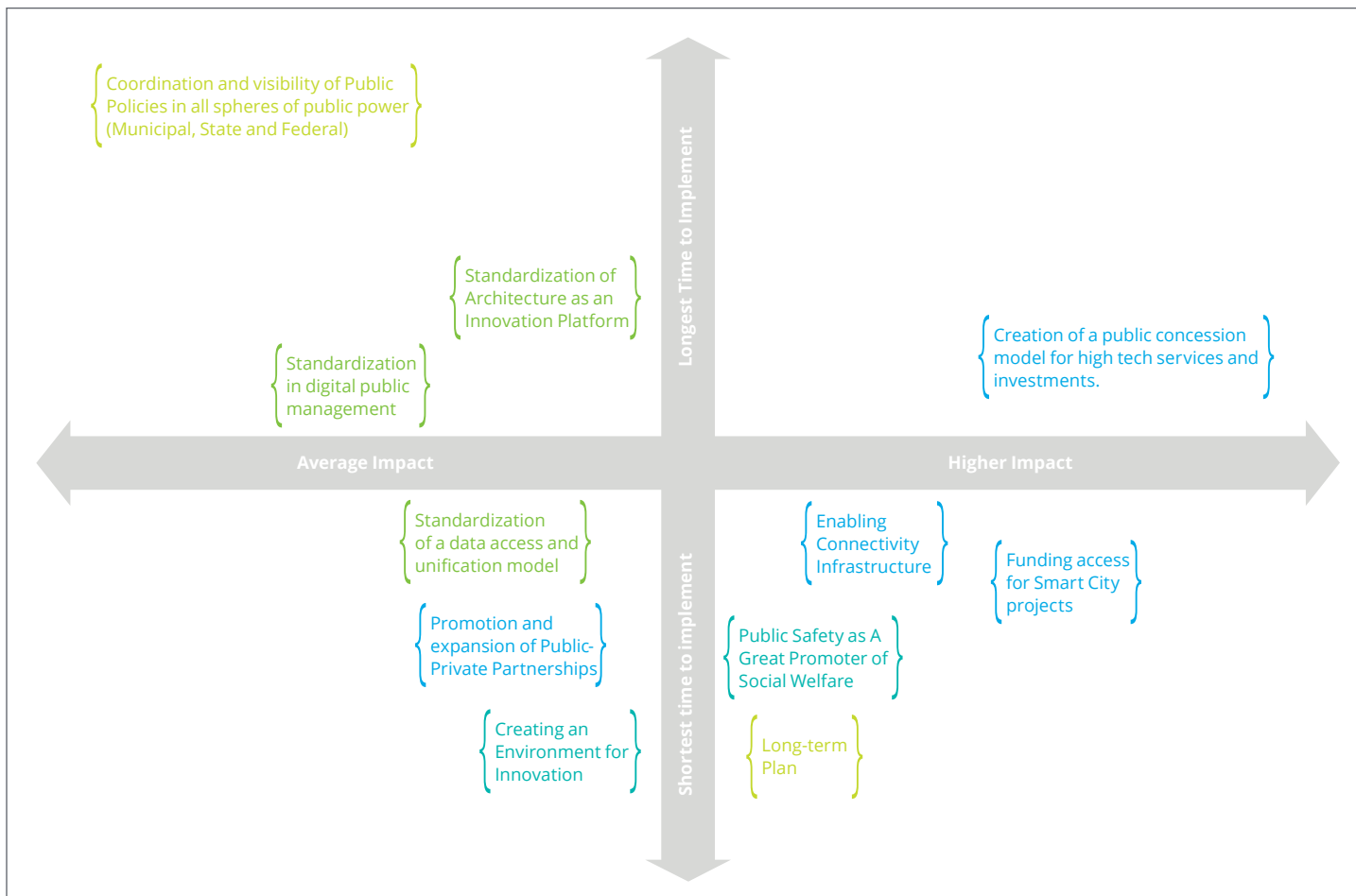
Each suggestion has a specific impact in identified barriers, and the total impact is plotted in the figure below. According to how easy can be implemented, low complexity,

or number of actors for convergence, there is a different expectation to be released, captured in vertical axis below. The impact vs time shows a good orientation about how effective each recommendation is in the short, mid and long term, but also brings a strategy roadmap for pushing these recommendations.

**Table 2: Public Policy Suggestion**

Legal & Regulation Framework	Technology	Funding & Business	Innovation & Others
<b>Coordination of Policies in all spheres of public power (Municipal, State and Federal)</b>	Standardization of a data access and unification model	Funding access for Smart City projects	Creating an Environment of Innovation
	Standardization in digital public management	Enabling Connectivity Infrastructure	Public Safety as A Great Promoter of Social Welfare
	Standardized Architecture	Promotion and expansion of Public-Private Partnerships	
<b>Long-Term Planning</b>		Exclusive Public Concession Model for The Intelligent City's Exploitation of Services	

**Figure 1: Evolution of the Smart City Services Exploitation Model**



### First Step

In the First Step, **Long-term Plan** for a Smart City can easily be included/ considered in existing PDM (*Plano Diretor Municipal* -Municipal Master Plan) based on City Statute Law, bringing a prompt benefit for having a clear vision for long term investments and direction. The Long-Term Plan will be key for Funding Access for Smart City projects through investments in the public and/or private sector.

Other immediate action is Enabling Connectivity Infrastructure, and the Antennas' Law homologation in municipalities is a crucial step. It can attract investments by CSPs, ISPs, and NHNs telco companies without any investment by cities, and it can create a new way for public facilities exploitation. Finally, the telecommunication infrastructure is the main enabler for digital transformation in the cities.

**Public Safety** is another key initiative demanded by Latin America citizens since it brings immediate benefit for promoting overall welfare and increases the reputation of new investments. There is no economic prosperity or social cohesion without some degree of security. People need security in order to live, have freedom to interact with each other, establish relationships, do business, and communicate. In Latin America, based to the third edition of the IMD-SUTD Smart City report (2021), some of the main important cities, such as Bogotá, Buenos Aires, Mexico City, Rio de Janeiro São Paulo and Santiago, pointed out Safety and Health Services as the main problems to be solved. For instance, the implementation of technology for public security has mainly immediate effects on the reduction of crimes against property: According to the Brazilian Association of Electronic Security Systems Companies (ABESE), 94 percent of attempted thefts in monitored environments fail. In the world, the installation of CCTV had the greatest effect on drug crime with a reduction of approximately 20 percent. Significant

reductions were also observed in vehicle and property crimes. These solutions are enabling governments and police departments to better protect their citizens from everything from terrorist attacks to natural disasters. They are also supporting wider city organizations, such as public health, fire and rescue, border control and social services to better serve their citizens.

As an example, in 2011, the Tigre province in Argentina decided to implement the public safety platform to increase security and improve the quality of life of citizens.<sup>13</sup> The challenge was to centralize, integrate and consolidate security operations in one place, coordinating and optimizing the resources of various public security agents,

such as: first aid, traffic control, public transportation, civil defense, among others, with the objective of efficiently managing events and situations of protection and security in the city. The solution such as appears in the green board below reduced vehicle theft by 80 percent and they allowed Tigre to increase the number of tourist by 20 percent/year.

### Second Step

The Second Step is characterized by reorganization of mechanisms for funding and enabling smart cities. **Creation of a public concession model for high tech services and investments** can attract new investors for a smart city by bringing legal certainty and a long-term services exploitation.

#### Citizen Security Collaboration

**System:** It has allowed citizens to become protagonists in improving the safety of the city, through the request for services (ambulance, police, and firefighters) or by sending events such as accidents or situations that require a response from the city. This platform is able to receive alerts not only from dedicated anti-panic devices, but also from other channels, such as mobile applications, POS terminals, SMS, social networks, among others.

**Vehicle Registration Analyzer:** One of the world's leading Automatic License Plate Recognition systems and uses a high-speed, high-precision GLVQ (Generalized Learning Vector Quantization) algorithm.

**Behavior Detection:** Implemented to improve protection of specific areas by alerting the operator when the camera records abnormal situations such as property invasions, loitering, or fallen people.

**Crime and Evidence Map:** It is the automation of the processes of requests implemented for a broader control, decision making and planning for sending forces to the city.

**Machine Learning Technologies:** Customized solutions for City Hall, aiming to analyze certain behaviors and send an alert to operators. "People riding motorcycle without helmets" and "two people on the same bike" were the behaviors implemented.

**Intelligent Security Totems:** Originally installed more than 72 totems equipped with button and intercom. Depending on the type of emergency, different protocols are activated.

**Monitoring cameras as a Service:** Allowing the city to use by a working camera, ensuring the continuous operation of the system.

The interoperability of smart city applications promotes synergy among them but also innovation. The first step is **Standardization of data access** where existing and new applications can use the same databases.

The **Innovation Environment** is also already adopted by several cities by taking advantage of government incentives of existing Laws for attracting companies and investors, such as: Startups' Law; Informatica's Law; and others.

### Third Step

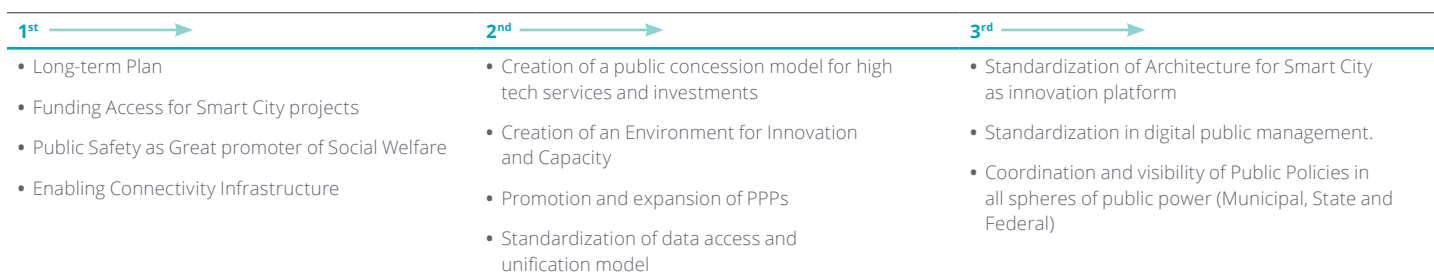
This final stage is motivated by the complexity of the implementation of

suggested actions. The **Standardization of Architecture for Smart City as innovation platform** has a big impact; however, it needs discussion with industry for establishing a model that makes sense for the Brazilian environment. Also, **Standardization in digital service for public management** can produce impact with growth of synergies among services, but it needs discussion with public agents in all public spheres for alignment and standardizing the same approach. The most complex action is **Coordination and visibility of Public Policies in all spheres of public power (Municipal, State and Federal)**, where it needs a long and complex discussion,

but it can solve problems around clarity of legal environment and certainty, bringing associated benefits.

There are many cooperation opportunities between government, industry, society, and academia around this topic. You are invited in this document to learn more about the current scenario of Smart Cities, including examples of the main initiatives, enabling technologies, challenges and the specialists' perceptions on the subject, which should provoke reflection on what actions need to be taken to enable the development of Smart Cities and, consequently, a better quality of life for its citizens.

**Figure 2: Strategy Roadmap for Suggested Policies**



# About the report

Smart Cities and the realization of projects and initiatives in Brazil have been in discussion for some years already. This study aims to provide an updated picture of the Brazilian smart cities' scenario, comparing local initiatives with global references.

This report aims to provide a snapshot of current Smart Cities status in Brazil by exploring some vertical projects, trends, public policies and main barriers. Also, it recommends a set of suggestions to improve the existing public policies, actions and slight modification or create new ones in order to minimize the barriers and capture some opportunities. Although the report refers to Brazil and Latin America trends, it will serve as reference for all countries in terms of insights and potential applicability for solving their existing concerns.

This document considered existing reports for Smart Cities on best practices, trends and projects from the most relevant research bodies and consultancies such as: Organization for Economic Cooperation and Development (OECD), World Bank, United Nations (UN), World Economic Forum (WEF), Brazilian Institute of Geography and Statistics (IBGE), Deloitte, Ministry of Regional Development (MDR), Ministry of Science, Technology and Innovation (MCTI), among others.

The report begins with an overview of Smart Cities around the world, including market size, drivers, benefits, domains, trends, sample plans, projects and initiatives. This analysis is applied for the Brazilian scenario, where the legal-regulatory issue and government actions are added.

Next, the main technologies and solutions for Smart Cities are discussed, since technology is a fundamental enabler. Technologies were chosen based on their application in the main use cases, presence in the consulted references for the study and mentions during interviews.

Finally, the main challenges and barriers for the development of Smart Cities in Brazil are listed, followed by recommendations to address these barriers. Both the challenges, barriers and recommendations were raised through insights obtained in conversations with specialists, analysis of the legal-regulatory framework and actions from government and private initiative.

The study was commissioned by NEC to Deloitte and was based on secondary sources (similar studies already carried out by Deloitte and third parties) and interviews with industry specialists, covering the main agents: government and secretariats (federal, state and municipal), industry (manufacturers, suppliers, service providers and associations), and academia (universities).

It is important to mention that it is **not objective** of this report to:

1. Exhaustively explore all aspects of and barriers to Smart Cities in Brazil;
2. Provide the current market size of Smart Cities in Brazil;
3. Evaluate or rank Smart City projects in Brazil;
4. Cover or analyze all suggestions for public policies in Brazil, but only the main ones based on interviewee insights.

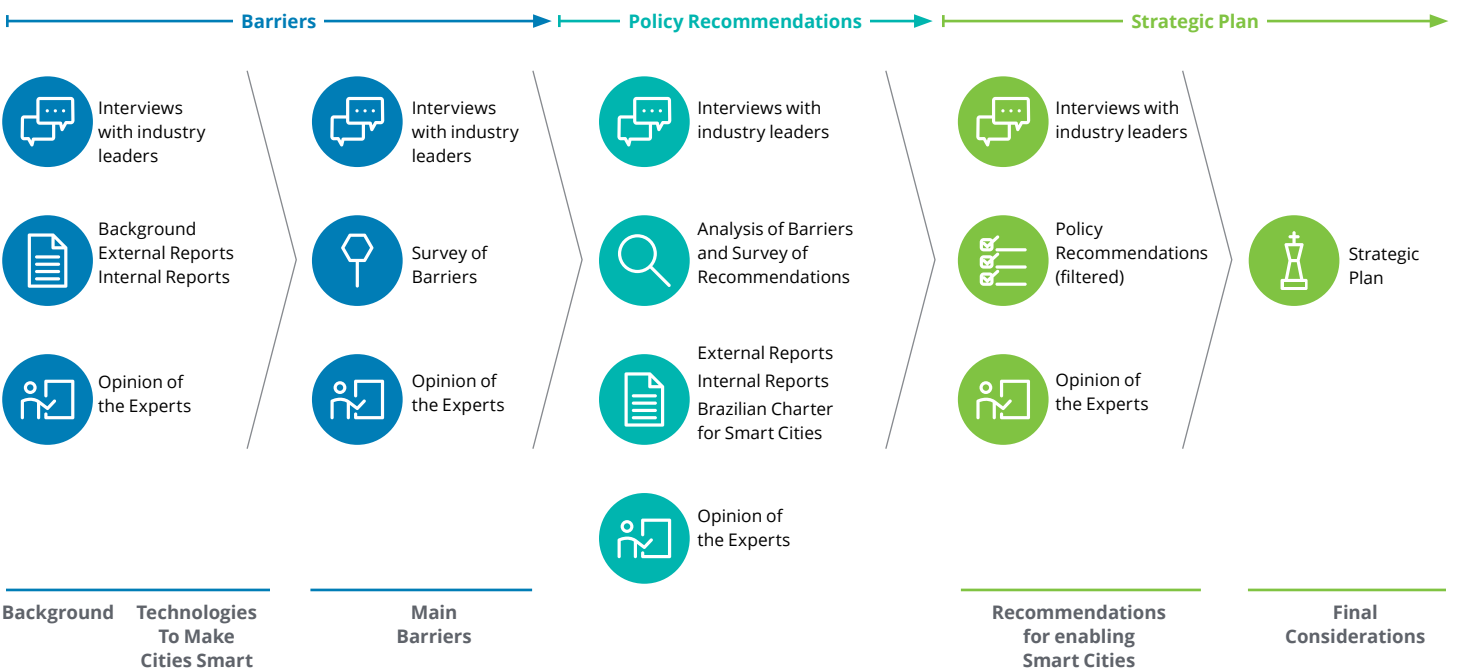
# Methodology

## Desk research

For this report, Brazilian and international literature reviews on Smart Cities were carried out, based on Deloitte's own studies, academic articles, market reports, news, in addition to data collection from public sources, such as the Organization for Economic Cooperation and Development (OECD), World Bank, United Nations (UN), World Economic Forum (WEF), Brazilian Institute of Geography and Statistics (IBGE), Ministry of Regional Development (MDR), Ministry of Science, Technology and Innovation (MCTI), among others. The reviews helped mainly in understanding the current scenario and complementing and corroborating certain challenges mapped in the qualitative interviews.

## Qualitative interviews

In order to obtain a comprehensive view, a total of 19 specialists were interviewed, with the participation of at least one representative for each agent. Exploratory conversations were conducted with executives, industry leaders, academics, government representatives and public administration, to collect and validate opinions, insights and trends. Among the topics covered were reporting on projects, experiences, challenges and needs, regulatory trends, technological trends, strategies, etc.



# Background

## Brief overview of Smart Cities context in the World

Smart cities use information and communication technologies to achieve long-term economic development, efficient resource management, and provide greater quality of life for their residents. A smart city can use its advanced infrastructure to help local businesses, environment, transportation and mobility, healthcare, lifestyle and governance. The adoption of smart city solutions is being driven by increased urbanization trends around the world and the desire for a higher quality of life.

Globally, governments have stepped up enablement and projects for smart cities through their regulations and initiatives focused on deploying smart services as an important part of their infrastructure. For example, China recently announced 500 digital city pilot projects,<sup>14</sup> which is again a major government investment in the region. In another example, Dubai has the goal of achieving the Smart Dubai Plan 2021 target to transform its country into a 100 percent paperless government that has boosted the adoption of smart services in the country.<sup>15</sup> The size of the global smart cities market is estimated to be valued at US\$1,025.9 billion in 2021 and is projected to reach US\$7,162.5 billion by 2030, growing at a CAGR of 24.1 percent from 2021 to 2030.<sup>15</sup>

Returning to the definition, smart city is a place where traditional networks and services become more efficient with the use of ICT and digital solutions for the benefit of its inhabitants and<sup>17</sup> businesses. However, its concept goes beyond the use of digital technologies and, for better

use of resources, to design, plan and operate a resilient city, there are two main components:<sup>18</sup> physical and social spheres. The physical sphere can be subdivided into resources and processes, while the social sphere has been subdivided into people, activities and institutions. As for services for smart cities, there are several classifications for establishing a comprehensive framework based on similar service domains. By simplification and reference, the classification will be used in 6 domains:<sup>19</sup> Natural Resources and Energy, Transportation and Mobility,

Construction and Infrastructure, Quality of Life, Governance, Industry and Human Resources – Figure below.

The needs of the cities are diverse, and the services indicated may be partially those indicated above or others. As an example, in the Table below are some cities and services considering the domains mentioned above extracted from the same reference. For the sample considered, among the services and practice stand out the most adopted: Transportation Operation; Traffic Information; Open data among others.

**Figure 3: Smart City Services Domain**

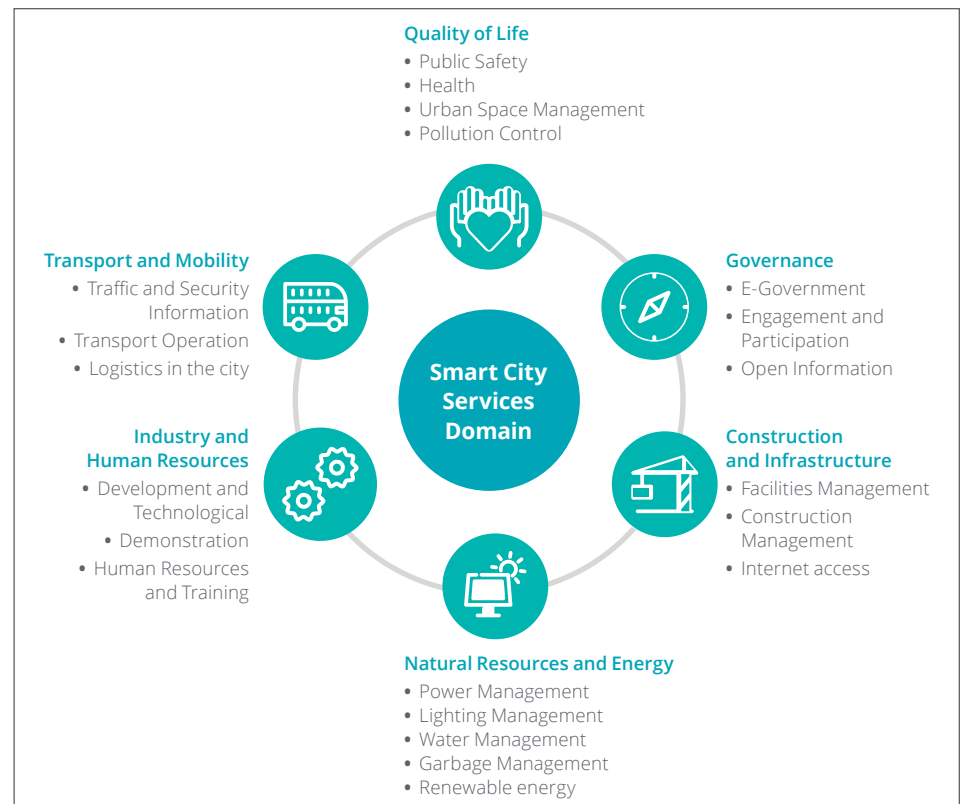


Table 3: Smart City Services and Projects Domain – Not Exhaustive<sup>20</sup>

		Europe							USA				Asia Pacific			Main Services domain
		London	Amsterdam	Barcelona	Paris	Vienna	Berlin	Stockholm	New York	San Francisco	Chicago	Boston	Singapore	Seoul	Tokyo	
Quality of Life	Public Safety						•		•	•	•	•			•	Monitoring of crimes and anomalies Disaster prediction
	Health	•	•	•		•	•	•					•	•	•	Emergency Management Remote Health Quality of life information
	Urban Space Management	•			•	•			•			•				• Participatory management of urban spaces
	Pollution Control			•		•	•		•		•				•	Air quality monitoring
Transport and Mobility	Traffic and Security Information	•	•	•	•			•		•	•	•	•	•	•	Traffic Information Sensing and parking
	Transport Operation	•	•	•	•	•	•	•		•			•	•	•	Real-time toll Vehicle sharing
	Logistics in the city	•	•		•	•										Logistics Optimization
Natural Resources and Energy	Power Management	•	•		•	•	•	•		•	•	•			•	Smart Grid
	Lighting Management		•	•			•	•						•		• Motion sensing in lighting
	Water Management	•		•			•		•				•		•	Smart Water Leak control
	Waste Management	•	•		•	•	•	•					•		•	• Smart Waste Recycling
	Renewable energy		•	•	•	•		•				•		•	•	• Solar panel • Wind power
Governance	E-Government					•	•	•		•	•		•	•		Electronic Services
	Engagement and Participation	•	•	•	•	•	•	•		•	•		•		•	Citizen policies
	Open Information	•	•	•	•	•	•	•				•	•	•		• Open data • Digital files
Construction and Infrastructure	Facilities Management	•	•	•			•		•	•			•	•		• Infra 3D Modeling
	Construction Management		•		•	•	•	•					•	•	•	• IoT for construction
	Internet access	•		•	•	•	•	•		•	•					• Public Wi-Fi
Industry and Human Resources	Development and Technological Demonstration	•		•	•					•			•			• Living labs
	Human Resources and Training	•		•		•		•		•			•			• Training in Data Science • Business support



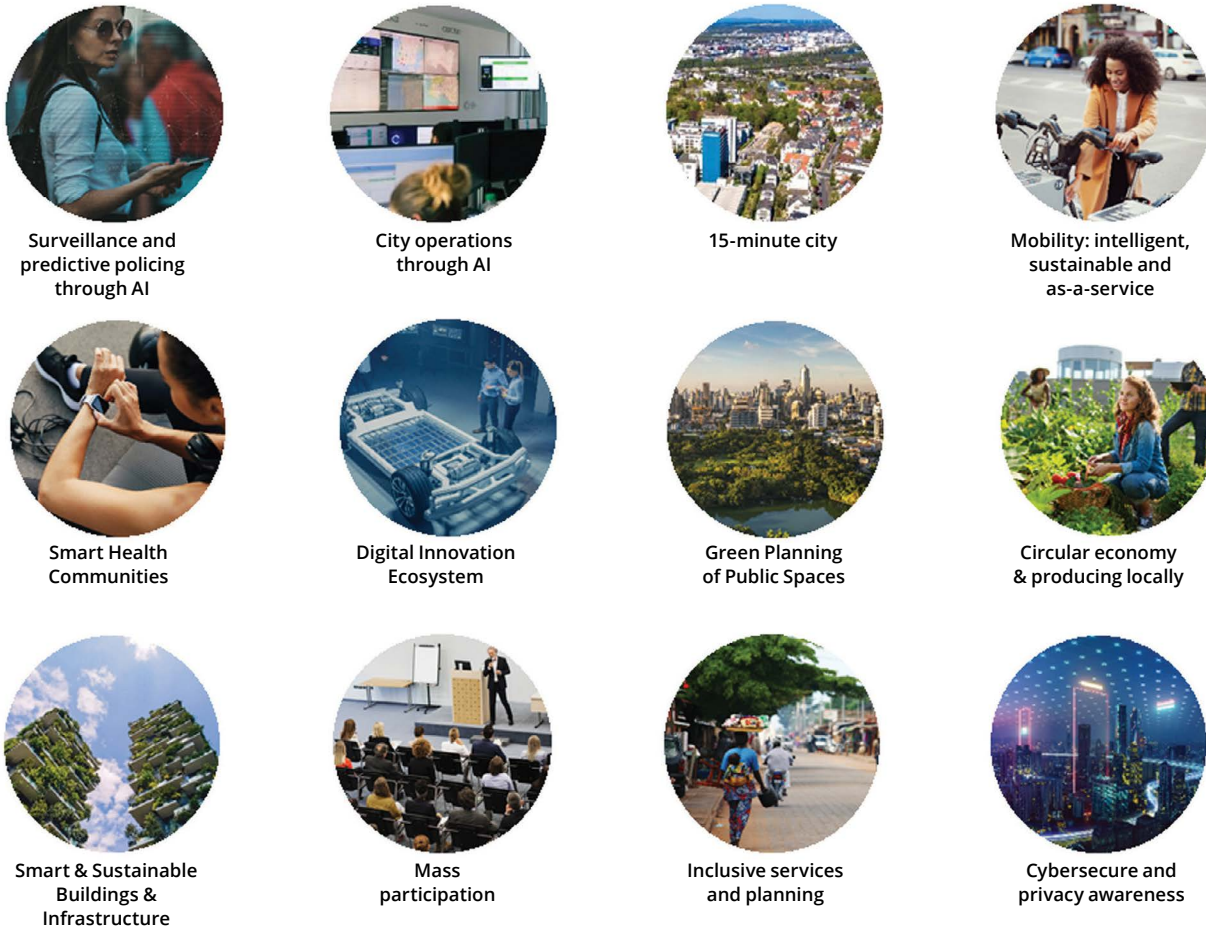
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Deloitte recently published a report on 12 key trends that will affect our urban life in the near future.<sup>21</sup> These trends cover: the need to deal with climate emergency – both through mitigation (low-carbon cities) and adaptation strategies (resilient cities); the data and technological environment that supports and strengthens the capacity of cities (smart cities); and the human-centered approach, unavoidable for attaining Sustainable Development

Goals and nurturing strong communities (inclusive cities).

In this project, Deloitte listened to experts from around the world. They include mayors of leading cities around the world, leaders of international organizations, urban policy institutions, as well as leading urban planners, professionals and researchers. Their views and insights give more depth to our analysis. Covering areas such as: Mobility, Life and Health, Government and Education, Energy and Environment, Safety and Economy. The goal was a comprehensive 360-degree analysis to create a constructive tool for everyone to use and practice what moves us on a day-to-day life: predicting, designing, and building better cities.

**Figure 4: Urban Future with a Purpose - 12 trends are shaping the future of cities**



**Benefits**

The services, enabling technologies and ecosystem above can bring several benefits to cities and their inhabitants. In a survey conducted by consultancy ESI ThoughtLab<sup>22</sup>

commissioned by a consortium of companies, including Deloitte, with the leaders of 100 cities worldwide, brought an insight into the benefits for some of these services, technologies and ecosystem, summarized in the following table.

Cities may adopt part of the above, or other, procedures and practices. This different situation of the services provided and practices may be associated with their needs and priorities, but also the stage of adoption maturity.

**Quality of Life**

**Public Safety:** Cities that adopt technologies for public safety find substantial benefits in quality of life. The most commonly used technologies are smart stations/kiosks that enable emergency calls, emergency notification apps, smart surveillance and police officers' cameras. Many leaders interviewed indicated that they are using intelligent surveillance (72 percent) and facial recognition (68 percent).



**41%**

IMPROVED CITY REPUTATION



**36%**

INCREASED CITIZEN WELLBEING



**34%**

INCREASED CITIZEN ENGAGEMENT



**33%**

IMPROVED ANXIETY



**33%**

ATTRACTION OF NEW BUSINESS

**Public health.** Public health and wellbeing initiatives not only drive quality of life but can also generate significant ROI for cities. First aid alerts provide the highest returns in general. However, their adoption rates remain low – only about a third of all cities use them. Remote patient monitoring, which is more common, results in high returns: 6.5 percent for leaders and 4.3 percent for all cities. Regardless of ROI, the life-saving benefits of many other projects should make them a priority for cities.



**36%**

INCREASED CITIZEN HEALTH & WELLBEING



**31%**

DECREASED RESPONSE TIME FOR EMERGENCY SERVICES



**27%**

DECREASED MORTALITY & MORBIDITY

**Transport and Urban Mobility**

**Information and Traffic Management.** Smart traffic management initiatives offer great benefits and considerable return on investment in cities. According to the survey, almost all leaders (96 percent) adopted real-time traffic management technologies, whose ROI (Return of Investment) is around 6.1 percent.



**32%**

IMPROVED PRODUCTIVITY, DELIVERY TIMES, ECOMMERCE



**31%**

REDUCED EMERGENCY RESPONSE TIMES



**29%**

REDUCED TRAFFIC-RELATED DEATHS



**28%**

REDUCED TRAVEL COSTS



**26%**

REDUCED CONGESTION



**25%**

DECREASED VEHICLE ACCIDENTS

### Natural Resources and Energy Management

**Energy and Lighting Management.** Dynamically priced electricity power management offers the benefit and ROI among energy technologies. Also, SmartPoles help cities save through lower electricity costs and reduced maintenance costs. They also provide a platform for cities to deploy various sensor and service technologies. Nearly 70 percent of cities that have deployed SmartPoles have incorporated video surveillance, 58 percent traffic monitoring technologies and 54 percent Wi-Fi hotspots, according to research.



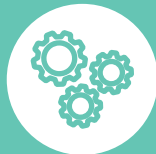
**43%**

MORE STABLE  
ENERGY PRICES



**43%**

DECREASED ENERGY  
CONSUMPTION



**37%**

GREATER  
RELIABILITY AND  
RESILIENCE



**36%**

REDUCED  
ENERGY COSTS



**36%**

INCREASE IN RENEWABLE  
ENERGY USAGE

**Waste Management.** Cities at all maturity levels are adopting intelligent waste collection and environmental technologies at a much lower rate compared to other areas of the urban ecosystem. But cities may want to turn their attention to these projects, as many of them generate great investment returns (ROIs) for leaders. For example, digital waste tracking has an average ROI of 6.8 percent for leaders, but only 44 percent of them – and 37 percent of all cities – are using it. Real-time air quality monitoring offers an even greater ROI for the 60 percent of leaders who use it, only 40 percent of all cities do. In addition, waste management and environmental projects offer a number of other benefits, including improved health and waste reduction, that contribute to the reputation and quality of life of the city.



**45%**

INCREASED  
CITIZEN HEALTH  
& WELL-BEING



**40%**

REDUCTION IN  
THE AMOUNT OF  
UNRECYCLED WASTE



**39%**

INCREASED WASTE  
MANAGEMENT  
EFFICIENCY



**37%**

REDUCTION  
IN LITTER

### Governance

**eGovernance.** Digitized systems make overall activities and work more productive. Most cities have adopted digital payments and are seeing average returns of 4.7 percent. While digital tax records have the potential to generate higher ROI than digital payments, cities have been slower to adopt this solution. These innovations – which reduce paper and simplify processes – bring productivity gains to labor activities and other benefits, such as greater transparency and improved city reputation.



**47%**

PRODUCTIVITY  
GAINS FOR CITY  
WORKERS



**43%**

INCREASED CITY  
TRANSPARENCY



**41%**

IMPROVED  
REPUTATION OF  
THE CITY



**37%**

INCREASED  
CITIZEN  
ENGAGEMENT



**36%**

ATTRACTION OF  
NEW BUSINESS

### Public Safety and Safe City

With more than half of the world's population living in urban areas in cities, there is direct impact on the precariousness of access to their resources, associated services, bringing problems of urban planning, urban mobility, safety, health, energy consumption, pollution among others. In Latin America, 81 percent of the population already lives in urban areas. Crime rates have a direct relationship with population density in urban areas. A study entitled "More crime in cities" on the scaling laws of crime and the inadequacy of per capita

rankings—a cross-country study,<sup>23</sup> points out that crime rates have a positive correlation with the size of the population of the order of  $Y \sim N^{\beta}$ , where N is the size of the population and Y is the crime rate as shown below (figure 5).

Among the services for Smart Cities are those associated with the safety and management of public living environments to help public managers and governments, communities and companies reduce the possibility of crimes and provide an environment where people feel safe and comfortable.

From the third edition of the IMD-SUTD Smart City report (2021),<sup>24</sup> in a survey involving ranked Smart cities worldwide, a list of 15 indicators was used, and respondents were asked to select five that they perceived as the most urgent for their city. The cities from Latin America pointed out as the main problem to be solved: Security and Health Services (table 4).

Public safety is the right of every citizen and their perception is responsible for their right to come and go, to perform work and recreational activities, quality of life, their wellbeing, etc. There is a great mobilization of resources for its guarantee through traditional investments in the training of the police force and allocation of equipment. Unfortunately, security spending follows a non-linear relationship with the population increase and, according to the Public Security Forum, in Brazil it is above 1.3 percent. However, technological availability, such as: increased connectivity in cities and technological bargaining; new monitoring modalities; sensing; data analysis, brings other mechanisms, cheaper and more effective, that can greatly improve public safety with a more preventive focus. Applications and solutions that make use of images and videos, combined with sensing information, can recognize faces, patterns, active for performing predictive policing with mapping of real-time activities for crime prevention; detection of anomalies; crowd behavior; emergency and disaster management, etc.

Figure 5: Criminal rate (Y) vs Population (N)

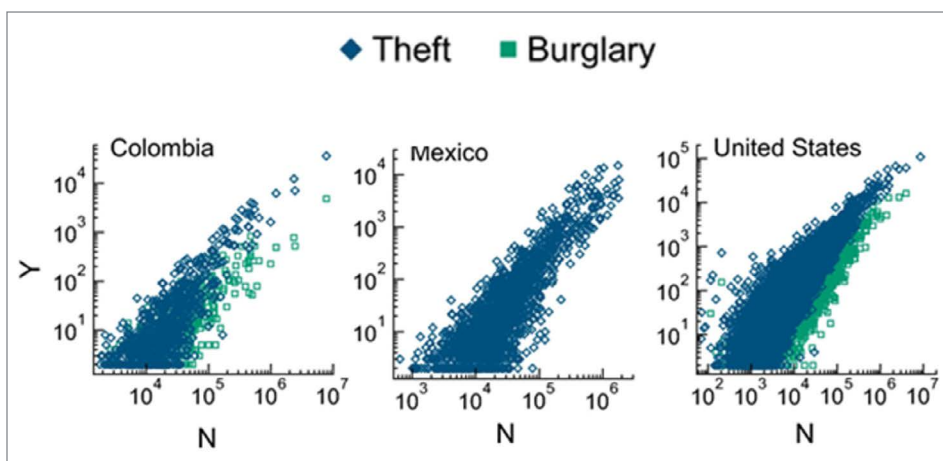


Table 4: Priorities in Latin America cities

Bogotá (116 ▼ -24)	Buenos Aires (98 ▼ -10)	Mexico City (108 ▼ -18)
74% Security	77% Security	86% Security
44% Health services	54% Health services	57% Health services
Rio de Janeiro (102 ▼ -16)	São Paulo (100 ▼ -17)	Santiago (91 ▼ -19)
87% Security	71% Security	63% Security
76% Health services	70% Health services	61% Health services

In addition to the benefits mentioned above, in the study presented by the consulting firm ESI ThoughtLab, applications for public safety bring positive investment returns (ROI) according to leaders of the 100 municipalities interviewed, according to the table below (table 5).

Given the critical importance of safety in cities, IoT innovations are increasingly improving the safety of city dwellers. New services, such as remotely connected CCTV and automated incident detection, enable faster response to threats. IoT-enabled crowd management solutions help protect city dwellers in busy, crowded areas. Smart street lighting, which helps reduce crime rates and improve driving conditions, is another example of the measures city planners are taking to improve people's safety.

Governments in several countries are investing in security systems in cities to make streets safer for their general population, in particular those more vulnerable as women and children. For example, in July 2022, the UK government awarded \$41.40 million through its Safer Street Fund program to street authorities and police officers to combat violence against women and girls (VAWG). The funding will be used to integrate CCTV and smart street surveillance systems into several UK streets.<sup>25</sup>

**Table 5: Return on Investment (ROI) and Adoption according to leaders interviewed**

Digital solution	ROI	Adoption
Gunshot detectors	7%	20%
Real time crime mapping	7%	48%
Crowd-sourced crime reporting	6%	36%
Emergency notification apps	6%	80%
Smart stations (kiosks)	6%	80%
Body cameras for police	3%	60%
Facial recognition software	3%	68%
Smart monitoring	3%	72%

In 2013 the Ministry of the Interior (MHA) and the Economic Development Council of Singapore (SEDB) began its public safety project: "Safe City test bed".<sup>26</sup> The project included government investments in ICT equipment, crime control system and police cameras (PoICAM), and surveillance. Predictive analytics tools have been deployed to detect where security issues can occur, supported by social media intelligence, behavioral analysis software, crowd size analysis, and facial recognition. In addition to preventing anomalies and crimes, the system is also able to detect abnormal scenarios such as traffic congestion, abandoned objects and garbage accumulation. A combination of rule-based algorithms and machine learning can enable agencies to analyze large amounts of data to provide meaningful insights to public and private organizations. In 2016, there were already more than 62,000 cameras (CCTV), with continuous expansion of the project nowadays.

According to an IHS study in 2017, this project brought an improvement of several scores for the quality of its inhabitants,<sup>27</sup> as social benefit of the city by 35 percent, appreciation of the government by 54 percent, credibility of the police in 49 percent and the ratification of the citizen by 47 percent. Furthermore, it allowed a reduction in traditional investments in police and public security (of the order of 8 percent) due to preventive investments in ICT.

With a population of two million more citizens than New York City, in recent years, Mexico City to fight crime has installed 58,000 video surveillance cameras on public transportation and in neighborhoods of the city, which are connected to the City's C5 (Command, Control, Computers, Communications, and Citizen Contact).<sup>28</sup> The high-capacity solution allows citizens or professional security agents to quickly upload videos through a mobile app or request help and can easily integrate fixed, body, and vehicular cameras into a single interface to provide unprecedented

information about city operations. For the future, the cloud-based platform will be expanded with new features to enable additional public safety services, including board reading, behavioral analysis software, video analysis, and facial recognition software.

Another example is the city of Tigre in Argentina. Due to the increase in population and tourism, the city faced problems related to theft, drug trafficking, automobile accidents, and episodes of violence. In 2011, the city decided to implement the public safety platform to become safer and improve the quality of life of citizens.<sup>29</sup> The challenge was to centralize, integrate, and consolidate security operations in one place, coordinating and optimizing the resources of various public security agents, such as: first aid, traffic control, public transportation, civil defense, among others, with the objective of efficiently managing events and situations of protection and security in the city.

The use of video surveillance in public spaces – both by government agencies and private citizens – has become popular in recent years, particularly due to rapid advances in facial recognition technology.

However, accurately estimating the spaces and quantities required for correct sizing has not been an easy task. There is neither a single rule nor a linear relationship between the amount of inhabitants in a city and the spatial dimensioning and distribution of cameras.

Cameras are needed in areas where there is a high volume of foot traffic, such as busy streets, shopping districts, and public transportation hubs. This increases the likelihood of capturing criminal activity on camera. Also, areas with a history of criminal activity: Cameras should also be placed in areas that have a history of criminal activity, such as parks, parking lots, and residential areas with high crime rates. Other candidate places are: The key points of entry and exit to a building or area, such as doors and

gates, to monitor comings and goings is another; Obscure areas: Cameras should be placed in areas that may be obscured from view, such as alleys, stairwells, and elevators, to help deter crime and aid in investigations; Outdoor and indoor: Outdoor cameras should be weatherproof and vandal-resistant, while indoor cameras should be placed in well-lit areas; Angle of View: Placed at an angle that allows them to capture the most useful footage, such as a face or license plate; etc.

In the study, "Surveilling Surveillance: Estimating the Prevalence of Surveillance Cameras with Street View Data",<sup>30</sup> the model was built for distribution and placement of

cameras on a road. In 16 cities analyzed, the estimated number of surveillance cameras per linear kilometer ranges from 0.2 (in Los Angeles) to 0.9 (in Seoul).

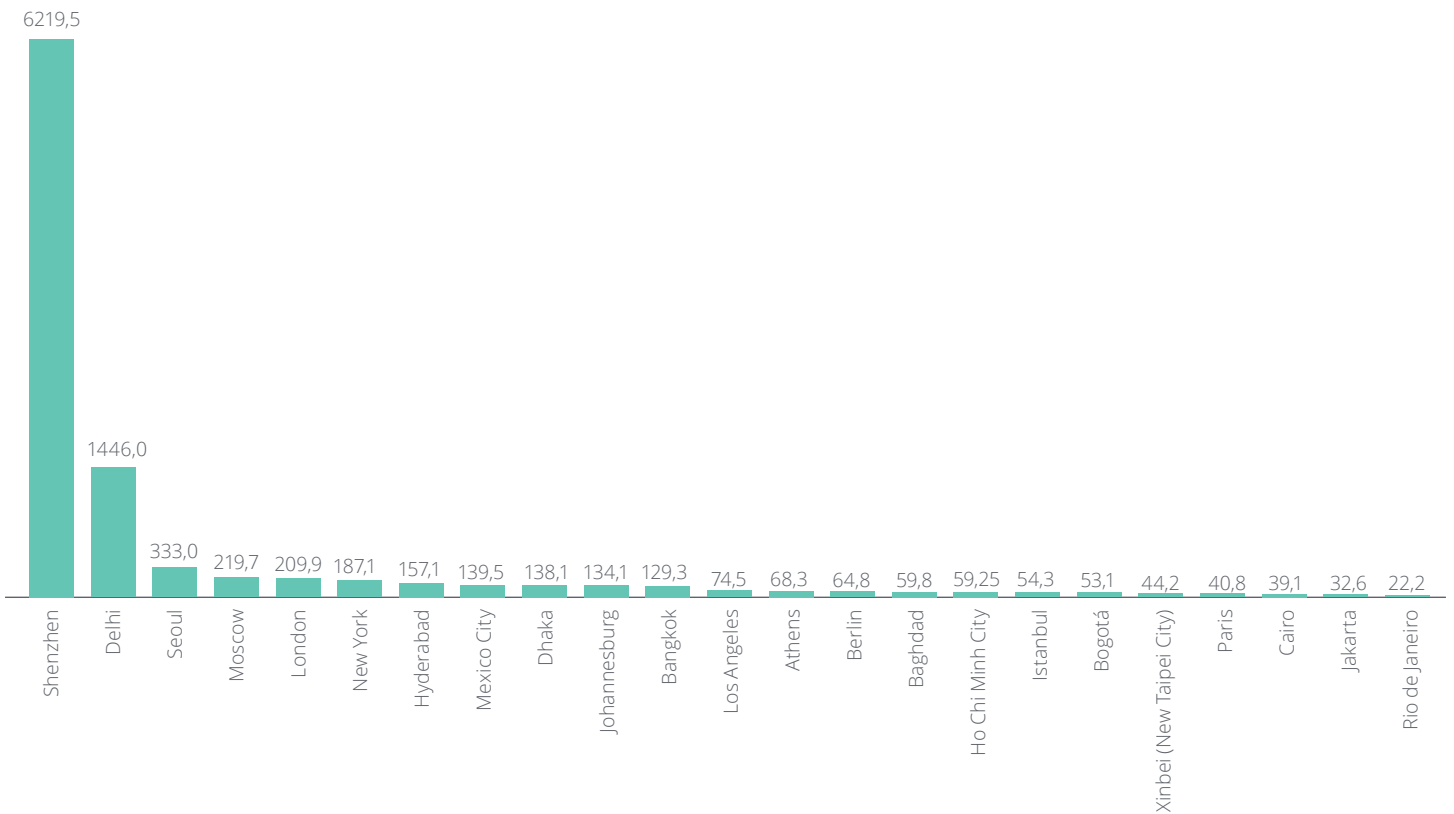
Thus, there is no a specific rule and in order to have an average or a proxy for dimensioning is population density and coverage area (square kilometers or miles).

According to the IHS Markit report, 54 percent of the world's cameras are located in China, which would equate to 540 million CCTV cameras as of 2021. With a population of approximately 1.46 billion, this means that there are 372.8 cameras per 1,000 inhabitants in China. Today in the USA,

this number varies widely from city to city, from 6 cameras per 1000 inhabitants to 50 per 1,000 inhabitants in the city of Atlanta, with an average of 15 cameras per 1000 inhabitants.

The chart below (figure 6) shows the distribution of the number of cameras by square mile. According to the chart, the city with the highest density of cameras per square mile in Latin America, Mexico City, has nearly 50 times fewer cameras than Shenzhen in China. Brazil appears in the last place in this list with the city of Rio de Janeiro, the highest density of cameras per square mile, but less than 280 times fewer cameras than the city of Shenzhen.

**Figure 6: Number of Cameras per square miles<sup>31</sup>**



## Introduction to the current scenario of Brazilian cities

Today in Brazil there are more than 210 million people and 84 percent living in urban areas of more than 5570 cities. Although 87 percent of all municipalities have less than 30,000 inhabitants, there are almost 18 populous cities with more than 1 million inhabitants, with São Paulo being the most emblematic case with just over 12 million inhabitants.

Brazilian urbanization, mainly from the 1970s onwards, became widespread and was spread from processes of urban expansion, today with 84 percent of the population living in urban areas of cities. This phenomenon is called metropolization, characterized by a process of integration of the territory from a core city, with emphasis on the center-periphery relationship and conurbation processes<sup>32</sup>. The metropolization and densification of cities brought several problems, such as urban mobility, public safety, public lighting, public health, among others.

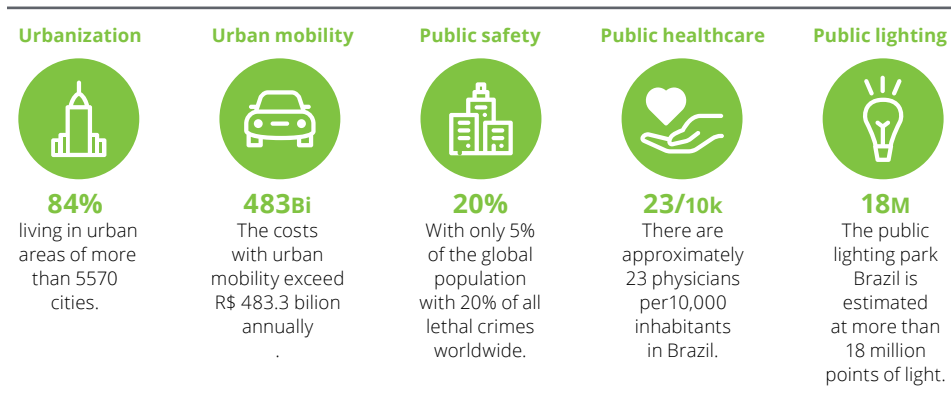
According to data from the ANTT (National Land Transport Agency), costs associated with the socioeconomic impacts of urban mobility exceed R\$483.3 billion annually,<sup>33</sup> accounting for individual expenses of transport users or employers. In addition to resources of the Government to keep the system running and the social impacts of people's movement. In Brazil, it is estimated that the time lost in traffic in large centers represents 32 days a year, bringing a loss in displacements that can exceed R\$111 billion, according to a study conducted by the FIRJAN (Federation of Industries of Rio de Janeiro) in 37 metropolitan areas.

Among the measures to avoid traffic congestion more intelligently, there is a need for efficient centralized controls to oversee traffic flow; adjust the traffic lights according to the movement of the vehicle; automatically administer penalties for traffic violations and speeding; Adaptive traffic signs, smart lanes, autonomous vehicle technology, real-time traffic feedback etc. Traffic management, intelligent traffic control, smart parking, transportation management and others are projects already implemented in Brazil.

As regards public safety, cities such as São Paulo, with more than 10 million inhabitants, there is a broad spectrum of crime, such as high rate of property crime, organized crime, kidnapping, trafficking etc. According to data from the Brazilian Yearbook of Public Security 2022,<sup>34</sup> the statistics are not promising. With only 5 percent of the global population, Brazil has more than 53 criminal factions, with 20 percent of all lethal crimes worldwide. In this same report, there was a growth in the period 2020 to 2021: 6.5 percent in the rates of theft to a commercial establishment; 4.7 percent in home theft rates, 11 percent increase in theft rates at the financial institution and an increase of 2.4 percent; in cargo theft.

Public lighting is fundamental to the quality of life in modern urban centers and is result of an important coordination of municipal governments and electricity distributors. According to the World Bank, the<sup>35</sup> public lighting park in Brazil is estimated at more than 18 million points of light. This represents about 4.3 percent of the country's total electricity consumption, and compromises between 3 and 5 percent of the municipal budget.<sup>36</sup>

**Figure 7: Summary of Brazilian cities problems**



However, this is fully funded by citizens by collected CIP or COSIP (Contribution to The Cost of Public Lighting), tax for public lighting, as stipulated in the Brazilian Constitution.<sup>37</sup> It is the responsibility of the municipalities, through the Municipal Councils, to establish the criteria the tax collection. According to a study by the ABDIB (Brazilian Association of Infrastructure and Basic Industries), the collection of CIP/COSIP in 2017 was already around R\$6.84 billion.

The possibility of evolution of lighting with LED lamps has provided substantial savings and opportunities to use this surplus, exceeding the expenses with Operation and Maintenance and expenses with the electricity bill (consumption and collection fee). This opportunity brought the attention of the private sector, through exploitation via partnership with public sector (PPPs).

The model of public lighting PPPs being disseminated in Brazil in recent years is characterized as an administrative concession, under Federal Law 10.079/2004. In it, the private sector is responsible for modernizing, expanding, operating, and maintaining the municipal public lighting park for a specified period, upon monthly receipt of a public payment, and the remuneration is tied to criteria of performance, quality and obtaining gains in energy efficiency. In January 2022, Radar PPP indicated<sup>38</sup> the existence in Brazil of 450 PPP projects in the public lighting sector in various stages of development, from those in the initial phase of structuring to projects with contracted providers.

Public Health faces several structural problems. Differently from the other ones, it not only exists in large city centers, but also in remoter areas. Because of recurring issues and the new challenges, those who can end up choosing to pay for a health plan or pay for a private consultation.

According to the World Health Organization (WHO),<sup>39</sup> there are approximately 23 physicians per 10,000 inhabitants in Brazil, while in Europe this number reaches 33 or higher. Although the national average is 2.18 medical for each group of 1,000 inhabitants, this indicator differs greatly from one region to another in the country, materializing a picture of inequality in the geographical distribution measured also between states, capitals and municipalities in the interior. The Southeast is the region with the highest medical density per inhabitant (ratio of 2.81) against 1.16 in the North and 1.41 in the Northeast. As an aggravating factor, although today there is more access to education, mainly due to distance learning resources, there are still many qualified professionals — especially those who prepare at colleges that do not offer the necessary educational support and equipment.

A survey conducted by the Social Perception Indicator System (SIPS) showed that 39.8 percent of the interviewees decided to hire a private health plan to get rid of the long waiting period of the Unified Health System (SUS). Depending on the complexity of the required public service, the locality where the patient lives, the waiting time being too long, discourage the population to enjoy this care. This scenario is also a reflection of the problems mentioned above, such as the lack of physicians and qualified professionals, reducing the supply of services or directing them to other locations that experience the same drama.

According to research conducted by cgi.br,<sup>40</sup> TIC na Saúde 2021, it is estimated that 94 percent of public establishments utilized computer and Internet, while among private individuals this use was universal. Among the types of establishments, of a universe of 40,600 UBS considered in the research, about 2,500 had no computer (representing 6 percent of the total) and 3,400 did not have internet access (about 8 percent). Also, from the same report, with the effect of the pandemic, there was an increase in interaction services with the medical team, which went from 9 percent in 2019 to 16 percent in 2021. The 11 percent increase was driven by private establishments and the Connect SUS Citizen, which allows patients to access health information related to attendance records both in the public system and in the private network. Also, according to the research, there was a positive impact on the availability of telehealth services. Teleconsulting, which took place in 15 percent of establishments in 2019, rose to 26 percent in 2021. Remote monitoring of patients started to become present in 20 percent of health facilities, compared to 5 percent in 2019.

Despite this advance, telemedicine solutions can still be a major inducer for improving health in the municipalities, minimizing the low rate of physicians and qualification, readiness to access to health care and reduction of waiting time.



One important example in this direction is the OpenCare5G project conducted by Hospital das Clínicas (HC) of the USP Medical School, Deloitte and partners with the use of 5G connectivity. Tests have been conducted with the doctor located a different room from the patient. After the tests within the HC itself, the solution will be taken to patients in a city in the interior of the São Paulo State. Also, it is planned to conduct tests with real-time remote monitoring in remote regions of the North of the country, with portable ultrasound scan equipment. Tests will be carried out in three locations in the North: an HC base in Santarém, a riverside community on the Amazon River and a hospital boat.

Connectivity is a great enabler of Smart Cities. In general, smart cities ecosystems and digital cities are designed to work in ICT frameworks that require connection to multiple dedicated networks of mobile devices, sensors, connected cars, appliances, communication gateways, and datacenters.

In Brazil, connectivity is not a major problem for a large portion of applications for smart cities. Today, according to Teleco,<sup>41</sup> 100 percent of the Brazilian population

is already covered with one of the mobile technologies (2G, 3G, 4G or 5G) and of the 5570 municipalities, 5157 already have 4G coverage. For IoT and LPWA (Low Power Wide Area) technologies, there is great coverage with diversity of solutions, as shown (table 6).

### Brief overview of Smart Cities Initiatives in Brazil

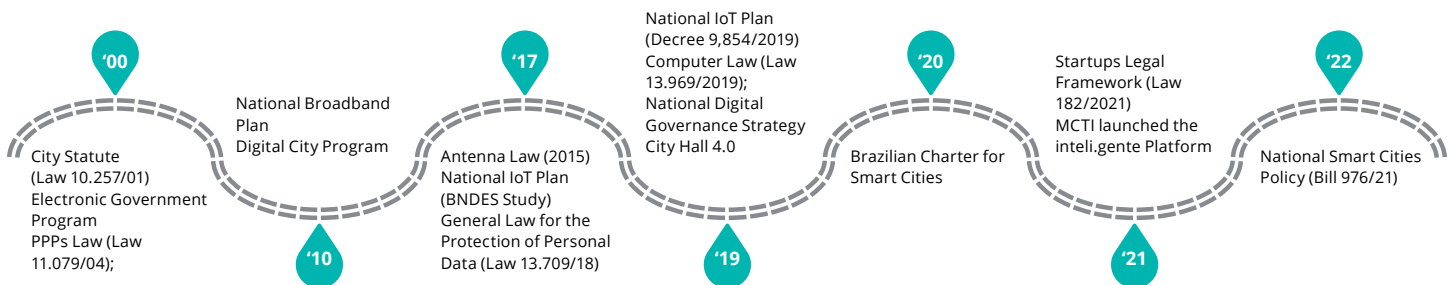
Attempts to transform the smart cities began with the City Statute (Law 10257/2001). The Statute created a series of instruments so that the city could seek its urban development, being the Municipal Master Plan (PDM Plano Diretor do Município) the basic instrument of urban expansion policy and now an important guiding instrument for Intelligent Cities.<sup>42</sup>

However, the start of ICT applications to cities dates to the beginning of the last decade with the creation of the IoT Chamber in 2014. Since then, smart cities are on the agenda of discussion of the technological chambers, such as the prioritization made by the National IoT Plan in 2017 in a work carried out in conjunction with BNDES and MCTIC.<sup>43</sup>

**Table 6: LPWA/IoT Technologies and coverage**

Technology	Covered Municipalities	Population (%)
NB-IoT	4,587	96.0
CAT-M	3,024	87.2
Sigfox	492	51.3
LoRa	286	51.1

**Figure 8: Roadmap summary of public polices in Brazil**



In 2019, the Brazilian Government instituted, through Decree 9854/2019, the IoT Plan, which motivated the creation of City Hall 4.0, whose objective is to raise the quality of life in cities through the adoption of technologies and practices that enable the integrated management of services for citizens and the improvement of mobility, public safety and resource usage.

After the creation of the Chamber and, as an initiative affiliated to the National Urban Development Policy (PNDU), which is in formulation, the Brazilian Charter for Smart Cities was launched in December 2020. It is a public document formulated from interministerial cooperation (between MDR - Ministry of Regional Development, MCIT - Ministry of Science, Technology and Innovations and MCOM - Ministry of Communications), the support of the German cooperation agency GIZ (GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH) and the active participation of more than 120 people and institutions from various areas of knowledge such as urbanism, regulation, and economics, as well as the information and communication technologies area itself.

The Charter presents more than 160 recommendations in 8 strategic objectives, also involving the private sector, financial institutions and civil society organizations, brought the perspective of sustainable consolidation of digital transformation processes and urban development.

In addition to the Charter, the MDR also implements the Pro-Cities Program, which provides FGTS financing resources for technological modernization actions for public services.<sup>44</sup>

### Maturity of Projects in Brazil

MCTI launched the *inteligente Platform*, which aims to make a maturity diagnosis for Smart and Sustainable Cities and propose guidelines and axes of action for the elaboration of the National Policy and municipal policy for sustainable smart cities.<sup>45</sup> It has also created initiatives to promote sustainability in Brazilian cities through innovative technologies and integrated urban planning, such as the *CITinova* project, support to innovation environments, covering Technology Parks, incubators, innovation districts, open laboratories, coworking spaces.

In addition to the *inteligente Platform*, Urban Systems and Necta developed a study called *The Connected Smart Cities Ranking* with annual publications since 2015 on criteria for evaluating and ordering cities based on 75 indicators on 11 thematic axes: mobility and accessibility,

urbanism, environment, economy, governance, technology, and innovation, entrepreneurship, education, health, safety, and energy, comprising from issues of city infrastructure, public services offered, planning instruments, transparency, human capital, spaces for generating knowledge, communication and more. Today the 10 cities best scored according to these criteria are represented in Table 7 - (a).<sup>46</sup>

For the development of the *Connected Smart Cities Ranking*, Urban Systems uses its own indicator weighting methodology, called the *Market Quality Index (MQI)*. The calculation of the *Market Index* allows the use of specific values of each information that vary in nature, complexity and units of measure, to reach weighted values that can be analyzed in the same equation. The common basis allows for important factors to be cross-checked, enabling a consistent analysis of market dynamics.

**Table 7: Smart Cities and Connectivity Ranking**

(a) Urban Systems and Necta	(b) Conexis
1 <sup>st</sup> – Curitiba (PR)	1 <sup>st</sup> – Ponta Grossa (PR)
2 <sup>nd</sup> – Florianópolis (SC)	2 <sup>nd</sup> – Porto Alegre (RS)
3 <sup>rd</sup> – São Paulo (SP)	3 <sup>rd</sup> – Curitiba (PR)
4 <sup>th</sup> – São Caetano do Sul (SP)	4 <sup>th</sup> – São José dos Campos (SP)
5 <sup>th</sup> – Campinas (SP)	5 <sup>th</sup> – Uberlândia (MG)
6 <sup>th</sup> – Brasília (DF)	6 <sup>th</sup> – Jacareí (SP)
7 <sup>th</sup> – Vitória (ES)	7 <sup>th</sup> – São Paulo (SP)
8 <sup>th</sup> – Niterói (RJ)	8 <sup>th</sup> – Joinville (SC)
9 <sup>th</sup> – Salvador (BA)	9 <sup>th</sup> – João Pessoa (PB)
10 <sup>th</sup> – Rio de Janeiro (RJ)	10 <sup>th</sup> – Chapecó (SC)

Connectivity is among the great technological enablers for smart cities. To this do so, it is necessary to ensure that investment in telecommunications infrastructure is possible. In this sense, Conexis created the Ranking of Cities Ranking of Internet Friendly Cities that identifies, among the 100 largest Brazilian municipalities in population, those that most stimulate the provision of telecommunications services, through policies and public actions that facilitate the installation of infrastructure (antennas and fixed networks). In this Ranking, information on legislation, bureaucracy, time and effectiveness for the implementation of telecom infrastructure is considered. A stratum of this Ranking of the best scored 10 Cities are represented in Table 7 - (b).

### Recent Brazilian Government Movements

In 2021, the Startups Legal Framework (Law 182/2021) was created, which was an important step taken to regulate and defend the interests of Brazilian startups and their investors, providing the stimulus to creation and investments in these companies. This milestone created the Public Innovative Solution Agreement

(CPSI), which facilitates govtech solutions to advance very effectively, with the development of technologies aimed at improving smart cities.

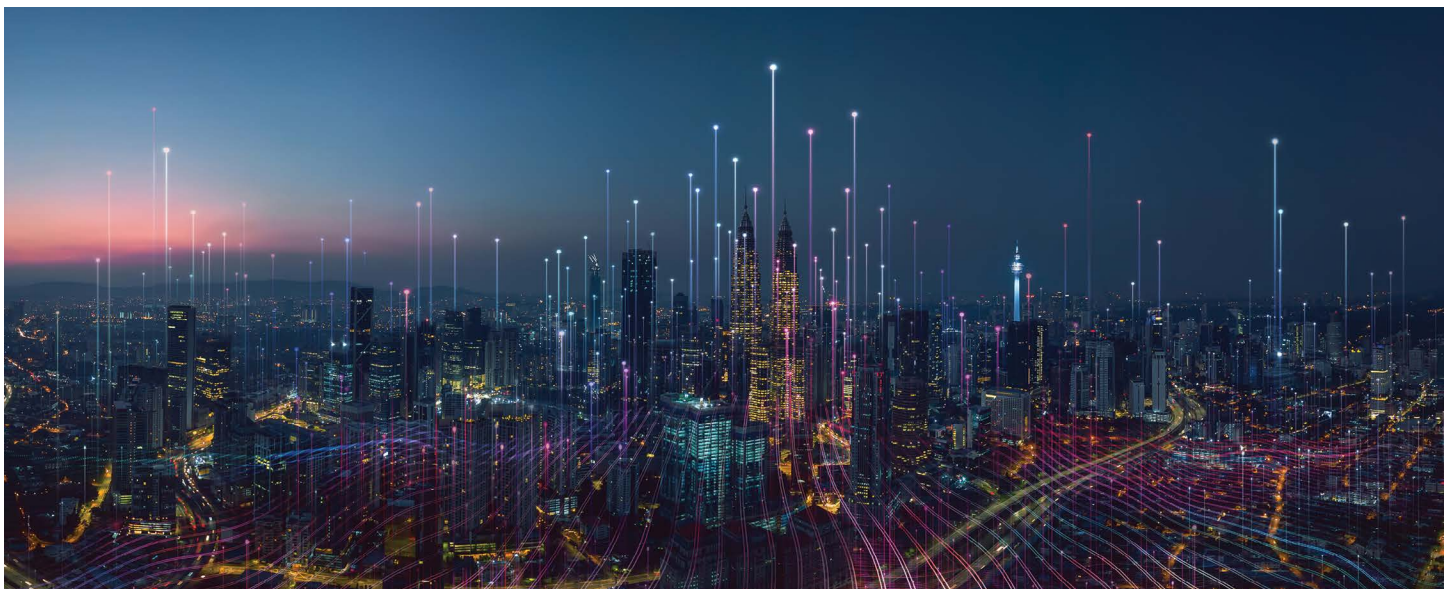
More recently, the Bill 976/21<sup>47</sup> is under discussion. Being reviewed in the House of Representatives, it establishes a policy to stimulate the development in Brazil of so-called smart cities, which take advantage of state-of-the-art technologies in the management of urban space and in the relationship with citizens. The Law, approved by the CDU (Commission for Urban Development), contains 20 articles and is divided into 8 chapters dealing with the National Policy of Smart Cities (PNCI). It defines the smart city as "an urban space oriented towards investment in human and social capital, sustainable economic development and the use of available technologies to improve and interconnect the services and infrastructure of cities, in an inclusive, participatory, transparent and innovative way, focusing on raising the quality of life and wellbeing of citizens."

The project foresees the creation of an intelligent city plan by States, Municipalities and the Federal District. The construction of the standard should have contributions

from society and follow principles such as: sustainability, reduction of barriers to innovation and entrepreneurship, stimulation of competitiveness and the involvement of educational actions.

Originally, for funding purposes, there was the provision of the National Fund for the Development of Smart Cities (FNDCI), with resources obtained through contributions and donations from individuals and legal entities and other sources of revenue. Although the fund was maintained in the first analysis of the House, in the Committee on Urban Development (CDU), but was rejected in the CFT (Committee on Finance and Taxation). In this sense, the financial assistance will be exclusively from the Union, in addition to technical assistance, for the regional actions of the National Smart Cities Policy, provided that local governments allocate all the value of the specific amount in the actions consistent with the plan.

Based on the PNCI, municipalities should adopt smart city plans, duly approved by municipal law and integrated into the local master plan, when any, or Integrated Urban Development Plan, in the case of metropolitan regions.



To facilitate the work of municipalities, the Union will make available on the Internet a repository of solutions for the development of smart cities. Cities that adopt these solutions will have priority in accessing technical and financial assistance provided by the federal government. Municipalities that have periodic programs to train public managers will also have priority.

**Analysis of Smart City Projects in Brazil**

Urban Systems and Necta annually present the Connected Smart Cities Ranking based on 75 indicators on 11 thematic axes. This report provides an assessment of how smart cities are at their stage of maturity, bringing not only sustainability agendas, but the implementation of technologies in these cities to make them smarter.

ICT services in cities were implemented exploring a given specific need, depending on technological availability, interest and momentum, with few synergies between

them. As noted, today the great difficulty is the possibility of reusing data generated by different verticals of services of different projects and technologies employed over time.

Also, due to specific tax budgeting, there is an asymmetry of investments favoring some services, which are being accentuated by concession auctions for PPPs. This is the example of public lighting, which with the collection of CIP or COSIP (Contribution to The Cost of Public Lighting), guaranteed by the constitution to municipalities.<sup>48</sup> The collection already exceeds R\$7 billion in more than 86 percent of municipalities, with more than 460 lighting projects.

Other services also benefit from PPPs, but in smaller numbers, such as traffic monitoring and traffic violation control such as: public health, public security of important social impact and that

guarantees the wellbeing of the population for the development of their work activities, recreational, social, etc.

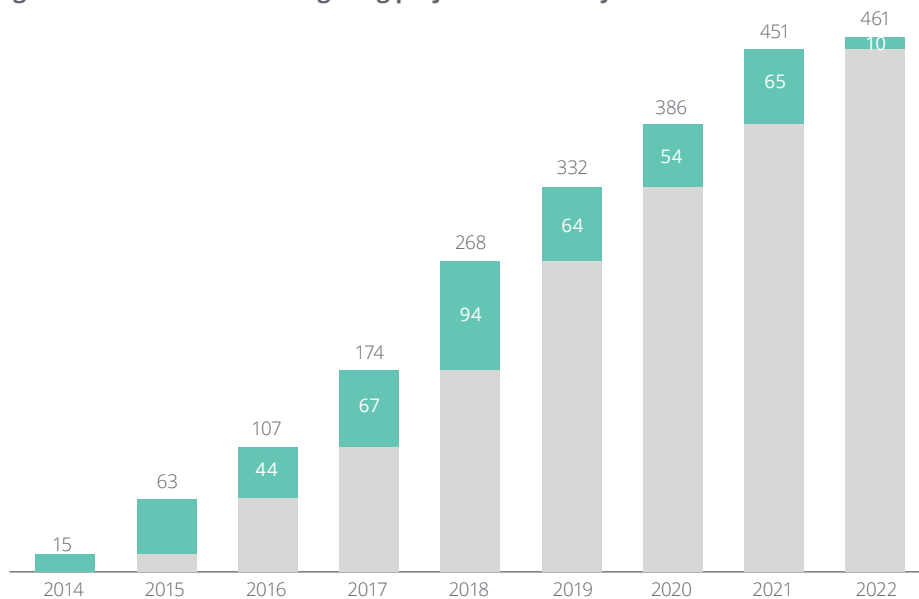
Some infrastructure resources are being developed to take advantage of CIP/COSIP and the modernization of public lighting, such as the Qualcomm and Juganu project to provide the fixture of lighting poles with 5G base station.<sup>49</sup> Other smart city enabling technologies, such as parking sensors, security cameras, Wi-Fi networks – and their applications could take advantage of this same concept and movement for their deployment.

As already indicated, there was an increase in the period from 2020 to 2021 of 6.5 percent in the theft rates to commercial establishments; 4.7 percent in home theft rates; 11 percent increase in bank theft rates and an increase of 2.4 percent; in cargo theft.

According to the Brazilian Association of Electronic Security Systems Companies (ABESE), 94 percent of attempted thefts in monitored environments fail.<sup>50</sup> In the world, the installation of CCTV had the greatest effect on drug crime with a reduction of approximately 20 percent. Significant reductions were also observed in vehicle and property crimes.<sup>51</sup>

The implementation of technology for public security has mainly immediate effects on the reduction of crimes against property. According to the survey conducted by the consultancy ESI ThoughtLab, investments associated with public safety increase the wellbeing of citizens, improve city reputation of the city attracts investments and new businesses. In summary, cities that adopt technologies for public safety find substantial benefits in quality of life.

**Figure 9: Number of Public Lighting projects in recent years**

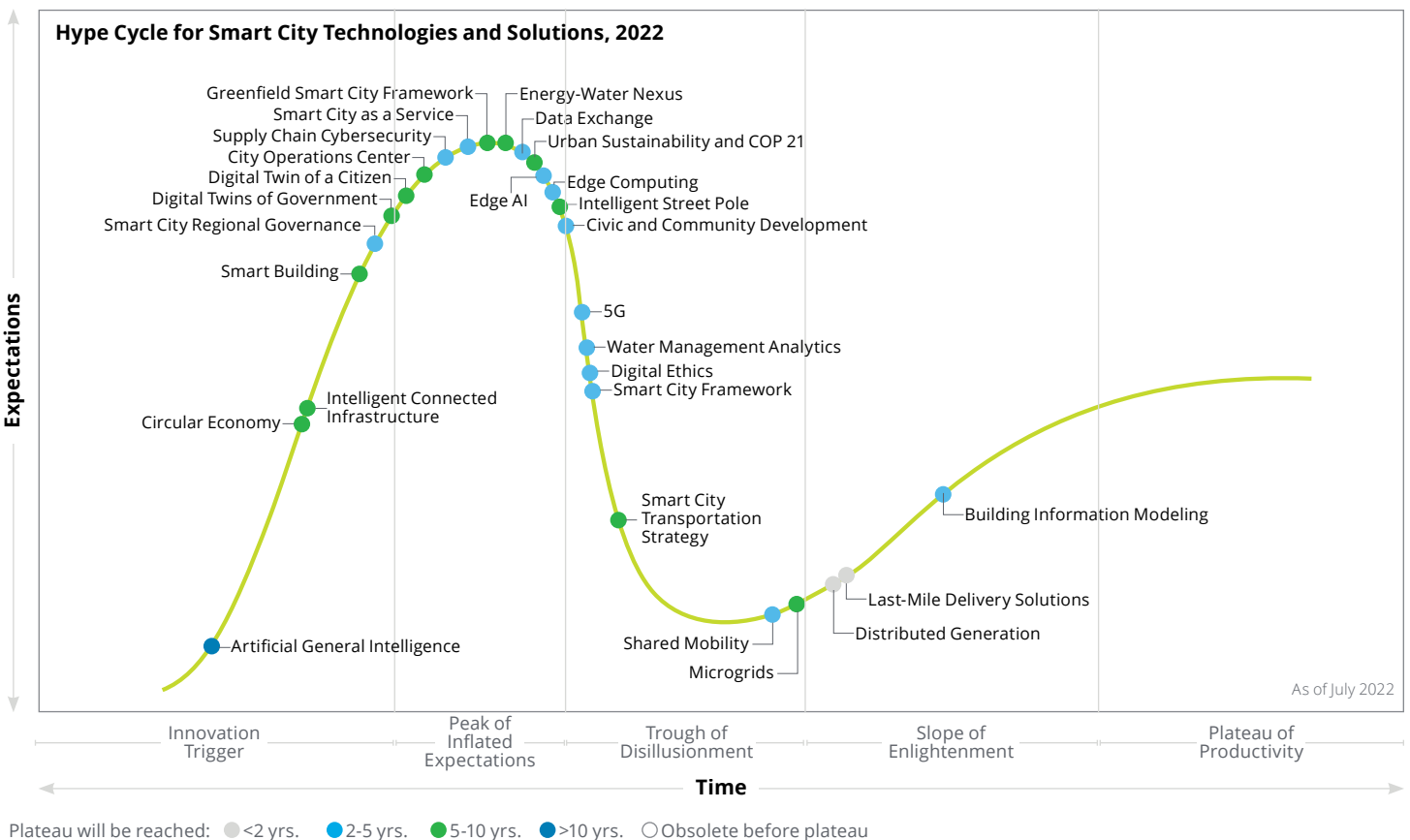


# Technologies to Make Cities Smart

In this chapter the objective is to provide a non-exhaustive overview on some of the main solutions and enabling technologies for Smart Cities. Among them: the Internet of Things (IoT) and Smart City Platform; Big Data, Analytics and Artificial Intelligence; Biometric Identification; Blockchain;

Connectivity and 5G; Virtual Reality, Digital Twin and Metaverse, each at its own maturity stage. However, they share the fact they are present in the main discussions and forums on the subject, in addition to keeping a certain dependence on each other, as described throughout the chapter.

Figure 10: Gartner Hype Cycle for Smart Cities Technologies and Ecosystem

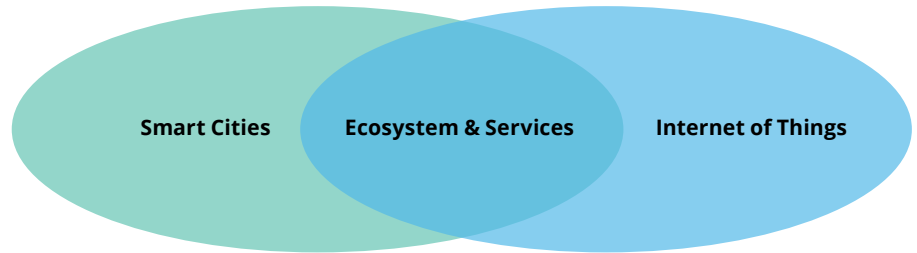


### Internet of Things and Smart City Platform

It is impossible to dissociate Smart Cities from Internet of Things (IoT). There is an overlap between both subjects and in a certain level the first depends on the second. Many solutions for Smart Cities use connected devices and sensors, such as public safety (cameras and microphones), public lighting (lamps and sensors), public parking (sensors or cameras), among others. And both share the same barriers and challenges to be able to develop themselves in the country, for example, finding funding sources for innovation and expansion, and the need of a revision in the legal and regulatory framework.

In June 2019, **decree 9854**<sup>52</sup> was published establishing the **National Plan for the Internet of Things**<sup>53</sup> which aims to implement and develop the Internet

Figure 11: Context of Technologies, Ecosystem and Services for Smart Cities



of Things in the country, based on free competition and data circulation, with the necessary information security and privacy. The plan prioritizes the verticals of health, **cities**, industries, and rural areas, defining a model for governance and monitoring of initiatives (mobilizing projects) and actions.

The decree defines IoT as the infrastructure that integrates the provision of value-added services with physical or virtual connectivity

capabilities of things, with devices based on existing information and communication technologies (ICT) and their evolution, with **interoperability**.

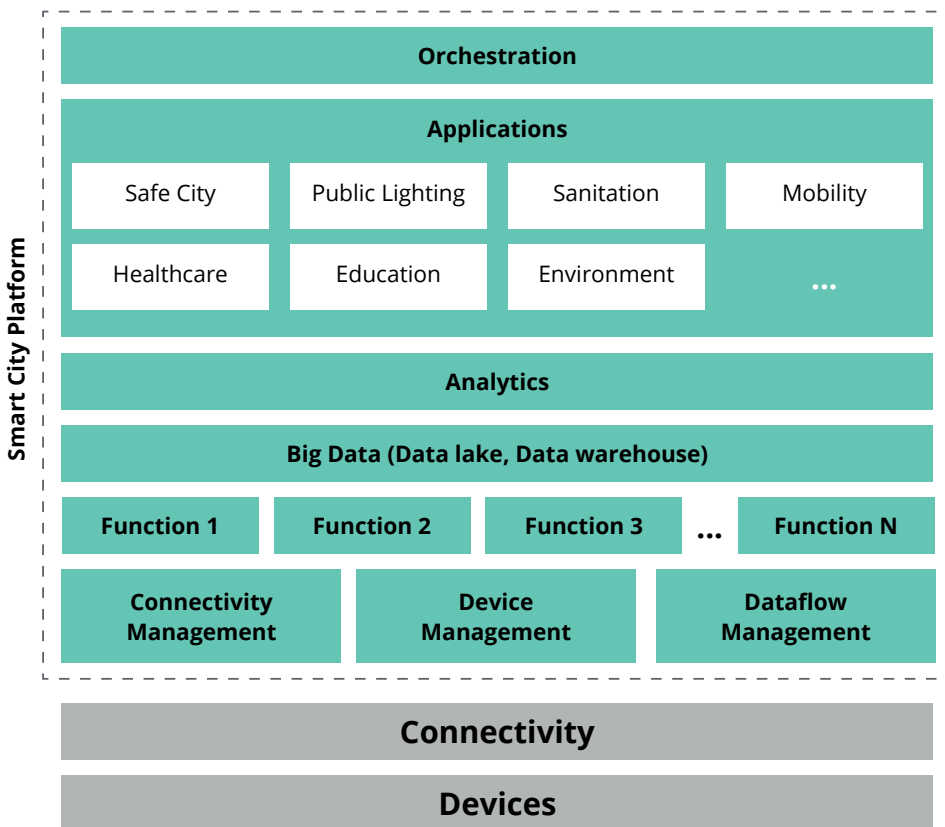
Law **14108**<sup>54</sup>, of December 16, 2020, also known as the **IoT Incentive Law**, promotes tax incentives for the Internet of Things until 2025, such as the exemption from the Installation Inspection Fee (TFI), the Operation Inspection Fee (TFF) and the Contribution for the Promotion of Public Broadcasting and the Contribution for the Development of the National Film Industry (Condecine) over telecommunication stations that integrate machine-to-machine communication systems and exemption from prior operating licensing.

An important part of an IoT solution is the platform. IoT platforms are systems that integrate several functions to deliver value through the set of devices and the data generated by them. The benefit a platform offers is the possibility to manage devices, connect them to applications, orchestrate different use cases, receive the generated data flow, extract valuable insights, among other functions, in a frictionless, centralized way, as a Command & Control Center for the city, that provides real time information.

The figure 12 illustrates a simple architecture for an IoT platform:

- The first layer performs specific management. Ex. connectivity (activation, control and distribution of data allowance, etc.), devices (activation, configuration, active/idle/fail-state, battery, inventory, etc.), data flow (ETL – extract, transform and load, etc.).

Figure 12: Layered Architecture for a Smart City Solution



- The functions layer performs real-time analysis on the data stream (e.g. recognition of image, video, text, audio, scene, behavior, etc.).
- The Big Data and Analytics layer contains the repositories (Data lakes and Data Warehouses), that are the destinations of the data flows generated by the devices, for further processing and analysis (correlation, modeling, simulation, prescriptive/predictive/semantic analysis, etc.), and presentation of insights.
- The application layer employs functions, analyzes, and reacts to events in specific use cases (e.g., Smart Meter, Smart Parking, Smart Public Lighting, Public Safety, etc.) to generate the desired outcome (e.g., resource savings, crime reduction, mobility management, etc.).
- Finally, the orchestration layer performs integration and allows interoperability between different applications to create complete solutions and generate broader value.

An important point to note is that it is not mandatory to use a complete platform with all the layers and functions described above to start implementing an IoT solution. What usually happens is to start with a vertical solution to meet a specific scenario. Nevertheless, it is mandatory to employ open solutions that allow the integration of functions and data, which consider the existence of a legacy (devices and applications) and enable the evolution to a more complete platform.

### Big Data, Analytics & AI

As discussed in the previous section, Big Data, Analytics, and AI play an important role in IoT and Smart Cities solutions, as they enable value extraction of the large volume of data generated by IoT devices by automated analysis.

Artificial intelligence allows automation of decisions, based on the recognition of an event (image, scene, behavior, sound, pattern or sequence of data). Examples of artificial intelligence applications are: image recognition, text, sounds, voice and music, autonomous driving, process optimization, among others. The value of Artificial Intelligence lays in the possibility to automate the analysis of large information volumes (e.g. hour of audio and video, thousands of photos, text and document images). These tasks would take long time for a human to execute or would demand a large amount of workforce, with higher accuracy in comparison to human performance in many situations.

The main component of an artificial intelligence solution is called algorithm or neural network. This neural network is composed of nodes that are organized in a sequence of levels, where each node is related to one or more nodes of the next level. Each node has an internal function with parameters that can be adjusted and generates a response according to the inputs and this function. And unlike traditional programming where the expected behavior is described through a code, the artificial intelligence algorithm needs to be “trained”, adjusting the functions and parameters.

There are basically two ways to train an artificial intelligence algorithm. The first one assumes the existence of a large volume of already qualified data (hence the importance of BigData and Analytics). These data are repeatedly processed (iterations) by the algorithm and its functions and parameters are adjusted until the algorithm produces an output according to the previously known answer. Typical examples are image, text and speech recognition. The other way is used when these pre-qualified data are not available, but one wants to obtain a certain result or optimize it by adjusting the input parameters. Typical examples are reducing air conditioning consumption in a datacenter or optimizing traffic in a city.

From the examples mentioned in the previous paragraph image recognition, scenes and video analytics are probably the most versatile application of artificial intelligence and machine learning, being employed in a variety of use cases for recognizing events in real time and analysis of images and videos historic to obtain insights:

- Objects and people statistics
- Presence and motion detection
- Behavior detection and analysis
- Analysis of traffic, accidents, vehicle identification, parking control, and traffic violations
- Facial identification, iris, gender, age, dimensions

The combination with edge or embedded computing allowed many of these analysis to be performed on the device, reducing dependency, or even eliminating the need for Internet connection. And the main benefit is the automation of tasks that would demand repetitive and demotivating human intervention.

Within the smart cities' context, artificial intelligence and analytics play a key role in public safety solutions (facial recognition and identification, license plate, detection of violence, adverse events, firearm shooting, traffic prioritization for vehicles), urban mobility (traffic optimization), disaster prevention (floods, landslides), and maintenance of urban infrastructure (streets, avenues, bridges, poles).

Under World Economic Forum administration, the **Centers for the Fourth Industrial Revolution (C4IR)**<sup>55</sup> initiative offers a toolkit<sup>56</sup> (AI Procurement in a Box) with best practices for procurement of AI in the public sector and provides inputs to public managers for a more confident and responsible decision making. Two pilot projects were already implemented at the

São Paulo Metro and Hospital das Clínicas. A common challenge faced is the complexity of highly restrictive processes that were not designed with innovation and broad added value<sup>57</sup> in mind. This is one of the problems that the toolkit seeks to address. In the São Paulo Metro's case, the toolkit was used to acquire a predictive model that would indicate in real time the points in the network in need of maintenance to be able to program and reduce downtime.

Another initiative that involves universities, governments and the private sector aimed at promoting the use of artificial intelligence within cities and is called **Artificial Intelligence Recreating Environments (IARA) Network**.<sup>58</sup> According to one of the network coordinators, André Carlos Ponce de Leon Ferreira de Carvalho, "the objective of IARA is to create a national research network, for technologies such as Artificial Intelligence, IoT, 5G with a focus on the main axes: communication, energy, mobility, sanitation, health, education, leisure, and security. The city of Canaã dos Carajás/PA was chosen to host the network's pilot project."<sup>59</sup>

### Biometric identification

The spread of Artificial Intelligence usage, mainly in recognition image (e.g., faces, scenes, objects, license plates) has enabled a multitude of biometric identification use cases. Biometric identification has wide applicability in public safety scenarios or where unambiguous identification is required. Examples include crime and fraud prevention, identification of criminals, access authorization, and presence control.

Some real use cases examples of biometric identification in Smart Cities:

- Since 2016, the Brazilian Federal Police has been using a facial recognition solution at the country's airports that allows it to automatically and non-invasively identify potential threats and misdemeanors, such as fugitive criminals and suspected terrorists, smuggling and drug dealing, through images of passengers boarding and disembarking from international flights, in a matter of seconds, by cross-referencing information from the Internal Revenue Service, Federal Police, and Abin (Brazilian Intelligence Agency).<sup>60</sup> In 2017, this solution enabled a 50 percent increase in the number of seizures compared to the previous year.



Source: <https://www.nec.com/en/global/solutions/biometrics/face/index.html> / Copyright: Elnur/123RF



- The Ministry of Justice wants to unify 27 state databases and approve a Federal Police project, which provides for the use of a biometric identification system to gather criminal information.<sup>61</sup>
- Check-in for boarding on the flights between Congonhas (SP) and Santos Dumont (RJ) airports can be performed using facial recognition, without the passenger required to produce air tickets or traveler documents. It has generated a 27 percent gain in passenger boarding processing time.<sup>62</sup>
- Bus companies in São Luís - MA and Jaraguá do Sul - SC are testing facial biometric systems to identify passengers entitled to free or half-rides. In case of suspected fraud (e.g., use of another person's card), the legal sanctions are applied, which can range from temporary to the total blocking of the benefit.<sup>63</sup>

The main challenge faced by biometric identification is privacy and access control to citizens' biometric data. In the private sphere, people feel more comfortable in sharing this type of information, and the use of biometrics is common (e.g., unlocking smartphones, banking applications, time stamps) as there is a direct perception of value. In the public and governmental spheres, there seems to be a greater concern with security and data access control. To address this challenge, initiatives are emerging using Blockchain in security, access control, integration, and data distribution.

### 5G connectivity for private government networks

Connectivity is part of the foundation for any IoT or Smart Cities solution, as the ability of devices to transmit and receive information, as well as all communication between systems, depends on it. It would not be an overstatement to say that a Smart City presupposes being a Connected City. On the other hand, it is not enough to simply make Wi-Fi available to the public to consider the city as being smart.

## NEC Success Case Face Recognition for 14 International Airports

- Used to enhance efficiency and effectiveness of customs operations in 14 international airports in Brazil.
- Facilitate the identification of passengers who have been registered for suspect activity by the agency, contributing to the improvement of the country's border controls.
- Contributing to prevent trafficking and smuggling activities.

“The biggest bottleneck for digitization and for the implementation, on an urban scale, of innovative services for the city, is the absence – in most Brazilian cities - of a high-capacity and low-cost Multiservice Connectivity Infrastructure necessary for the implementation of services in the entire urban and rural area of Brazilian municipalities. This is the greatest challenge that Brazil needs to address in the coming years if it really wants to achieve all the benefits and impacts of the digitization of cities and urban services.”<sup>64</sup>

The device connectivity can happen via fixed or wireless networks. In the case of wireless networks, they can still be divided into licensed and unlicensed spectrum. The difference between licensed and unlicensed spectrum is that the former requires an authorization for use by the granting authority (ANATEL) and allows exclusive use of the frequency band. As for unlicensed spectrum, more than one person, organization or service can make simultaneous use of the frequency band, making it more susceptible to interference.

“The smart city is supported by a data network that needs to be reliable and fully available. The spread of optic fibers has enabled the construction of these

cities, as well as the improvement of the mobile band both in terms of speed and latency. The arrival of 5G should further reinforce network redundancy and hyper connectivity.”<sup>65</sup>

Although 5G is a wireless connectivity technology, its implementation and expansion will imply an improvement in the capillarity and availability of the fiber network. This is due to two factors. First, because the frequency spectrums available exclusively for 5G in Brazil (3.4 to 3.8 GHz and above 26 GHz) allow for a shorter range (coverage radius) and lower penetration (ability to overcome obstacles, e.g. walls), thus requiring 5 to 10 times more antennas to cover the same area with 4G.<sup>66</sup> Second, because it will require a large amount of traffic throughput in the backhaul, due to eMBB and mMTC, which will only be possible through optical communication.

For Smart Cities, 5G proves to be an excellent option for connectivity technology in several use cases, such as to connect cameras for public security and Intelligent Traffic Management, Smart Public Lighting, communication between public transport vehicles, Smart Parking sensors, public education and healthcare, and sensors in disaster prevention and emergency detection, among others.

Another important feature of 5G is the native use of network functions virtualization (NFV), eliminating the need for dedicated network equipment, allowing the usage of a cloud computing infrastructure, making network slicing and bandwidth guarantee for essential services simpler. In this way, in case of disasters, when the network is congested by the simultaneous use by the population, critical communication between hospitals, and public safety is prioritized.<sup>67</sup> That is, it is possible to have private government 5G networks (i.e. for exclusive use) for Smart City services. And the 5G network infrastructure can be provided by both telecom operators and infrastructure providers or, if applicable, acquired by the government itself.

Virtualization has also accelerated the disaggregation of wireless access networks (RAN). Instead of all functions being provided by the same equipment vendor, now each of them can be provided by different specialized vendors, enabling greater competition between them in addition to opening the market to new players. This is what the Open RAN (O-RAN)<sup>68</sup> and Telecom Infra Project (TIP)<sup>69</sup> initiatives are looking for.

A recent success story in the use of a private 5G network based on Open RAN architecture in public health is the OpenCare 5G<sup>70</sup> project. An initiative of the Institute of Radiology (InRad) of Hospital das Clínicas de São Paulo, coordinated by Deloitte and with the participation of Itaú Unibanco, Siemens Healthineers, NEC, Telecom Infra Project (TIP), Brazilian Agency for Industrial Development (ABDI), Banco Inter-American Development Bank (IDB), and the Polytechnic School of the University of São Paulo (Poli-USP). Its goal is to bring take healthcare to regions

lacking from doctors and specialists, enabling a better quality of life. The first use case was the performance of remote prenatal ultrasound exams.

### Blockchain

Blockchain importance goes far beyond what cryptocurrencies (cryptocurrencies and NFTs) have to offer. The proposal to have a distributed ledger (several copies shared), decentralized (without a single controlling entity), with security and validation mechanisms that make it impossible to tamper with the records (based on current computing power), brings the necessary consensus and trust for direct communication between two parties, without the need for intermediaries. It is a permanent record of fraud-proof transactions.

Smart Cities have a series of technological solutions that generate and process a huge amount of data, such as public and private data on their inhabitants and their urban infrastructure. As will be discussed in the next chapter, one of the biggest challenges of Smart Cities is the integration of data from different solutions. In this sense, Blockchain provides several unique features, such as reliability, scalability, fault tolerance, and emerges as a potential technology for the development of new solutions capable of providing features aimed at the integrity, reliability and privacy of this data.<sup>71</sup> And its integration with devices in a smart city enables a common platform where all devices and solutions can communicate securely.<sup>72</sup>

Some examples of possible uses of blockchain within the scope of Smart Cities:

- Authentication, authorization and audit data generated by IoT devices across the network, as well as eliminating the need to rely on third parties and having no single point of failure.<sup>73</sup>

- Single medical records for citizens, guaranteeing integrity and security in the collection of all appointments, in such a way that they can be accessed in real time by doctors and patients equipped with encrypted codes.<sup>74</sup>
- A tool that allows better communication between governments and citizens, through a digital interaction that facilitates bureaucratic processes, such as notary services (**e- notariado**)<sup>75</sup> or transparency so that citizens have access to the destination of public resources (**Rede Blockchain Brasil**).<sup>76</sup> And eventually the possibility of increasing the direct participation of the population in the city administration through greater use of plebiscites.
- Operationalize value transactions, such as trading of renewable energy.<sup>77</sup> (Surplus generated by solar panels.)<sup>78</sup>

Initiatives such as **Blockchain4Cities**, carried out by the United Nations (UN), aim to study and enable applications of this technology in the smart cities planning.<sup>79</sup>

A reference for the use of blockchain in public administration is the city of Dubai,<sup>80</sup> considered one of the smartest cities in the world, which has developed a platform that allows reducing the cost of the State with bureaucratic processes. The technology allows for greater efficiency in government transactions, in addition to the creation of a new technological market, being a reference for more efficient governance.

In Brazil, in addition to the examples mentioned above (e- notariado and Rede Blockchain Brasil), there is blockchain used for planning public transport in Teresina-PI<sup>81</sup> city, the distribution of digital currencies as an incentive to protect the local environment in Itajaí-SC<sup>82</sup> and the digital rotating parking system in Belo Horizonte.<sup>83</sup>

**Other technologies (AR/MR/VR/XR, Digital Twin and Metaverse)**

Finally, one cannot fail to mention a technological trend that although still incipient is much in vogue: the Metaverse and its enabling technologies AR, MR, VR, XR and possible uses. A brief description of the meanings and their relationship can be found in the glossary at the end of this study. Simply put, these technologies allow

information to be presented and delivered in the form of computationally generated virtual representations.

From the merge between these computationally generated virtual representations and IoT sensors arises what is called Digital Twin, whose concept is to be a virtual representation of something physical, which simulates not only its



appearance and composition, but also its behavior based on historical patterns. This virtual representation interconnects with the real world through the sensorization (IoT) of the physical twin. Taking this concept to Smart Cities means having a digital representation of a city that reproduces it in the virtual world, allowing to compare the behavior in real time with what was expected and, in case of discrepancies, to take preventive actions.

Another use for the virtual representation of a city would be the metaverse. Unlike the Digital Twin, the metaverse of a city is not obliged to reproduce its behavior in the virtual environment. However, they can share the computational effort needed to generate this virtual representation, to optimize resources. The metaverse can serve as an immersive interface for the population to obtain information and services, carry out commerce and participate in events. Served in this way for offloading (migrating) actions that would occur in the physical world and relieving urban infrastructure.

An example is the city of Seoul, which by 2030 intends to invest €2.8 billion according to the "Seoul Vision 2030" plan released at the end of 2021, which among other initiatives, includes becoming a metaverse city.<sup>84</sup> A project called "Metaverse Seoul" is being conducted by the Seoul Institute of Technology (SIT) in partnership with the local government and as a pilot will launch Seoul City Square into the metaverse. In addition to a virtual tourist spot that will replicate the landscape in real time, the environment will serve to provide cultural and historical experiences, hold meetings, presentations, conferences, press conferences, and events such as Seoul Beauty Week.<sup>85</sup> Another example is the city of Dubai with the "Dubai Metaverse Strategy" plan, which aims to place the city among the top 10 economies in the metaverse, attract more than 1,000 companies specialized in metaverse and blockchain, and support more than 40,000 virtual jobs by 2030.<sup>86</sup>

In Brazil, until the conclusion of this study, there is not yet public administration initiatives in this regard. Only actions of private companies<sup>87</sup> aiming the commercial use for advertising, sale of virtual assets (land and NFTs), games or use the metaverse as a platform for virtual meetings.<sup>88</sup> However, it is reasonable to expect that soon there will be policies and projects dealing with the subject, given the momentum it has gained in the Smart Cities forums.

# Main Barriers to Smart Cities Development

After a brief understanding of the Smart Cities background and the enabling technologies, this chapter lists the main barriers to the Smart Cities development in Brazil, raised through qualitative interviews with specialists directly involved in the development and execution of policies, programs and projects around the theme. For this study, a total of 19 experts were interviewed, including representatives of the main actors: governments (federal, state, and municipal), industry (manufacturers, suppliers, service providers, and associations) and academia (universities).

The barriers were grouped under a few macro themes organized according to their nature: political-administrative, knowledge and training, economic, legal, or technological.

## Political-administrative barriers

Lack of planning and focus are the political challenges mentioned almost unanimously by the interviewees.

The planning challenge is to decouple initiatives from the 4-year electoral cycle. It is having a long-term plan that brings a vision of where you want to get and contains a plan of action with steps of compulsorily fulfillment. Having this plan and following it is fundamental for the success of the evolution towards a Smart City. And the problem begins with the focus on short-term actions and accomplishments, within the current political term, that provide greater visibility and exposure, without these actions being aligned with a long-term vision. And this results in solutions and services with low lifespan, which will not continue by the next administration.

The issue of focus is to know what the city, i.e., the citizen needs and wants, and what is the real problem to be solved. In other words, the Smart City needs to be oriented towards solutions to existing problems rather than the pure technology deployment. As examples of this lack of planning and focus, there are cities with

**66** So that's it (about the barriers): there is no planning, communication infrastructure, and funding. **99**

**66** The problem becomes more political than technical. As I said, technically the industry provides whatever the market needs. The issue is what the market wants, the issue is a long-term planning policy, the issue is a regulatory framework to bring legal stability to investors, the issue is citizens being able to have access to services and, consequently, to technology. **99**

“One thing I noticed right away is the lack of planning. And this is obvious, even before the lack of resources or anything like that. And planning means knowing what the city wants. So, managers usually have a problem by not knowing what they want.”

“And is it still working? No! Everything stopped because the administration changed.”

the population living predominantly in rural areas, whose municipalities installed smart traffic lights to solve a non-existent problem or installed emergency totems (public health and safety) but forgot the necessary connectivity for the service to work. In the case of large cities, the examples are the execution of proofs of concept (PoCs) or the solution deployment in areas of low representativeness of the population's reality or where the problem, which the solution proposes to solve, does not occur.

Still in the political-administrative point of view, another barrier to the success of Smart Cities initiatives is the existence of multiple secretariats operating in independent silos, which makes the collaboration between them difficult. And this collaboration is necessary for the integration of the respective data sources under the same process. This challenge can be even greater when we are faced with a lack of ownership and leadership, i.e., not having someone named and responsible for the project. Or, when this nomination occurs, then the next problem is the lack of empowerment, i.e., the autonomy to decide and the determination to deliver the results. For even in the existence of a vision of the future with a long-term plan, the short-term tactical actions are not carried out due to the lack of leadership to execute them. A possible cause for these problems may be the lack of human resources available to dedicate themselves to the projects, or when such resources are available, another issue arises, the knowledge and competence, which will be addressed later.

#### Economic barriers (Economic feasibility/ Funding Sources)

After the political-administrative issues, the next barrier for the development of a smart city most commented by specialists was obtaining financial resources for the projects.

In a country where almost all<sup>89</sup> municipalities have their revenues dependent on federal or states transfers, and about 35 percent<sup>90</sup> of municipalities do not collect enough

taxes to support their own administration structure (city hall and chamber), and the largest share of these revenues are committed to paying civil servants (limited to 60 percent of Net Current Revenue by the Fiscal Responsibility Law,<sup>91</sup> but it is not uncommon to find cases where this limit is exceeded),<sup>92</sup> it is a great challenge to have resources available to invest in innovation. It remains the options of committing resources already foreseen (when foreseen. Ex. CIP/COSIP), depending on state and federal programs and funds (Pro-Cidades, Avancar-cidades, Refrota, etc.), or depending on investments from private sector through Public Private Partnerships.

However, to attract the private sector to invest in solutions for the cities, long-term guarantees that the rules will not constantly change are needed. Otherwise, companies will not invest, or if so, the price charged for the service will embed the associated risk. Another essential point to attract private investment is scale. For large urban centers this is not a problem. But as mentioned

“Normally in smart cities it is a solution looking for a problem. And the perspective cannot be from the technology company to the municipality. The municipality must want it. I think there is this big challenge, that we have a lot of solutions looking for problems. But the problems of each city administration, even in cities of equal size, can be different. If the Mayor doesn't engage, it will never happen. And it must be a perennial state policy. Installing is easy, maintaining is difficult.”

“Let's take as example concrete cases of the most known technology parks. None of them are in the city center. All 3 are located in isolated areas of the city. And you must test the Smart City model where you have the mess going on!”

**66** The problem is the 100 percent dependence on public resources. And when you depend 100 percent on public resources, you must look for a financing mechanism, or a subsidy fund - which is very difficult -, or these creative moves **99**

at the beginning of this study, 87 percent of the 5,570 Brazilian municipalities have less than 30 thousand inhabitants, making them unattractive to large investors, besides adding another challenge that is to individually manage small projects in several cities. The adoption of municipal consortia to increase attractiveness and the PPP model mentioned in the previous paragraph can be a solution. However, the criteria for selecting the company or companies' consortium to be contracted though this model needs to be carefully defined, to allow investment in innovative solutions, in addition to the simple provision and maintenance of the contracted service. Otherwise, something similar to the public lighting PPP model will occur, where the selected party will be the one that offers the biggest discount, allowing a business plan only sufficient for the replacement to LED luminaires, the respective maintenance and service provision. As consequence, a part of the CIP/COSIP that could be used for innovation (e.g., smart street lighting, integration of cameras, sensors, and antennas in the luminaire), remains in the municipal fund once its use is established and restricted by a specific law.

#### Human resources availability, knowledge, and competence

Part of the planning and focus problem can be explained by the lack of human resources availability with knowledge and trained within the public authorities. First, there is heterogeneity of graduation and attribution distortion. This generates a loss of quality and speed when dealing with specific topics, often due to communication and understanding difficulties. There are about more than five thousand municipalities,

with different needs and low technical qualifications of civil servants. However, this lack of knowledge is not restricted to civil servants, and extends to elective positions such as mayors, governors, councilors, and deputies, mainly being these the agents directly involved to the Smart Cities issues (Security, Mobility, Health, Sanitation, Education, etc.). The lack of knowledge starts with the definition of a Smart City, where in some cases the public manager just wants to implement a technology park, an innovation ecosystem or offer free Wi-Fi coverage and believes that by just doing this it is enough to have a Smart City. Topics that are in vogue at that particular moment and having other solutions more adequate to the specific problems of your city have not come to their attention.

It is not new that data is treated as the "new oil"<sup>93</sup> of the digital age, being mentioned in studies on Smart Cities by the OECD.<sup>94</sup> Industries and companies already make decisions based on data and insights that managers would not otherwise have access to. However, this data-based decision-making is still not a reality in public administration. Even managers having access to a huge volume of information, continue to make only politically biased decisions. There is an unpreparedness to deal with the excess of data and information.

Another aspect that falls within the lack of knowledge of public managers is related to the mechanisms and devices available<sup>95</sup> for Smart Cities initiatives and projects. For example, the MCTI's<sup>96</sup> *inteli.gente* Platform assists in the maturity diagnosis, competencies, needs, and proposes guidelines and areas to focus. However, few municipalities know about its existence or have the knowledge to fill in the requested information.

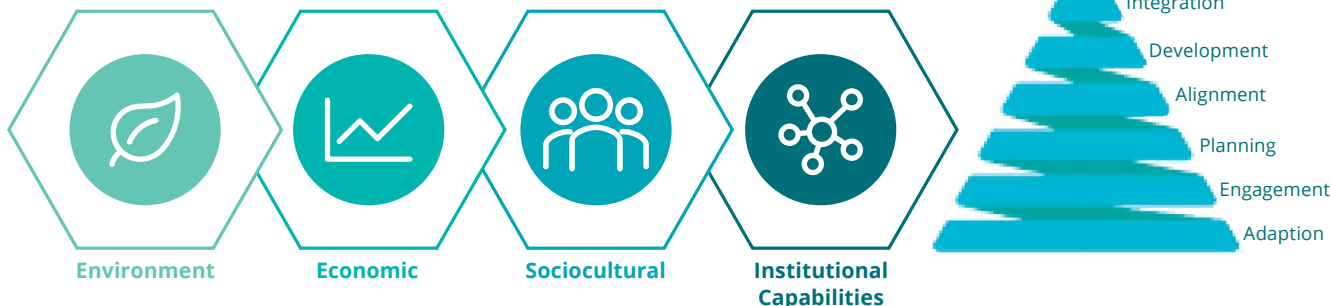
On the other hand, there is also a lack of knowledge on part of the population.

**66** They don't know what they want. Every public manager wants to make their city smart, but they don't know what it means, or what they need. And they come here with totally different visions, with the majority either wanting connectivity or creating a technology park. **99**

**66** I think this is perhaps one of the great challenges, due to the diversity of the municipalities: the low technical qualification that you have in these municipalities. And usually, in smart cities there is a solution looking for a problem. And the perspective cannot be from the technology company to the municipality. The municipality must want it. **99**

Figure 13: Brazilian Smart and Sustainable City Maturity Model (source: MCTI<sup>97</sup>)

Dimensions of the model



“The problem is that maybe at most 10 percent of mayors know that these mechanisms exist or that we are going to offer them. Even if we bid and get a billion Reais to do this, 90 percent of city halls won't even notice that we opened this call for projects.”

“There is a lack of awareness among people about the benefits, so that they can push the public authorities. Because people don't know. And this is due to the industry itself or whoever develops the systems. It needs more publicity.”

Either to be able to push public managers for smart solutions that meet the citizens' needs, or to be able to access and enjoy the benefits that these solutions for Smart Cities offer. It is essential to include the population in the discussion and resolution of urban problems.

As these are public resources, the projects will inevitably need to go through a bidding process, be approved and audited by the respective courts of accounts. And there is again the barrier of knowledge and competence. Members of the respective courts need to understand what is being

proposed, what are the benefits and gains of a Smart City solution for the population, compared to a conventional solution. This often involves benefits beyond the requested scope, which may be interpreted as unnecessary, superfluous, or irrelevant by the respective court of accounts.

Another challenge is the outdated tax laws that prevent funding from being committed to innovation. The to the CIP/ COSIP example is representative. Despite finding a foundation in the Federal Constitution, through article 149-A included by Constitutional Amendment 39/2002, for 18 years it was the center of a discussion whether the fund's resources could be used for the modernization and expansion of the public lighting service, or should it follow the constitutional text *ipsis litteris* and be restricted to only the cost of the service (maintenance of what already exists). In the meantime, LED lamps have become popular and smart street lighting solutions have been developed. This discussion was finally settled by the Extraordinary

**Legal system and regulatory framework (use of funds, procurement process)**

The legal system and regulatory framework were also one of the most commented barriers. Because the economic viability and access to funds, funding sources, or tax incentives necessary to pay for innovation and implementation of a Smart City solution depend on them.

“The first problem is to have the money. The second is to have the legal system to buy what I planned. Because sometimes you planned to have technology X, but after the bidding process comes Y... So, these are the two big pains.”



Appeal 666.404 SP<sup>98</sup> judged by the Federal Supreme Court in August 2020. However, there is still no authorization in the legislation to commit surplus resources to any other innovation (e.g., security cameras, connectivity, etc.) around lamps.

The Regulatory Framework for Artificial Intelligence (PL 21/2020)<sup>99</sup> and the principles for the use of AI in Brazil (PLs 5051/2019<sup>100</sup> and 872/2021)<sup>101</sup> are currently under discussion. And at this moment of definition, these discussions need to be taken very carefully, so we don't end up with a restrictive legislation that makes the implementation of solutions for Smart Cities unfeasible. Take, for example, the European<sup>102</sup> example, which is at a more

advanced discussion<sup>103</sup> stage and is expected to forbid facial recognition in public spaces (a fundamental point for smart public security solutions), forbid the use of predictive crime models, demand transparency and auditing of AI models. Something impractical in the case of neural networks, whose processes are so complex that it is impossible to prove how certain results and conclusions were generated.

On the other hand, having a permissive, vague legislation or the absence of a legislation can also bring difficulties to the development of Smart Cities. We can cite as an example the Antennas' Law (13116/2015),<sup>104</sup> regulated by Decree 10.4080/2020,<sup>105</sup> which regulated the right

of way, reducing bureaucracy in the process of installing new antennas and limiting the period for issuing licenses to 60 days. However, it maintained the competence of the municipalities to legislate on the subject, without stipulating any deadline for each municipality to have its own law. And until the conclusion of this study, 11 of the 27 Brazilian capital cities did not have adequate legislation.<sup>106</sup> See the case of Sao Paulo city, which only this last year sanctioned a new law 17733/2022 to replace the previous one (13,756/2004), which was already outdated.

Two negative aspects of the regulatory process that are evident are that it is very time consuming and leaves many dubious points, subject to discussion and interpretation. And while regulation is being discussed, the solution and the technology could already be used for the benefit of Society.

#### Technical and technological barriers

Finally, there are technical and technological barriers. And within this theme everything related to technology, standardization, integration, connectivity, infrastructure, operation, and management was grouped.

The first barrier of this theme is related to the existence of legacy and proprietary solutions, implemented to meet specific demands and that were not planned to have a future integration on view. And therefore, this leads to the existence of many silos and scattered databases. Part of this problem

**66** The problem is to create a law to restrict more and more. Because the law does not come with the objective of clarifying, but of restricting. 'Oh, that cannot and period!' And Brazil is unbeatable in this point. **99**

**66** Many mayors discovered one thing: 'Look how interesting! I discovered something called the Antenna Law' And they began to realize that they didn't have legislation on that. Legal stability in Brazil is bad, I remember that the first PPPs were not successful because of this. **99**

is due to the lack of interest in integration from the developers of these solutions. Each vendor tends to impose its solution, its own system. Additionally, the lack of standardization (protocols, technologies, and reference architecture) contributes to the problem. Which makes it a big challenge to combine these different technologies, integrate the data, and manage them as a single platform.

In a Smart City, it is expected that there is integration of the data from different services and sources (health, education, security, mobility, etc.). And the resulting challenge involves the data itself in technical issues of security, privacy, access control versus the democratization of its use. However, the discussion about the value of data, how it can be used, who can access it, goes beyond the scope of Smart Cities.

**66** So, precisely because of the lack of who would integrate that all. Each company has its solution for charging vehicles, supermarket solution, healthcare solution... But it lacks from an integrator to integrate it all. **99**

**66** There is a lack of public policy, a lack of advocacy to be able to bring everyone together to talk and define a solution. **99**

**66** Bringing technology to the benefit of society would be interesting because the gains are immediate. Of course, in small towns some things don't make sense. But connectivity is extremely important. **99**

The infrastructure that includes the physical area, the energy network and especially connectivity and the correct planning of the solution that needs to have an end-to-end integrated vision are fundamental for any Smart City solution. And as pointed earlier, the lack of a high-capacity, low-cost connectivity infrastructure becomes a major bottleneck for digitization and for the urban-scale implementation of innovative services for the city.

# Recommendations for Enabling Smart Cities

## Summary

Worldwide, the articulations for the creation of a public policy model are fragmented into several associations with different agendas, and there is no single model. In general, the models for Smart Cities can be grouped into two directions, where public policies are developed: Focus on ICT to manage the city through a technological perspective; or focusing on how technologies and joint actions can help in the development of human capital, education, economic development, sustainability and governance.

In Brazil, the Brazilian Charter of Intelligent City (CBCI), a Brazilian interministerial manifesto, brings a set of 160 recommendations for policies and actions in eight objectives that deal with various issues: technological feasibility, innovation, training, sustainability, wellbeing among other aspects.

In this chapter, despite the importance of the modern and comprehensive foundation for the Smart Cities concept brought by the CBCI framework, the analysis carried out, as a suggestion for prioritizing public policies, focused on policies that promote the development of ICT applications and associated investments. It considered the list of suggestions of policies of the CBCI, its objectives and strategic recommendations to expand the dimensions and applicability. Also, it brought, mainly, the recommendations by relevant specialists, public agents, technology suppliers, etc. interviewed during the elaboration of this work.

## International public policy trends for Smart Cities

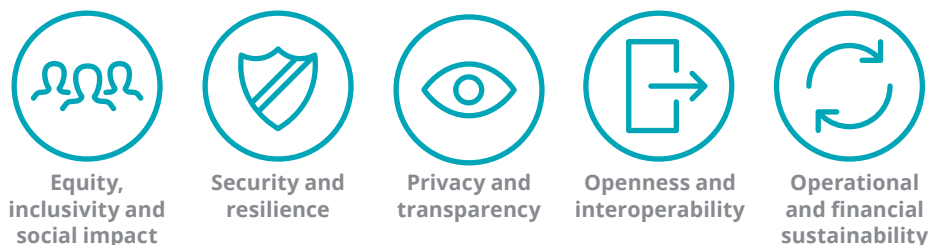
A Smart City can be conceived from two different strands: It can be seen with a focus on ICT to manage the city through a technological perspective; or with a focus on how ICT can help the development of human capital, education, economic development and governance.<sup>107</sup> Examples of cities that have chosen the first approach, highly technical and intense in infrastructure are: Santander, Rio de Janeiro, Barcelona, and London, while cities such as Amsterdam, Copenhagen, Helsinki, Manchester, and Milan chose the second approach, more citizen-centered. The strategies and policies for smart cities may be different depending on the above aspects, their needs, priority service areas, etc. that are part of the construction of their vision. Depending on how the vision for a given Smart City is, a direction and set of policies are defined.

In recent years, the idea of smart and sustainable cities has come to light. In addition, it is rapidly gaining strength and global attention as a promising response to the challenge of urban sustainability. This concerns especially ecologically and technologically advanced nations.

At the international level, articulations for the creation of a model of public policies are fragmented into several associations, and there is no single model. There are efforts to harmonize and convergence of common understandings, through standardization, including ISO itself (International Standard Organization)<sup>108</sup> defining vision, objectives and performance measurements for Smart Cities, adopted by Urban Systems and Necta in Brazil with Connected Smart Cities Maturity Ranking.

One of important move to highlight is a report produced by the World Economic Forum together with Deloitte, "Governing Smart Cities: Policy Benchmarks for Ethical and Responsible Smart City Development",<sup>109</sup> which brought the efforts of the G20 Global Smart Cities Alliance, seeking to promote the responsible and ethical use of smart city technologies. The Alliance and its partners represent more than 200,000 cities and local governments, leading companies, startups, research institutions and civil society communities. This report also brings the set of five key principles, based on discussions with G20 ministers, to help cities identify and adopt priority policies for C-ages Technologies.

**Figure 14: Key Principles for Smart Cities Governance – Source World Economic Forum<sup>110</sup>**



To this do so, the G20 Global Smart Cities Alliance<sup>111</sup> is committed to creating a Roadmap to which policymakers and technology providers can refer as a baseline for technological governance.

These principles incorporate fundamental requirements that all smart cities must meet, regardless of their strategic objectives. For example, a city can invest in smart lighting to reduce its carbon

footprint and meet the strategic goal of environmental sustainability. However, they must ensure that there is sufficient security and resilience in smart lighting so that the poles stay on when needed.

**Equity, inclusivity and social impact.** Accessibility of ICT in public procurement. Build accessibility standards in purchases to ensure that digital-related services are accessible to people with disabilities.

**Privacy and transparency.** Assessment of the impact of privacy. Define processes to assess privacy implications of new urban technology deployments.

**Security and resilience.** Cybersecurity responsibility. Defining the main accountability measures to be taken to protect the assets of cities and their citizens

**Operational and financial sustainability.** Dig Once for digital infrastructure. Establishing planning policies that improve coordination among city stakeholders and reduce the cost and complexity of the deployment of digital infrastructure.

**Openness and interoperability.** Open data. Developing an open data strategy model policy in a city.

The Alliance, with the help of global government experts, private sector partners and civil society, has launched the first set of policies, Roadmap v1.0, compiling and analyzing policies from around the world with policies for smart cities.

Despite multiple efforts, including standardization, there is no single, worldwide model for public policies, which are fragmented into several distinct associations and agendas. In general, the models for Smart Cities can be grouped into two directions, where public policies are developed: Focusing on ICT to manage the city through a technological perspective; or focusing on how

Figure 15: Cities participating in the World Economic Forum survey (Source)



technologies and joint actions can help in the development of human capital, education, economic development, sustainability and governance. In this study, in the following section, we focused on the first direction, where the policies analyzed are those for enabling the adoption of ICT solutions.

## Suggestion for Prioritization of Public Policies for Smart Cities in Brazil

In 2020, the Ministry of Regional Development (MDR) in cooperation with the Ministry of Science, Technology and Innovations (MCTI) and Ministry of Communications (MCOM) presented the Brazilian Charter for Smart Cities, with 160 recommendations in 8 strategic objectives, whose themes are similar to those presented by the G20 Global Smart Cities Alliance – table below. CBCI addresses themes in its text six dimensions:<sup>112</sup> Smart Economy, Intelligent People, Intelligent Governance, Intelligent Mobility, Smart Environment and Intelligent Living. However, there is a greater focus on Governance, Environment and People. The Intelligent Mobility dimension does not mention transport and logistics systems and refers only to information and communication technology (ICT) infrastructure issues.

CBCI seeks adaptation to the Brazilian reality through aspects considered in the concept, including being a diverse, fair, living city for people, connected, innovative, inclusive, welcoming, safe, resilient, self-regenerative, economically fertile, environmentally responsible, articulating different notion of time and space, conscious, reflective, and maintaining its principles.

Despite the importance of the modern and comprehensive foundation for the Smart Cities concept and its needs brought by the G20 and CBCI framework, **the analysis** carried out, as a suggestion for prioritizing public policies in this study, **focused on policies that promote the development**

## Objectives of the Brazilian Charter of Smart Cities (CBCI)

1. Integrate digital transformation in policies, programs, and actions of sustainable urban development, respecting diversities and considering the inequalities present in Brazilian cities;
2. Provide quality equitable internet access for all people;
3. Establish data and technology governance systems, with transparency, security, and privacy;
4. Adopt innovative and inclusive models of urban governance and strengthen the role of public authorities as a manager of the impacts of digital transformation in cities;
5. Foster local economic development in the context of digital transformation;
6. Stimulate models and instruments for financing sustainable urban development in the context of digital transformation;
7. Foster a massive and innovative public education and communication movement for greater engagement of society in the process of digital transformation and sustainable urban development;
8. Build means to constantly and continuously understand and evaluate the impacts of digital transformation on cities.

of ICT applications and associated investments. Nevertheless, **the list of policy suggestions** for prioritization **took into account CBCI**, its objectives and strategic recommendations to expand the dimensions and applicability. Finally, it **considered mainly the recommendations** by **experts, public agents, technology suppliers, etc. interviewed** during the performance **of this work**.

Among the priorities identified are:

- 1. Coordination of Policies in all spheres of public power (Municipal, State and Federal).** Guidance for the creation of broader policies, laws and regulations in the three spheres of.
- 2. Long-Term Plan:** Having a long-term baseline for guiding investments and evolving Smart Cities.
- 3. Standardization of a data access and unification model:** Search for the standardization of Smart Cities starting with the standardization of access to data of all services.

- 4. Standardization in digital public management:** Standardization and standardization of processes for common public services.
- 5. Standardized Architecture:** Standardizing the architecture for digital platforms and access to associated services.
- 6. Creation of Development and Innovation:** Creating an innovation environment through integration with industry, academia, startups and etc.
- 7. Enabling Connectivity Infrastructure:** Construction of connectivity infrastructure either through enabling policies (Law of Antennas) or new business models for exploitation;
- 8. Promotion and expansion of Public-Private Partnerships:** Consolidation of PPPs as a means for enabling smart cities, bringing several benefits, such as: investments, guarantee of service management and maintenance, technological evolution, dishonoring the municipality in the complex task of creating skills and technological investments;

**9. Exclusive Public Concession Model for The Intelligent City's Exploitation of Services:** Evolution of concession models to house the combination of profitable services, high-cost essences;

**10. Funding access for Smart City projects.** It consists of enabling access to public, private, local and international aid and financing programs, through the dissemination of information about these programs to public agents, also providing a professional support for submission and approval of projects.

**11. Public Safety as A Great Promoter of Social Welfare:** Promoting public safety as means of wellbeing and quality of life, but also of attractiveness of companies and new investments for municipalities;

The following will be the basis of the suggestions with some recommendations of international practices.

**Coordination of Policies in all spheres of public power (Municipal, State and Federal)**

The Brazilian Federal Constitution of 1988 guarantees Brazilian federalism with the political and administrative autonomy of the municipalities, recognizing them as federated entities, allowing the deepening of participatory democracy. Municipalities

then have essential constitutional competences in a sustainable development process, such as those related to urban development.

At the same time, the potential of local governments is compromised in Brazil, due to the concentration of tax resources in the Union, with more than 53 percent of the Brazilian state's revenue; administrative and management difficulties; criteria for the transfer of financial resources between municipalities,<sup>113</sup> there is also the need for coordination of federal scope of projects that affect the country. One example is the Antenna law, the Federal Law necessary for the development of telecommunications infrastructure, where despite being created in 2015, is only recently being adopted and approved as major cities as it was in São Paulo in 2021.

Smart Cities projects require joint action to harmonize the legal framework to integrate all spheres of power to bring clarity and security to all participating ecosystem agents including investors.

**Long-Term Plan**

The technological adequacy for Smart Cities is time-consuming, requires high technology investments, whose economic and social impacts are in the same proportion.

However, the mandate of mayors, governors and their associated administrations is 4 to 8 years depending on the extension associated with reelection and may hinder long-term projects.

The need to have a perennial Long Term Smart Cities Plan that overcomes the limitations associated with power alternation is imperative for city projects to become real, according to experts interviewed for this study.

“It needs to be a perennial plan, regardless of the exchange of mayors and governments. There must be continuity...”

The City Statute (Law 10.257/2001) guides the development of the Municipality Master Plan (PDM - Plano Diretor Municipal) for actions regarding the development of the social functions of the city and urban property, aiming at environmental balance, the collective good, safety and wellbeing of citizens. However, the PDM can be an instrument adapted to be an important guiding instrument for Smart Cities, combined and adapting others: Multiannual Plan (PPA), Budget Guidelines Law (LDO), Annual Budget Law (LOA).

The adaptation of the PDM should count on the mission and vision of each municipality, its main values and strategic objectives for Smart Cities. The vision should be integrated into municipal planning based on sector planning instruments. It should be emphasized the areas of sustainability, urbanism, housing, basic sanitation, urban mobility, water security, disaster reduction, environment, information and communication technologies among other aspects.

“Dissemination of government plans of the federal sphere. Less than 10 percent of mayors know what this is...”



1. Creation of guideline that clarifies the applicability of Laws for the viability of Smart Cities, such as: Statute of the City (Law 10257/01); Computer Law (Law 13969/2019); Marco Legal das Startups (Law 182/21); National Smart Cities Policy (Bill 976/21); PPPs Law (Law 11079/04); municipal laws, including those for the establishment of COSIP. Also combining with important documents such as CBCI.
2. Simplification and consolidation of the entire legal and regulatory framework for Smart Cities projects through exclusive law – such as the Law of Antennas in telecommunications.

Deloitte, in its Practice of Smart Cities & Urban Transformation, offers<sup>114</sup> guidance for building vision, ambition, goals, fundamentals, etc. based on addressing solutions to the following areas: Quality of Life; Creation of Economic Value; Sustainability and Resilience, composing an important equation as shown below (figure 16).

“There is an expectation of the creation of urban policy instruments by the end of 2023 to continue the planning (Master Plan, Financing Line). National Urban Development Policy (Digital Transformation is one of the pillars), inspired by the SDGs...”

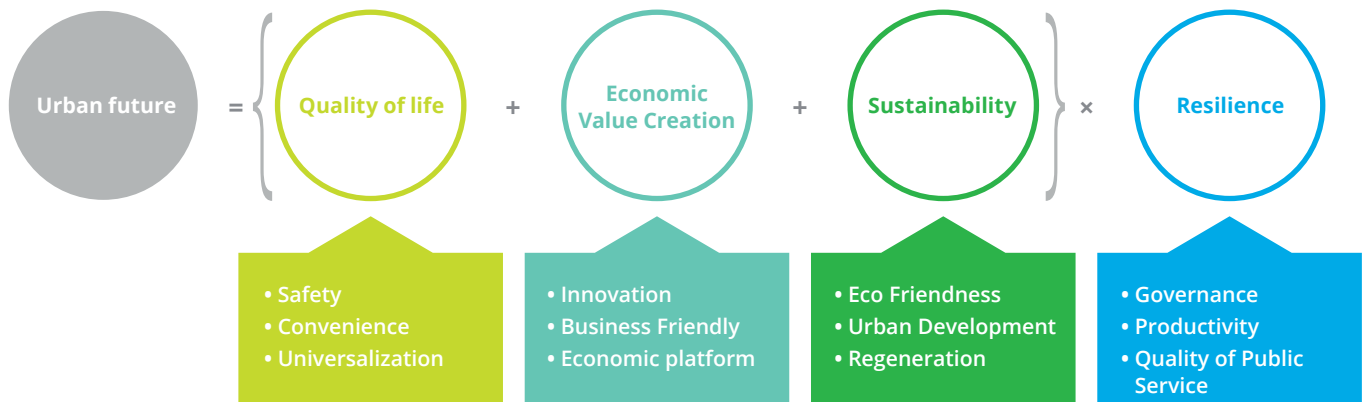
Long-term planning should take minimally into account four key actors: Government, Business, Academia, and Citizens. The Government is the main agent and interested in Smart Cities. They play the role in building the vision, mission and objectives for the Long-term Plan, but also in the elaboration and implementation of public policies, prioritization and budgeting of projects for Smart Cities. Until recently the Government was the only leading agent in the implementation and management

of Smart Cities projects, but this role changed with the exploitation of services through companies in public-private partnership.

The group indicated by Companies represents the private sector, for the supply of technology, solutions and technologies, investments and also can carry out the exploitation of smart cities services in the regime of public private partnerships, as well as the creation of new business models.

The possibility of the inclusion of the private sector in the value chain of Smart Cities represents an important advance to bring new technologies, efficiency in service management, but mainly in releasing the municipality burden on management, maintenance and technological updating to guarantee services in cities. In this sense, public agents, municipalities, and other spheres of public power (Government) are focused on the development of public policies, monitoring the performance of

Figure 16: Areas that should be considered for the Long-Term Plan



services provided by the private sector (Companies), and addressing important agendas such as ESG (Environmental, Social & Governance).

The Academy (and R&D) group plays the role of providing each institution's capabilities in a variety of areas, such as policy discovery and institutional improvement for smart city expansion, technology development,

professional workforce training, overseas export support, and innovation. It plays a leading role in communication and technological development with industry, academia, research and the private sector based on the expertise of each institution. This group consists of universities, government-funded research institutes, and affiliated research institutes classified as public institutions.

The group represented by Citizens are users of all services and technologies provided by smart cities, can be citizens, entrepreneurs, public agents etc. A smart city does not provide services unilaterally through the construction of urban infrastructure. The goal of a smart city is for citizens to participate as members with a sense of ownership.

The PDM is approved by Municipal Law, is the basic instrument of urban development and expansion policy and must be reviewed before every 10 years through new Municipal Law. That is, the PDM must have a horizon of up to 10 years. However, for Smart City Long-term plan, the PDM should be updated in each 3-5 years due an evolution in technology, trends, and new practices.

**Table 8: Actors who should be considered for the Master Plan**

← Smart cities →			
Government	Companies	Academy R&D	Citizens
<ul style="list-style-type: none"> <li>• Public agents in the various spheres of power</li> </ul>	<ul style="list-style-type: none"> <li>• Technology Suppliers</li> <li>• Investors</li> <li>• PPPs</li> <li>• Utilities</li> </ul>	<ul style="list-style-type: none"> <li>• Universities</li> <li>• Research institutes</li> <li>• Startups and accelerators</li> </ul>	<ul style="list-style-type: none"> <li>• Residents</li> <li>• Entrepreneurs</li> <li>• Smart City Users</li> </ul>



1. Creation of a Long-Term Plan for Smart Cities that take into account the following topics: Quality of Life; Creation of Economic Value; Sustainability and Resilience, analyzing the actions and objectives for the following actors: Government, Companies, Academia, and Citizens;
2. Use of the PDM of the City Statute to contemplate the Smart Cities Plan;
3. Creation of goals and obligations for the fulfillment of the Long-Term Plan of Smart Cities;



### Standardization of data access and unification model

The standardization and guarantee of data interoperability for smart city applications is one of the main enablers to bring synergies and gains of existing applications and new applications through innovation. The OECD, in the Smart Study Inclusive Study,<sup>115</sup> recommends an architecture and creation of a set of common APIs and real-time access to data, as well as context information to structure data, a common but optional data platform for storage and availability – data lake. In this study, the OECD indicates that MiM (Minimal Interoperability Mechanisms) developed by Open & Agile Smart Cities, can be a reference model and with adoption in more than 140 cities worldwide, 26 of them in operation. This model presents the framework structure with three main components: context information management; common data models;

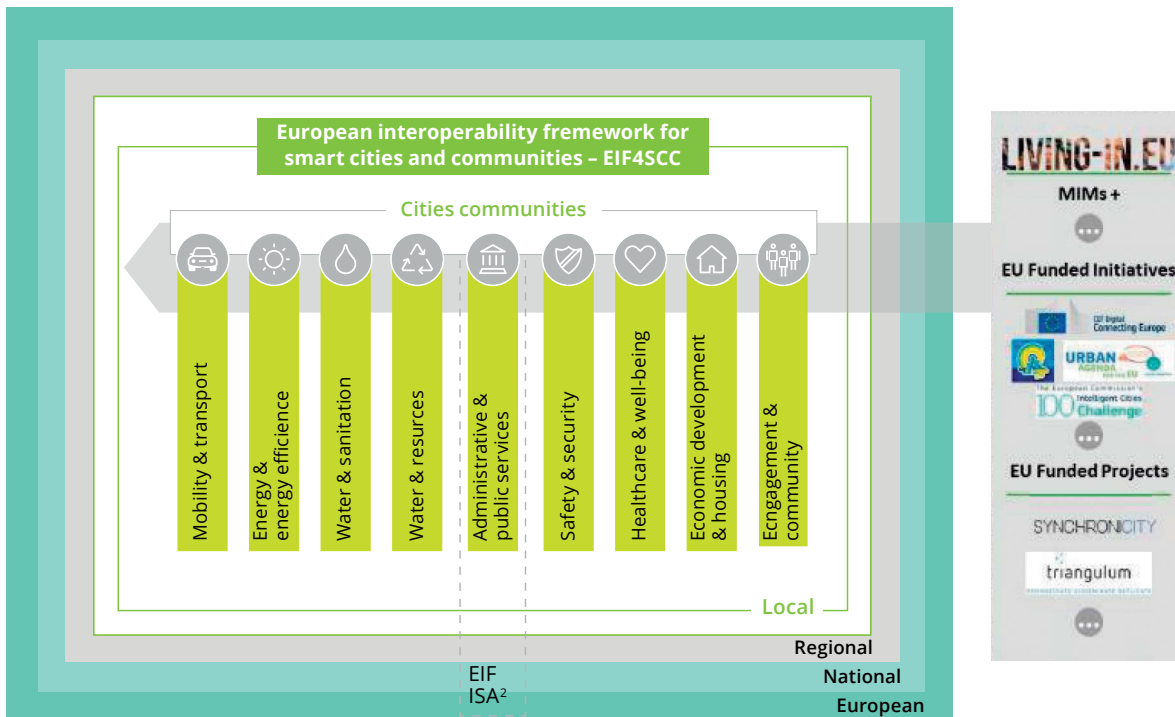
and ecosystem transaction management (market mechanisms on who has access to what type of data and how).<sup>116</sup>

Interoperability is a prerequisite for enabling digital services, communication and exchange of information between different actors and services, but it is much broader than technical in nature. Created by the European Union, the European Interoperability Framework for Smart Cities and Communities (EIF4SCC)<sup>117</sup> establishes a guide to interoperability for data administration managers. Deloitte helped build this proposal,<sup>118</sup> which includes principles, a common interoperability model, recommendations and practical use cases to enable interoperability between domains, cities, regions and borders, leading to better delivery of services to residents, visitors, businesses and city/community administrators – pictured (figure 17).

The integration and consolidation of data is another enabler for new services, where it ensures consistency and optimization of information. Typically, depending on the history of implementations, data from assets, real estate, territorial, personal records of inhabitants and entities, location among others may be duplicated on several bases. It is important for the public administration to have an architecture policy and management of distributed data.

Data processing algorithms should be transparent, open and non-discriminatory. Therefore, information and communication technology companies should be encouraged to have high standards of transparency about the criteria and assumptions they use in their algorithms, but also strengthen algorithmic auditing processes and encourage the use of open source or free source software.

Figure 17: EIF4SCC Reference Model



Finally, in the context of access and interoperability, the General Law on the Protection of Personal Data (LGPD) must be observed and respected, while guaranteeing the fundamental rights of freedom, intimacy and privacy. Ensure that the sharing of personal data obeys the principles of purpose and transparency. To enable these actions, establish standards and procedures that enable the safe and ethical development of innovative data-based businesses.

### Standardization in digital public management

The digital transformation of public services, as well as connectivity, is one of the foundations for Smart Cities. Digital services are major promoters of inclusion and universalization, especially for the low-income population to help simplify access to health services, education, housing, transportation, basic sanitation, leisure, and culture.

In addition to data standardization and access, standardization of processes for digital services can facilitate and ensure the scale of applications and solutions. The principles adopted in the Digital Government Strategy<sup>119</sup> can be a great orientation for the standardization and standardization of processes for digital



1. Creation and standard to ensure data interoperability and synergy of services;
2. Adoption in public notices of this standard for the public services of Smart Cities;
3. Promoting the evolution of technologies and solutions already deployed to adhere to the standard and interoperability;

services including in municipalities, starting with the "Digital Identity of the Citizen", which should be necessary for single access to some municipal public services. Also, adherence to the collaborative public infrastructure of the National Electronic Process and its actions, such as the Electronic Information System (SEI).<sup>120</sup>

### Standardized Architecture

The standardization of architecture (interfaces, access to data and some enabling elements) for the provision of Smart Cities services is fundamental for rapid adoption, scalability, cheapening, ecosystem, synergy between solutions in the same municipality, innovation, among other aspects.

Some countries have been working on creating a technological framework through open standards to ensure investment direction and development by technology

and infrastructure providers. Among the most emblematic cases is the IES-City<sup>121</sup> (IoT-Enabled Smart City Framework) conducted by NIST (National Institute of Standard and Technology) supported by ETSI (European Telecommunications Standards Institute) and other global standardization bodies.

**66** ...Solutions depend on multiple players. The challenge is to make this ecosystem speak the same language and understand how they will work together... **99**

Current implementations within smart cities are limited in the integration of your systems because legacy and fixed solutions are patchwork-connected by custom integrations. In this sense, IES-City is based on the following principles:

**1. Interoperability.** Allow multiple systems and components to work together, even if parts from multiple sets of suppliers are replaced and integrated.



1. Standard creation for service applications and digital public management: services of a similar nature with similar journeys. Example National Electronic Process.
2. Adoption of single access to digital public management and service applications, such as "Citizen Digital Identity"

	Smart City 1.0	Smart City 2.0	Smart City 3.0	Smart City 4.0
Connectivity	Until the emergence of PC	Fixed Internet	Mobile Internet and IoT	Cloud+Edge+ Blockchain
Human	5 Senses	Neural Networks	Brain	Behavior (Life)
City	Sensors	Sensors + Communication	Sensors + Communication + AI	Sensors + Communication + AI + Citizens
City Size	Limited	Expansion	Gigantization	Self-organizing
Value	Sarnoff's Law (N)	Metcalf's Law (N <sup>2</sup> )	Reed's Law (2 <sup>N</sup> )	

**2. Composability.** Allow to add multiple functions while maintaining continuous integration and improvement of the overall system.

**3. Harmonization.** Allow technologies and systems to interact and integrate into the same environment, even when they at first seem incompatible. For example, these technologies can come from different domains (for example, transportation, public safety, or energy), or each of them can be designed to suit a pattern of a development organization of different standards.

Standardization helps public servants in government procurement of digital technologies through an open common technical specification, technological maturity and ecosystem diversity. However, specific needs must be observed and guaranteed for local technological development and innovation.

### Creating an Environment for Development and Innovation

Smart Cities around the world plan create and develop an innovation environment to promote ideas, develop new technologies, new public services, solutions to their



1. Creation of a standard for the architecture of the digital platform (interfaces, access to data and some enabling elements) for the provision of smart cities services;
2. Adoption in public notices of this standard for the public services of Smart Cities;
3. Promoting the evolution of technologies and solutions already implemented to adhere to this standard;

problems, improvements and optimizations of existing processes, sustainability, among other motivations.

Innovation can help cities achieve the Sustainable Development Goals and solve their challenges in a sustainable, inclusive, citizen-centric, efficient and collaborative way. As Intelligent Urban Innovations scale and increase the number in urban centers, they can pave the way for cities to become smart cities.

The role of technology has been fundamental to the viability of new services, production processes, distribution and governance; the transformation of organizational and institutional arrangements; and information on

individual choices and behaviors. However, information and communication technologies are not the only components in providing solutions for Smart Cities. It is important to consider social innovation that creates new social forms and forms of cooperation in society.

Innovation should not be considered a goal, but a journey to Smart Cities. During this journey, cities need to incorporate monitoring, learning and assessment approaches to quickly adapt to changing contexts.

Policies for creating this environment of innovation and investment with associates should use tools and practices such as: development collaborates with the industry, academia, entrepreneurs, startups; public and private managers trained; intersectoral vision and facilitation of procurement processes; academia and R&D investments in vertical sectors; reorientation of the legal framework to promote innovation and development among other aspects.

Some actions, such as the Startups Legal Framework (Law 182/2021), have been great allies to the viability of Innovation for Smart Cities, bringing legal certainty to investors in innovative companies. In Article 3, several objectives and guidelines that guide the relationship between public administration and private initiative – table below.

In addition to promoting cooperation and interaction between public entities, the Law brings: the Public Contract for Innovative Solution (CPSI), which facilitates that govtech solutions move forward in a very effective

## Principles and guidelines (Art. 3):

Innovative entrepreneurship as a vector of economic, social and environmental development;

Constitution of environments favorable to innovative entrepreneurship, with the improvement of legal certainty and contractual freedom as a premise for the promotion of investment and the increase in the offer of capital directed to innovative initiatives;

Companies as central actors of the innovative impulse in the context of the free market;

Modernization of the Brazilian business environment, in light of emerging business models;

Promotion of innovative entrepreneurship as a way to promote the productivity and competitiveness of the Brazilian economy and generate skilled jobs;

Improvement of public policies and instruments to foster innovative entrepreneurship;

Promote cooperation and interaction between the public and private sectors and between companies as key relationships for the formation of an effective innovative entrepreneurship ecosystem;

Encourage the hiring, by public administration, of innovative solutions developed or developed by startups, recognizing the role of the State in fostering innovation and potential opportunities for economy, benefit and solution of public problems with innovative solutions; and

Promoting the competitiveness of Brazilian companies and the internationalization and attraction of foreign investments. 8. Build means to understand and evaluate, in a continuous and systemic way, the impacts of digital transformation in cities.

way, with the development of technologies aimed at improving smart cities; and the Regulatory Sandbox, bringing flexibility with programs of experimental regulatory environment and rule out the incidence of standards in relation to the regulated entity or groups of regulated entities.

According to the report: "Public Policy Recommendation - Study on the 5G Innovation Ecosystem" conducted by Deloitte for the Ministry of Economy and UN in 2022 on the production of information technology (IT), there is a 22.9 percent deficit between 2019 and 2020 in the amount of manpower to meet the demand for information technology, which includes professionals for Smart City technologies. Among the reasons, one can mention a possible evasion of courses related to technology and the low interest of the population to enter the courses related to this area.

Also, there are questions regarding the quality of the workforce, which is the main bottleneck for actors in the Brazilian ecosystem, according to the research conducted by the same report. Still, there is the evasion of human capital attracted by projects in other countries with better working conditions, salary and quality of life. In cities far from large centers, this

“...General knowledge (industry disclosure). The spread begins from the layer with the greatest positive power and then massifies. Smart Cities can start from a different model...”

“...In addition to training and training, academia can help industry engage with municipalities...”

phenomenon reproduces itself, where the low incidence of trained professionals is also captured by large centers or eventually other countries.

#### Enabling Connectivity Infrastructure

Connectivity is at the heart of Smart Cities and is its biggest asset and enabler. Generally speaking, the smart cities ecosystem and digital cities are designed to work in ICT frameworks that require connection to multiple dedicated networks of mobile devices, sensors, connected cars, appliances, communication gateways, and datacenters.

The first and fundamental connectivity service is ubiquitous internet access in public spaces, but especially in remote and low-income areas, to broadly promote the availability of the municipality's digital

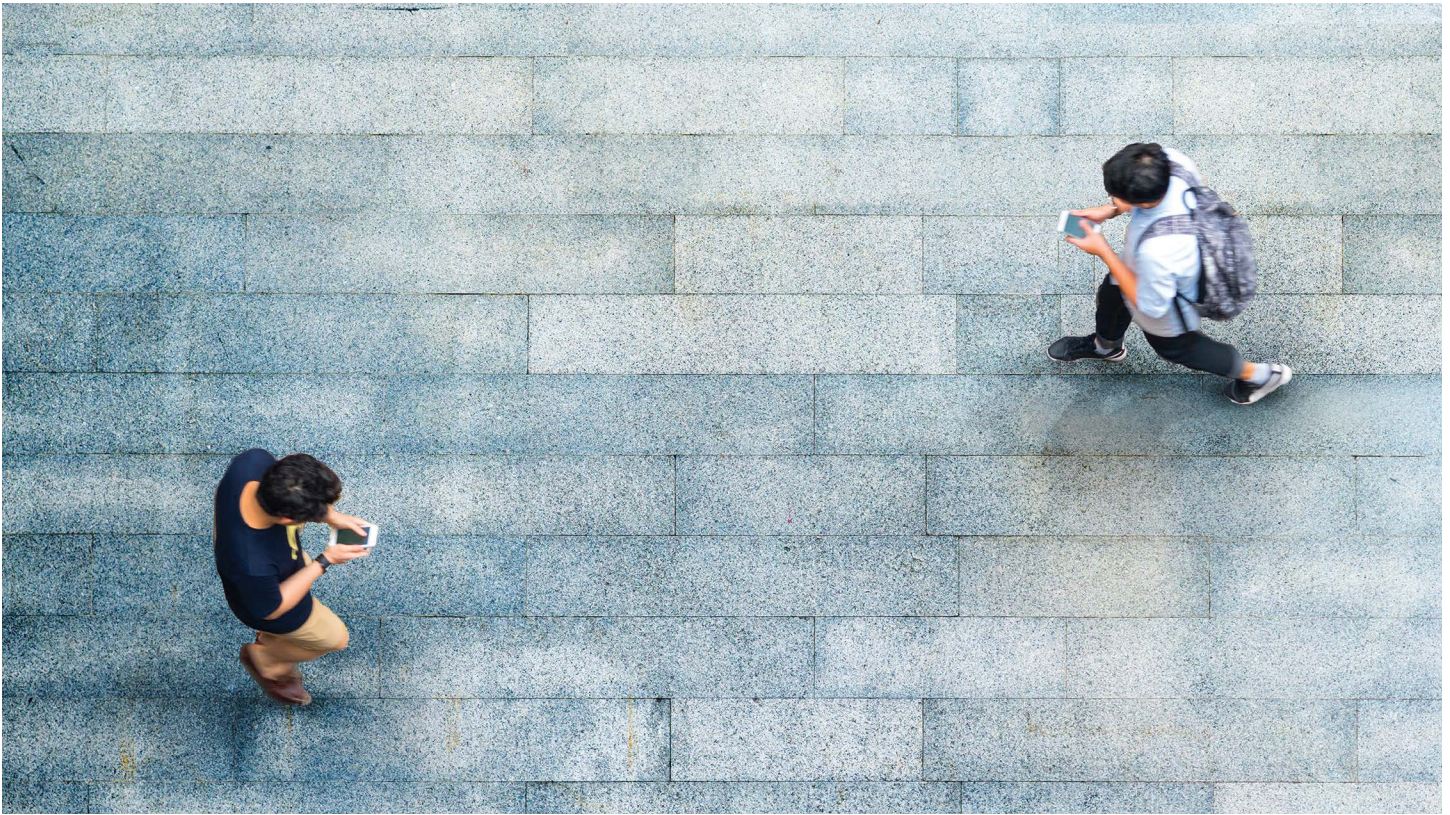
services, associated information, bring social inclusion and the general wellbeing of the inhabitants. Free Wi-Fi is a policy adopted by most municipalities in the world, recommended in the Brazilian Charter of Smart Cities (CBCI), where the public manager must deliver the service with quality, capacity, radio spectrum available and sufficient.

However, Wi-Fi is not enough to support all use cases, especially those requiring full mobility, such as public safety, where 4G and 5G coverage provided by operators is required. Another aspect in conditioning a single type of access technology, is the creation of a possible barrier with fundamental partnerships of other agents and investors that guide their investments in other technologies – example mobile operators with 4G, 5G, NB-IoT, eMTC technologies etc.

To ensure connectivity, municipalities should install not only antennas, but fiber optics and all necessary infrastructure for connectivity and use cases of the Smart Cities ecosystem to be made more flexible. Until recently, more than 300 municipal and state laws hindered the deployment of telecommunications infrastructure. The Antenna Law (13116/2015) represented a major advance in the flexibilization of the construction of telecommunications infrastructure, simplifying and disciplining in a single Law all the ordering and process for licensing and implementation. However, due to the federative pact, this Law is still being approved by municipalities, but with adoption by large urban centers such as São Paulo.



1. Creation of innovation programs (edicts) aimed at solutions that solve the problems of cities and involving: society, academic community, entrepreneurs, investors, etc.;
2. Use of levers brought by the framework of existing laws and exemption policies: Computer Law, Law of Good, Marco das Startups, City Statute;
3. Inclusion in innovation programs mechanisms that promote training and engagement: events for dissemination of knowledge; courses, training and specialized schools; viability of incubators with the academic sector; feasibility for the creation of techno parks; hackathons, etc.
4. Promotion for the popularization of knowledge of technologies associated with Smart Cities, through distance training programs;
5. Viability of collaborative spaces and experimentation of new solutions such as: Open Labs, living labs, etc.;



In addition to urban places and buildings real estate, the ground, underground, lampposts, power poles, airspace, etc. are important assets for the implementation of network technology infrastructure. Disciplinary norms and standards for the planning and management of these resources in municipalities are determinant for the rational use and creation of business models for their exploitation. Although the Antenna Law addressed part of the problem, but it is necessary to move forward to contemplate more assets and new guidelines for use and sharing.

The sharing of networks and infrastructure should be promoted by municipalities to make rational and sustainable use of urban spaces. For example, 5G will require a high density of antennas, it is estimated that for 1 Tbps/km<sup>2</sup> there will be the need for 100 Cell sites/km<sup>2</sup>, where three operators at national level and some regional providers can quickly deplete the possibilities of installation of antennas in urban furniture,

some may bring negative impacts such as visual pollution.

In addition to rational use, network sharing can bring new business and exploitation models. Worldwide, neutral host network (NHN) companies are taking on this role for operating telecommunications infrastructure services. Until recently, NHNs explored mobile network coverage in specific indoor spaces, such as airports, venues, sport stadiums, etc. Today they expanded this approach with the offer in open environments (outdoor), in addition to other assets such as fiber optics and services in the wholesale model. It was the solution for the implementation of 5G in many countries, due to the high need for investments, as in Brazil.

In Brazil, the NHN are especially applicable for the supply of optical fiber in the expansion of mobile broadband services (read 5G) and fixed (read FTTx), in addition to traditional colocation companies

and towers. Today NHN companies are becoming popular in Brazil, consolidating existing ones and emerging new ones such as: American Tower, I-System, QMC, V.Tal among others. In the UK, the creation of OpenReach has enabled the non-exclusive use of a wired and fiber optic network for a large number of ISPs and operators. In the USA, in addition to the fiber offer, with the creation of the CBRS (Citizen Broadband Radio Services) initiative allowed spectrum sharing, with non-exclusive use, for NHN companies to offer coverage of 4G and 5G networks for public or private use by operators and ISPs, creating models such as RAN (Radio Access Network) as a Service in the modalities of Small Cells and Open RAN.

NHNs can also bring an important business model to the viability and synergies in SmartCities, involving assets, resources and services of participants: municipalities that have rights to use urban furniture, technology and infrastructure companies to offer network resources, ISPs, CSPs and

Inweaks with connectivity and Operators making use of these resources and assets as a Service, focusing your investments on your core business – figures 18/19.

The European Community has created in horizon 2020 (H2020) the 5GCity<sup>122</sup> project

whose objective was to enable a platform (technology, architecture and business model) of cloud and mobile access radio to be explored by municipalities and Neutral Networks. The 5GCity platform and associated tools allow to orchestrate and deploy services in a completely

decentralized three-level architecture, where compute, storage, and networking are located between core segments and 5G network edge in the city. Living labs and 5GCity demonstrations were held in three different cities: Barcelona (Spain), Bristol (United Kingdom), and Lucca (Italy).

Figure 18: Example of a Win-Win Business Model for the exploitation of urban furniture for telecommunications

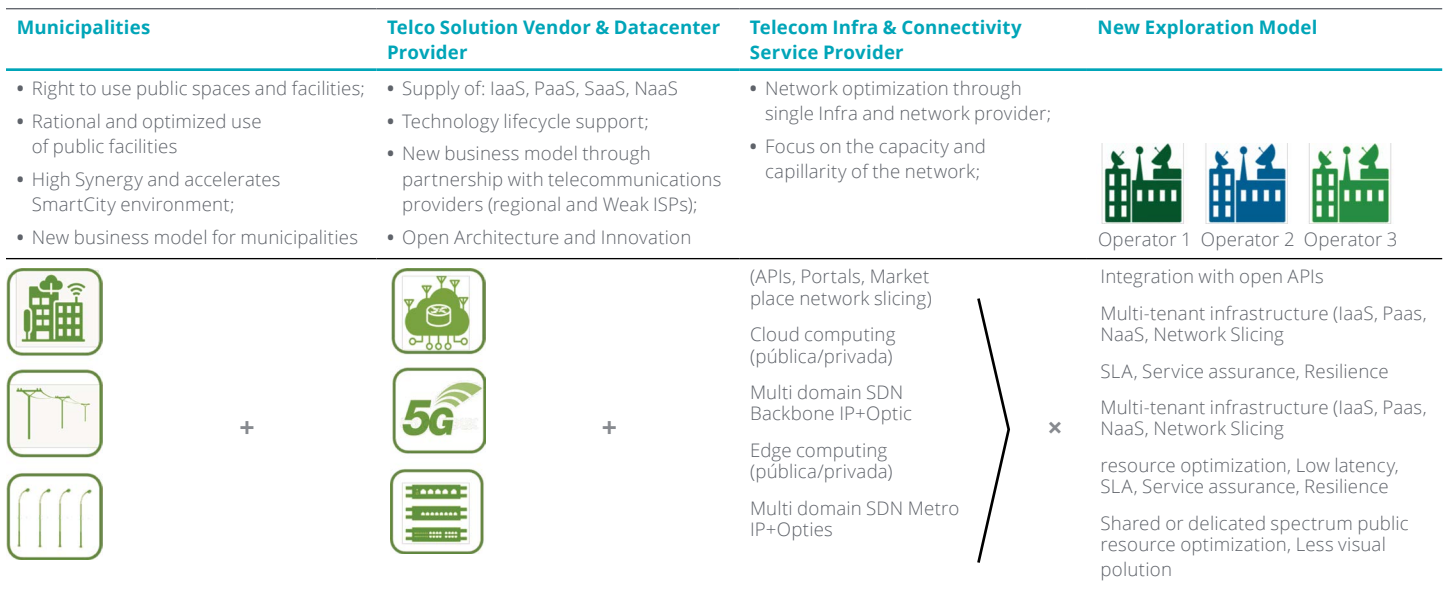
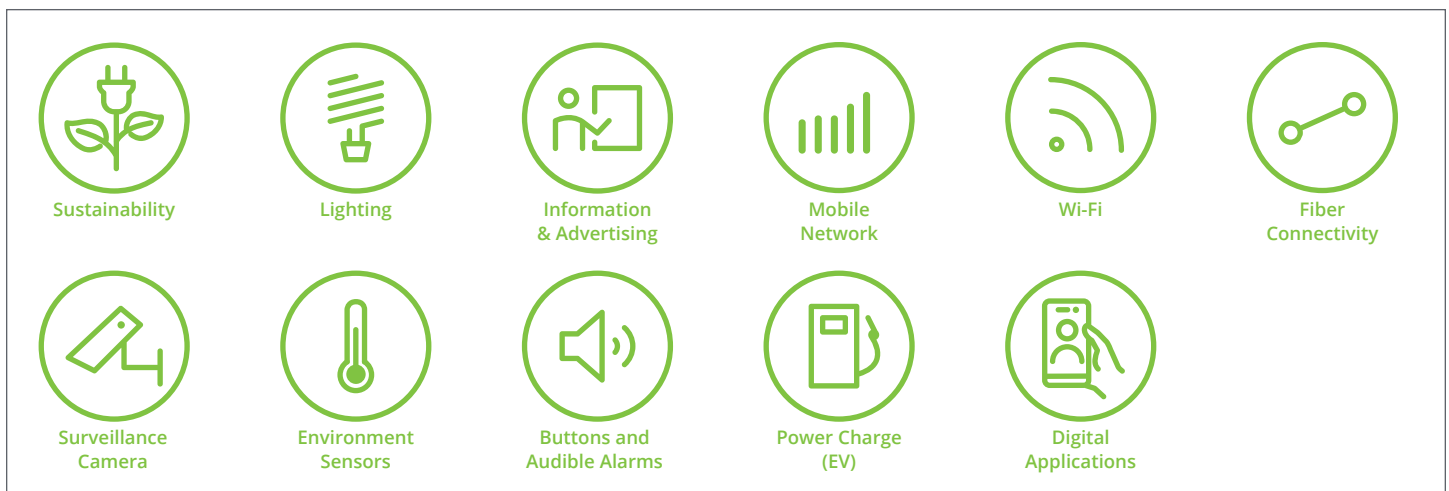


Figure 19: Smart pole not limited to connectivity services, but as Multi-service Smart City enabler





1. Approval of the Antennas' law at the municipal level to promote the implementation of telecommunications infrastructure;
2. Construction of a model for the operation of urban furniture, lighting lamps, power poles, soil and subsoil for companies of network neutrals and infrastructure exploitation;
3. Use of investments and exploitation of connectivity by telecommunications companies (CSPs, ISPs, NHNs);
4. Creation of commitment in the exploration of connectivity solutions that meet the needs of Smart Cities;

### Promotion and expansion of Public-Private Partnerships

The PPPs (Public Private Partnerships) are combined with the other recommendations as a major promoter for the viability of smart cities. PPP is an important mechanism to ensure the exploitation and long-term investments needed for smart cities by abstracting and minimizing technological complexity, costs associated with operational risks, impacts brought by the political agenda with the exchange of government and possible public policy orientation. They can be used for public services both with regard to infrastructure assets and social assets.

The PPPs institute emerged and developed mainly in England, where several public services were passed on, with advantage, to the private sector. In Brazil, the PPP model was introduced by Federal Law 11.079/04,<sup>123</sup> which is characterized by an administrative concession contract, in the sponsored or administrative modality. It is, therefore, a concession contract with new modalities: the sponsored concession and the common concession.

“PPP is key. And there's a lot of space between equipment companies and the government...”

Public Lighting is being the major beneficiary of this model, and in January 2022, Radar PPP indicated<sup>124</sup> the existence, in Brazil, of 450 PPP projects. However, this model can be expanded to other services combining

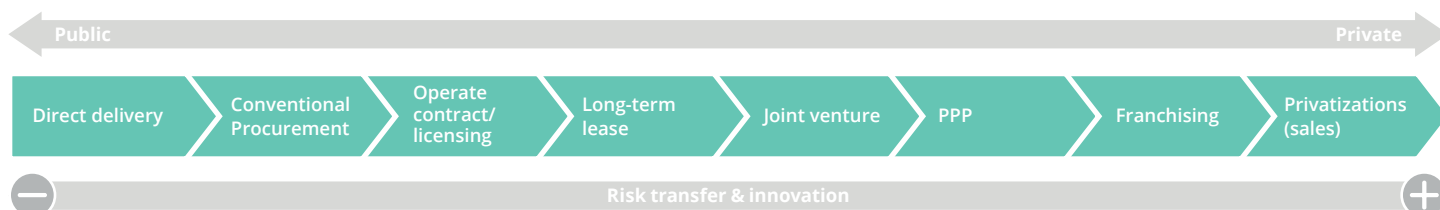
those that are more sustainable, such as Street Lighting, and other essentials, but with less appeal.

In 2014, the municipality of Itatiba,<sup>125</sup> in the State of São Paulo, bid for their first Smart City project, combining, in addition to public lighting (change of luminaires for LED and tele management), the control of traffic lights and their operation, control of surveillance cameras installed on public roads (including "OCR" cameras, enabled to identify vehicle plates), traffic control on public roads (identifying congestion and reporting such data to the CCO, responsible for traffic management and sending guidance to citizens for the electronic plates of variable messages installed on public roads), control of the consumption of water, electricity and gas in all municipal public buildings (Secretariats, Nurseries, Schools, etc.), control of the entire fleet of official vehicles of the Municipality (with the monitoring of their position, among other utilities, monitorable from a single network and a single Operational Control Center.



1. Exploring new partnership and investment models – Figure 19: Procurement Solution Models for Smart Cities
2. Promotion of PPPs for the exploitation of other services for Smart Cities in addition to Public Lighting;
3. Promotion of Notices that include multiple municipalities to improve the attractiveness of private investors;
4. Creation of Notices that include more than one service for Smart Cities;

Figure 20: Procurement Solution Models for Smart Cities<sup>126</sup>



This integrated service model above for Smart Cities could be perfected for wide reutilization. One possibility would be with an improvement in the legal framework bringing guidance to combine more and less attractive services, but both of public interest and the inhabitants of cities.

**Exclusive Public Concession Model for The Intelligent City's Exploitation of Services**

This suggestion is articulated with the previous one for the promotion of concession contracts with public-private partnerships (PPPs). It adds a magnifying glass on Smart Cities and the need for investments in ICT solutions to support high-tech services that require investment support.

The services presented in Background Chapter for Smart Cities can be combined through a possibility of joint exploitation by the private interested companies. This model can be inspired by that equivalent for authorizations and concessions for the exploitation of telephony, where investments in less profitable services can be transformed into fulfilment obligations and compensated in the amounts of concessions. The same can be used in training and innovation programs, bringing a guidance basis for investments in technology in cities.

The concession model can be replicated for all Brazilian municipalities depending on their needs and in the MPs.

**Table 9: Smart City Services Domain and Main Projects**

Quality of Life	Urban Mobility	Natural Resources and Energy	Industry and Human Resources
<ul style="list-style-type: none"> <li>• Public Safety</li> <li>• Health</li> <li>• Urban Space Management</li> <li>• Pollution Control and Environments</li> </ul>	<ul style="list-style-type: none"> <li>• Traffic and Security Information</li> <li>• Transport Operation</li> <li>• Logistics in the city</li> </ul>	<ul style="list-style-type: none"> <li>• Power Management</li> <li>• Lighting Management</li> <li>• Water Management</li> <li>• Garbage Management</li> <li>• Renewable energy</li> </ul>	<ul style="list-style-type: none"> <li>• Innovation</li> <li>• Development and Technological Demonstration</li> <li>• Human Resources and Training</li> </ul>

“Create business models that unlock and make sense - who understand the business...”

For example, despite the benefits associated with public safety solutions in the quality of life of citizens and for the city itself as a reputation and attractiveness of investments, for not bringing contributions of dedicated investments, such as Public Lighting, with more than 450 PPP projects in Brazil, the adoption of Public Safety solutions in Brazil is still very incipient in relation to the rest of the world.

The reason today Brazil is technologically aligned with the world for mobile communications, including 5G, is due to the model of authorization of services and use of spectrum at the national level. For Smart Cities, the inspiration in this model can bring the benefit of technological life cycle management,

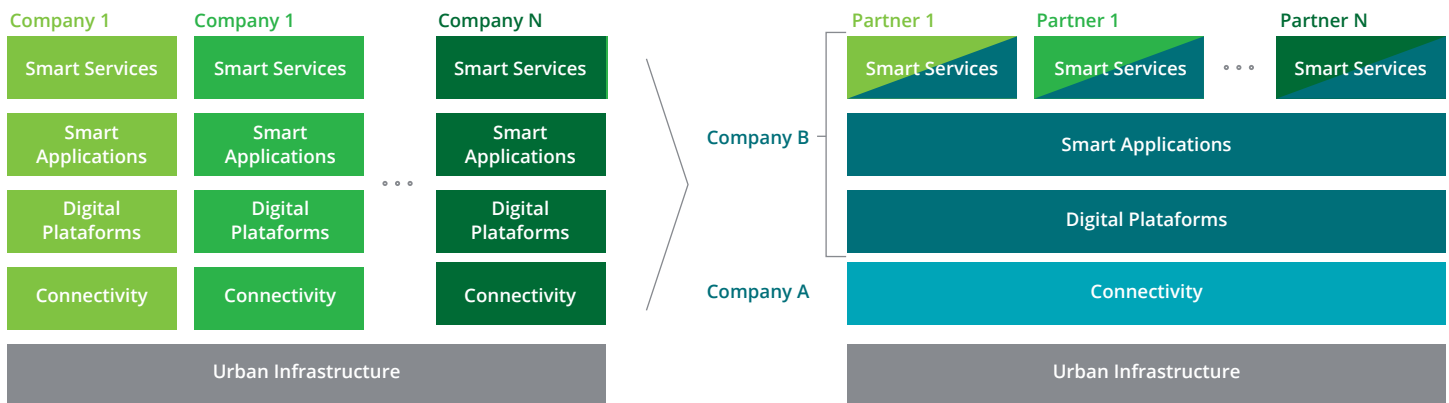
alleviating cities from creation of specific skills, new developments and hiring of new technologies, abstracting the public agent in the management of new hires and ensuring speed in the availability of resources, facilities, convenience and convenience to users.

The orientation for the exploitation of Smart Cities at the national level, as mentioned, could allow the standardization of technological architecture, data, processes, etc., in addition to bringing new business models.

This model goes beyond the definition of a technological platform of services, but rather a platform for the exploitation of digital services, where exploitation is aimed to be a hub for innovation, new companies and services.

The figure below (figure 21) presents a proposal for the evolution of the exploitation model, where a single Company and Partners (Company B) could

**Figure 21: Evolution of the Smart City Services Exploitation Model**







1. Creation of a comprehensive concession model, of federal level, for applicability to all Brazilian municipalities;
2. The Concession model should consider horizontal (e.g. Company B above) and long-term exploitation for Smart Cities services;
3. The Concession model may consider multiple municipalities – similar to telecommunications operating models;
4. The model should consider counterparts and service obligations to contemplate services of interest to society, but of lower economic attractiveness;

cross-explore the service opportunities of Smart Cities, ensuring standardization, synergies and allowing to concentrate innovation and investments in intelligent digital services own or through partners. This model can gain the necessary scale for technological cost-effective and wide adoption.

#### Funding access for Smart City projects

Several factors make it difficult to finance smart cities projects.<sup>127</sup> There are several obstacles, since they involve technology risk, where the project may be the first to deploy a particular technology, reducing investor confidence in the integration and usability of the technology in the absence of demonstrable proof of concept. It may also be hard to secure financing for a smart city project where it is difficult to monetize the benefits of the project. For example, a project might offer a clear positive socioeconomic impact, but there may be no way to assign a dollar figure to that benefit, including the potential to generate revenues.

Other impediments to financing include projects that do not have a clear path to steady revenue; where the return on investment (ROI) is uncertain; and/or the unconventional nature of smart cities projects based on interconnectivity with physical devices and infrastructure, which often lack the traditional, single-sector focus that conventional financing favors. Lastly, the types of financiers that will generally understand smart cities often have an infrastructure background; however, their preference is for long-term projects. The shorter-term nature of technology-related projects can be outside their remit or bring additional risk and challenges to smart cities projects that need to be considered.

A key step in any smart city financing effort is developing a comprehensive strategic plan, the long-term plan above mentioned, to capitalize on the project's strengths. This can help to improve the initiative's "investment readiness" and its access to finance. The Long-term plan should include a robust business model; a creative approach to funding and financing sources (finding new sources of revenue for projects and new business models for recovery and value capture); and innovative financing structures for investors.

**66** As cities look to upgrade their infrastructure with smart technologies, paying for those projects presents a significant challenge of introducing smart technologies on a wide-scale basis... **99**

While there are numerous options available to source finance for smart cities investments, a challenge in taking advantage of many of these options is matching the project to the most appropriate financing tool. This requires that you fully understand the project, its potential cashflows, the range of financing options available (locally and internationally), and available procurement methods to government in order to deliver – Figure below (figure 22).

In Brazil, Bill 976/21, called National Policy of Smart Cities (PNCI), is under discussion in House of Representatives. Originally, it considered for funding purposes a provision of the National Fund for the Development of Smart Cities (FNDCl), with resources obtained through contributions and donations from individuals and legal entities and other sources of revenue. Although the fund was maintained in the first analysis of the House, in the Committee on Urban Development (CDU), but was rejected in the CFT (Committee on Finance and Taxation). In this sense, the financial assistance will be exclusively from the Union, in addition to technical assistance, for the regional actions of the National Smart Cities Policy, provided that local governments allocate all the

value of the specific amount in the actions consistent with the plan.

Based on the PNCl, municipalities should adopt smart city plans, duly approved by municipal law and integrated into the local master plan, when any, or Integrated Urban Development Plan, in the case of metropolitan regions. To facilitate the work of municipalities, the Union will make available on the Internet a repository of solutions for the development of smart cities. Cities that adopt these solutions will have priority in accessing technical and financial assistance provided by the federal government. Municipalities that have periodic programs to train public managers will also have priority.

Although the PNCl provides for funding from the Brazilian government for smart city projects, other sources of public and private funding, national and international, are equally important for the viability of their projects. Among the entities that continuously support projects of this nature and briefly described here are: Inter-American Development Bank (IDB); Japan International Cooperation Agency (JICA) and the United States Agency for International Development (USAID). There

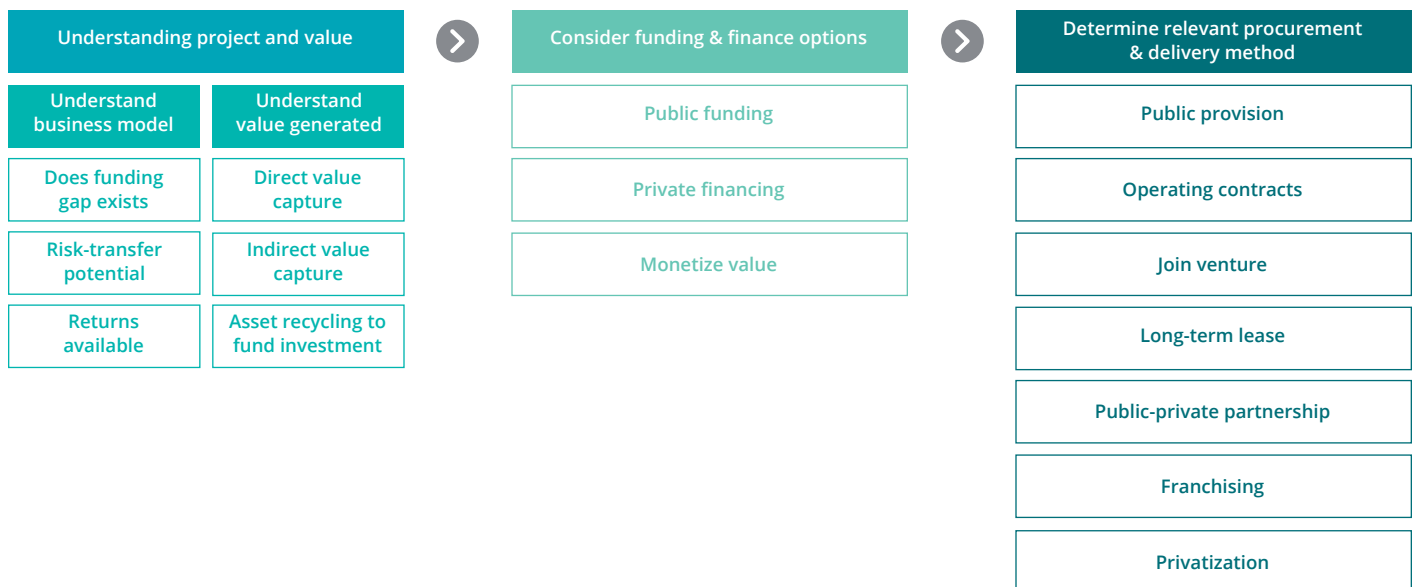
are other sources of international aid and funding such as the European Development Fund (EDF), not explored here.

**“...Constrained by tight budgets, cities need to identify business models that can help to attract private financing in order to make the introduction viable and financeable...”**

The Inter-American Development Bank (IDB) is an international financial institution headquartered in Washington, D.C., United States of America, and serving as the largest source of development financing for Latin America and the Caribbean.

IDB periodically defines and revises its country strategies through a structured and continuous dialogue with the borrowing member country<sup>129</sup>. The country and the IDB jointly identify initiatives to be incorporated to active pipeline. These initiatives are identified

Figure 22: Model for delivering a successful project<sup>128</sup>



through several important tasks: diagnostic studies, objective formulation, analysis of alternatives, and selection of the financial instrument. The results of these tasks are developed into a Project Profile (PP).

Additionally, IDB created the Emerging and Sustainable Cities Program (ESC)<sup>130</sup> of the Housing and Urban Development Division, as a non-reimbursable technical assistance program providing direct support to national and subnational governments in the development and execution of city action plans. ESC employs a multidisciplinary approach to identify, organize and prioritize urban interventions to tackle the main roadblocks that prevent the sustainable growth of emerging cities in Latin America and the Caribbean.

In 2021, IDB and its private arm Invest, closed the year with nearly \$23.4 billion in new financing, commitments and mobilizations for Latin America and the Caribbean, as the two institutions helped countries recover from the pandemic and usher in an era of sustainable and inclusive growth (figure 23).

The Japan International Cooperation Agency (JICA) is a governmental agency, new JICA formed on October 2003, that delivers the bulk of Official Development Assistance (ODA) for the government of Japan. It is chartered for the purpose of supporting the socioeconomic development, recovery or economic stability of developing regions. The ODA is classified into two types: bilateral aid and multilateral aid. Multilateral aid consists of financing and financial contributions to international organizations. JICA has a headquarters in Tokyo, 17 domestic branch offices throughout Japan, and about hundred offices located worldwide to promote projects that meet local needs.

JICA provides funds to low-income developing countries without the obligation of repayment, such as Grants, to support the construction of facilities necessary for social and economic development, such as schools, hospitals, wells, and roads,

**Figure 23: IDB Steps for project financing**

<b>Preparation</b>	<ul style="list-style-type: none"> <li>• The PP provides basic information on the project, including its justification and objectives, the technical aspects and its relevant sector background, the proposed environmental and social safeguards, a fiduciary evaluation, the projected funding amounts, and a preliminary agenda for the project's execution.</li> <li>• The PP is first evaluated at the Eligibility Review Meeting (ERM), which determines the eligibility of the operation, its strategy for development, and validates its timeline and resource requirements. Following approval of the PP by the ERM, the Proposal for Operations Development (POD) is drafted.</li> <li>• The POD specifies the activities, resources and a timetable that are necessary to prepare and supervise the project. The POD also includes the Development Effectiveness Matrix (DEM), Monitoring and Evaluation Plan (M&amp;E), and the Economic Rate of Return (ERR). The POD is evaluated to determine if the institution</li> </ul>
<b>Approval</b>	<ul style="list-style-type: none"> <li>• Further adjustments are made if needed, and then a Draft Loan Proposal (DLP) is prepared for the Operations Policy Committee (OPC) for approval. Once the OPC approves the DLP, the project team may proceed to distribute the document for Board consideration and approval.</li> <li>• Once the Board approves the project, the loan contract can be signed by the borrowing member country.</li> </ul>
<b>Implementation</b>	<ul style="list-style-type: none"> <li>• Once the loan contract has been signed, implementation can begin. Implementation of public sector projects includes periodic monitoring of the activities and outcomes through the Progress Monitoring Report (PMR). Implementation also includes supervision and monitoring activities on disbursement, financial management, procurement procedures, risk management, and/or safeguards compliance policy.</li> </ul>
<b>Completion &amp; Reporting</b>	<ul style="list-style-type: none"> <li>• Once a project has been executed, evaluations are completed to measure development outcomes for a project. The Project Completion Reports (PCR) contribute to institutional learning within the IDB, as well as the Bank's accountability, because they are a key source of information about a project's performance and outcomes. Under the Development Effectiveness Framework (DEF), the production of PCRs was improved and the results are being validated to establish baselines for the data contained in the PCRs.</li> <li>• The IDB also produces Impact Evaluations (IEs) and its Office of Evaluation and Oversight (OVE) collects ex-post evaluation data to include in comprehensive reports on broader trends in projects undertaken by the Bank.</li> <li>• These conclusions and findings will be useful in the planning and development of future projects based on empirical results.</li> </ul>

and the procurement of equipment and other supplies.

The ODA Loans are extended under generous lending conditions (long repayment periods, low interest rates) for projects supporting the development of developing countries. They are applied to infrastructure construction and other projects and programs requiring a large amount of funding. Also, they, which require repayment, promote efficient use of the borrowed funds and appropriate supervision of the project they finance, thereby underpinning developing countries' ownership in the development process. In addition, as ODA loans are financial assistance with repayment obligation, they place a relatively small fiscal burden on the Japanese government and represent a sustainable instrument for official development assistance.

Finally, Private-Sector Investment Finance, on the other hand, provides financial support for private sector activities in developing countries. The project financing processes are very similar to IDB and pictured in Figure below (figure 24).<sup>131</sup>

The United States Agency for International Development (USAID) is an independent agency of the U.S. federal government that



1. Use of the Long-term plan, pointed in this document, as a guidance for public, private and international investments in Smart city projects;
3. Creation of a council of municipalities to approximate international funding programs;
3. Creation of regional commercial chambers to support municipalities and public agents in the rules and financing projects;

is primarily responsible for administering civilian foreign aid and development assistance. The Budget Request for current Fiscal Year (FY) 2023 of United States Agency for International Development (USAID) is \$29.4 billion,<sup>132</sup> which is one of the largest official aid agencies in the world and accounts for more than half of all U.S. foreign assistance, whose primary focus was long-term socioeconomic development – the highest in the world in absolute dollar terms.

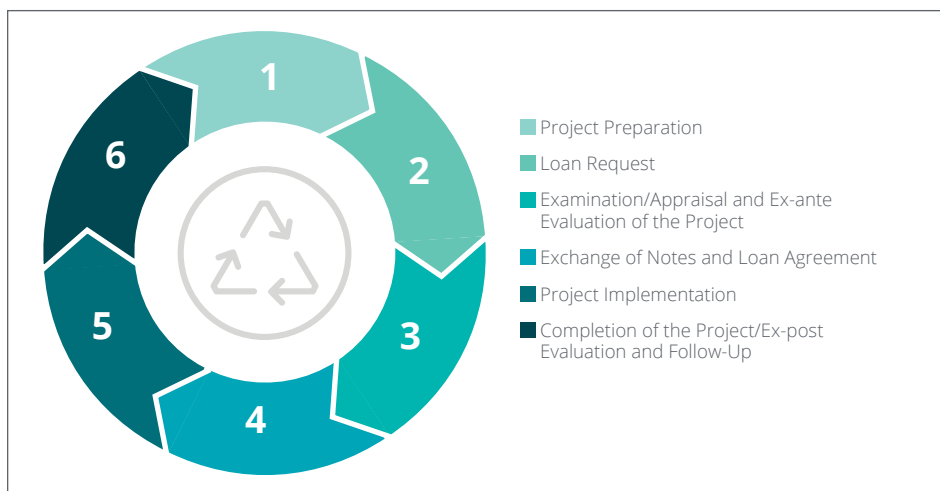
USAID has several programs to help cities increase their capacity to finance and build public infrastructure and services. These programs help cities engage a diverse cross-section of stakeholders – local, national, public and private – and address incentives for and challenges to mobilizing finance. Ultimately, they help put cities on a sustainable path to meet their development goals, ensuring they expand and thrive

economically while also curbing emissions and protecting residents from risks. USAID is committed to supporting improved urban services to help cities and countries achieve climate-resilient, low-emission, sustainable economic development, as outlined in its urban policy.

USAID's programs are authorized by Congress in the Foreign Assistance Act, which Congress supplements through directions in annual funding appropriation acts and other legislation. As an official component of U.S. foreign policy, USAID operates subject to the guidance of the President, Secretary of State, and the National Security Council.

Accessing these sources of funding is not an easy task depending on the requirements of the projects submitted. The creation of technical support for formatting and submission of projects is crucial for access to these resources.

Figure 24: Project Cycle of ODA Loans



### Public Safety as A Great Promoter of Social wellbeing

Public Safety is a major promoter of social wellbeing and quality of life, but it also brings many benefits such as improving its reputation, 41 percent increase according to ESI ThoughtLab Report, necessary for entrepreneurship and external investments. Also according to this report, return on investment is positive, higher than 3 percent, and may reach, depending on the solution – table 3. There are other economic benefits to public safety, not only clearer evidence of a substantial rate of return on investment, such as indirect savings associated with legal fees and settlements in legal disputes.

Public safety is an area where budget investments compensate for economic growth, crime reduction and community integration. In a study conducted in eight U.S. cities,<sup>133</sup> "The Economic Benefits of Reducing Violent Crime", it was estimated that violent crimes cost Americans US\$42 billion in direct costs per year.

This includes "the associated costs of the police, courts and correctional institutions, out-of-pocket medical expenses borne by victims, and gains lost by victims and perpetrators who are arrested and convicted." According to this study, "a 10 percent reduction in homicides may increase by 0.83 percent

housing values in the following year" (table 10).

According to a study "Benefits of Technology Investment and Public Safety Innovation", there are the following actions and policies for the viability of technologies for public safety in cities.

**Table 10: Source: Benefits of Technology Investment and Public Safety Innovation – Table 8<sup>134</sup>**

Benefits	Technology Investment
Economic Growth	A 10 percent increase in ICT investment leads to a 6 percent increase in growth
Productivity	Each percentage point increase in digital connectivity is associated with a productivity increase of 2.3 percent
National Competitiveness	Each percentage point increase in digital connectivity is associated with a 2.1 percent boost in competitiveness
Job Creation	An investment of \$275 billion in broadband infrastructure is expected to create 3 million jobs and add \$500 billion to Gross Domestic Product in USA
Innovation	Each percentage point increase in digital connectivity is associated with a 2.2 percent gain in innovation
Reduction in Police Complaints	Investing in police body cameras reduce citizen complaints by 88 percent and cuts police "use of force" incidents by 60 percent
Reduction in Crime Incidence	Increasing police force by 10 percent cuts homicide by 9 percent, robbery by 6 percent and vehicle theft by 4 percent each year
Increase in Housing Values	Cutting homicides by 10 percent increases housing values by 0.83 percent

**Invest in Digital Infrastructure.** Broadband technology coverage in cities, preferably wireless: 4G, 5G, Wi-Fi. These investments can be facilitated through policies that make it possible to build infrastructure already discussed in this chapter.

**Overcome funding challenges.** Despite the many benefits of ICT solutions in public security, investments are in equal proportion. Public security areas in governments must balance existing traditional demands and seek new technologies to make it more efficient, effective and preventive. Thus, an important path is the search for projects that are attractive to boost the private partnership. In this way, having the combination of other public services, seeking expansion in the basket of services can be the way.

**Integrated Command Centers.** Public security solutions must be interoperable: data, interfaces, technologies, etc. Today the designed systems are in various technological stages and from different suppliers. Furthermore, data can come from various formats, both in structured and unstructured formats, and there needs to be a way to analyze each type of information. There may also be problems making use of non-text information, such as high-definition video. Advances in facial recognition software help in this area because they can identify specific individuals who are known to authorities. This helps law enforcement specify certain threats and protect the general public. Best practices today involve integrated, visualized, and collaborative systems that provide real-time analytics. There are many new solutions that are popular, such as sensors, video surveillance, facial recognition and data analysis. But what's needed is automated information processing so that employees have the data they need instantly to make informed decisions about resource allocation and prioritization.

**Collaborative Solutions (Crowdsourcing through citizen participation).** Collaborative solutions are another way to promote innovation in public safety through crowdsourcing. For example, the Singapore Government Technology Agency conducted numerous tests using social media apps to encourage citizen participation. The Agency uses an online group of citizens to test products before releasing them to the general public. Some notable examples include OneService, where citizens send municipal questions to city authorities and my Responder, which notifies volunteers less than 400 feet from a cardiac arrest case to respond until emergency services arrive. This helps to ensure that innovation in public security responds to initiatives welcomed and accepted by the general public.



1. Facilitation and simplification in licensing for the viability of investments in wireless broadband.
2. Search for new sources of funding through the creation of new business models and partnerships;
3. Use of synergies in consolidated projects, such as Public Lighting, for public safety. E.g. Surveillance camera in luminaires;
4. Realization of municipal partnerships for the creation of integrated Command Centers;
5. Integration of Command Centers;
6. Use of applications that seek the engagement of society and community;

# Final Considerations

With more than half of the world's population living in urban areas in cities, there are issues of access to its resources, associated services, bringing problems of urban planning, urban mobility, safety, health, energy consumption, pollution, sustainability among others. In Latin America, 81 percent of the population already lives in urban areas and, in Brazil, out of 210 million people 84 percent live in urban areas of more than 5,570 cities, worsening this problem. In addition to the difficulties for their inhabitants, cities account for much of the world's carbon emissions, consuming about 2/3 of the world's energy and producing approximately 70 percent of greenhouse gas emissions.

Smart cities represent the answer to solve large cities and the effects of urbanization problems, with the use of information and communication technologies to achieve long-term economic development, efficient resource management and provide greater quality of life for their residents. A smart city can use its advanced infrastructure to help local businesses, the environment,

transportation and mobility, health, lifestyle and governance.

The adoption of smart city solutions is being driven by increased urbanization trends around the world and the desire for a higher quality of life and sustainability. According to a study by the Coalition for Urban Transitions,<sup>135</sup> there is potential to reduce carbon emissions by 90 percent by 2050 by implementing solutions of Smart Cities, making infrastructure more efficient, incorporating renewable energy into buildings, using different materials to build infrastructure, and improving transportation.

Globally, governments have stepped up enablement and projects for smart cities through their regulations and initiatives focused on deploying smart services as an important part of their infrastructure. The size of the global smart cities market is estimated to be valued at US\$1,025.9 billion in 2021 and is projected to reach US\$7162.5 billion by 2030, growing at a CAGR of 24.1 percent from 2021 to 2030.<sup>136</sup>

Smart City in Brazil has been an important agenda with many public policies and initiatives that remits beginning of 2000, when the City Statute (Law 10.257/01) was passed, and others such as: PPPs Law (Law 11079/04); Digital City Program; Antenna's Law (13116/15); National IoT Plan (Decree 9854/19); Brazilian Charter of Smart Cities (2020); Regulatory Framework for Artificial Intelligence (PL 21/20) and Principles for the Use of AI in Brazil (Bill 5051/19 and 872/21); Startups Legal Framework (Law 182/21); National Smart Cities Policy (Bill 976/21), among others. However, there are still identified barriers from experts interviewed during this study elaboration.

Our expert interviewees have identified a set of barriers, grouped in the following subjects: Political & Administrative Economic issues; Capacity & Education; Legal and Regulatory and Technology. Also, for minimizing or mitigating the above barriers, a set of suggestions was presented for intensifying existing policies or creating new ones from some existing policies. These have been inspired from CBCI and validated or suggested by our interviewers – table below.

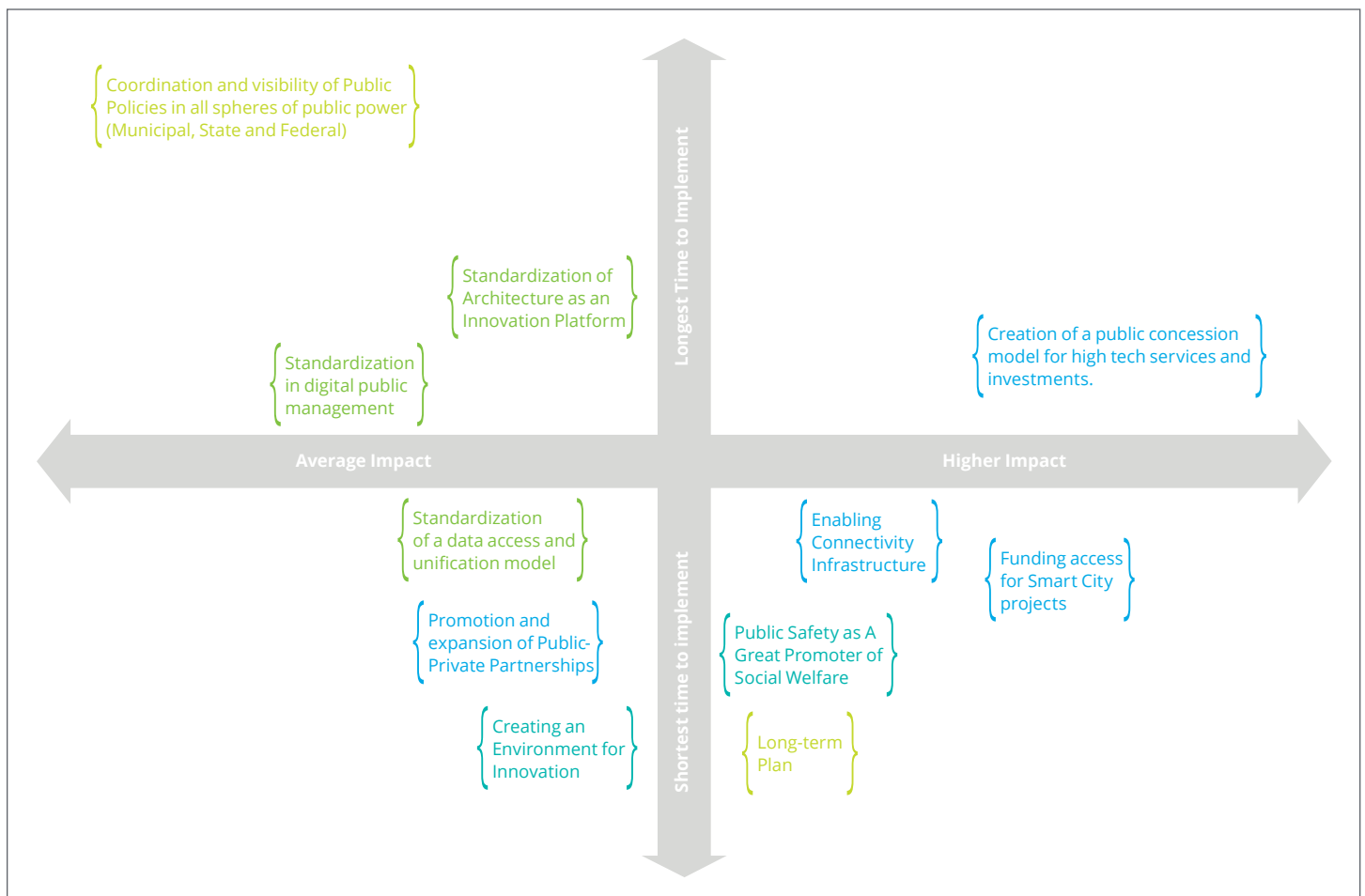
**Table 11: Public Policy Suggestion**

Legal & Regulation Framework	Technology	Funding & Business	Innovation & Others
Coordination of Policies in all spheres of public power (Municipal, State and Federal)	Standardization of a data access and unification model	Funding access for Smart City projects	Creation of Development and Innovation Public Safety as A Great Promoter of Social Welfare
Long-Term Plan	Standardization in digital public management	Enabling Connectivity Infrastructure	
	Standardized Architecture	Promotion and expansion of Public-Private Partnerships Exclusive Public Concession Model for The Intelligent City's Exploitation of Services	

Each suggestion has a specific impact in identified barriers, and the total impact is plotted in the figure below. According to how easy they can be implemented, low complexity, or number of actors for convergence, there is a different expectation

to be released, captured in vertical axis below. The impact vs time shows a good orientation about how is effective each recommendation in short, mid and long term, but also brings strategy roadmap for pushing these recommendations.

Figure 25: Evolution of the Smart City Services Exploitation Model



### First Step

In the First Step, **Long-term Plan** for a Smart City can easily be included/considered in existing PDM based on City Statute Law, bringing a prompt benefit for having a clear vision for long term investments and direction. The Long-Term Plan will be key for **Funding Access for Smart City projects** through investments in the public and/or private sector.

Other immediate action is **Enabling Connectivity Infrastructure**, and the Antennas' Law homologation in municipalities is a crucial step. It can attract investments by CSPs, ISPs and NHNs telco companies without any investment by cities, and it can create a new way for public facilities exploitation. Finally, the telecommunication infrastructure is the main enabler for digital transformation in the cities.

**Public Safety** is another initiative that brings an immediate benefit for promoting overall welfare of its citizens, enterprises, and increasing reputation for new investments. Also, safety is the main concern pointed by great part of Latin America cities, that reason of the important inclusion in short-term strategy.



**Long-Term Plan:** Having a long-term baseline for guiding investments and evolving Smart Cities.

1. Creation of a Long-Term Plan for Smart Cities that take into account the following topics: Quality of Life; Creation of Economic Value; Sustainability and Resilience, analyzing the actions and objectives for the following actors: Government, Companies, Academia, and Citizens.
2. Use of the PDM of the City Statute to contemplate the Smart Cities Plan.
3. Creation of goals and obligations for the fulfillment of the Long-Term Plan of Smart Cities;



**Funding access for Smart City projects.** Enabling access to public, private, local and international aid and financing programs, through the dissemination of information about these programs to public agents, also providing a professional support for submission and approval of projects.

1. Use of the Long-term plan, pointed in this document, as a guidance for public, private and international investments in Smart city projects;
2. Creation of a council of municipalities to approximate international funding programs;
3. Creation of regional chambers to support municipalities and public agents in the rules and financing projects;



**Enabling Connectivity Infrastructure:** It consists in the construction of connectivity infrastructure either through enabling policies (Law of Antennas) or new business models for exploitation.

1. Approval of the Antenna law at the municipal level to promote the implementation of telecommunications infrastructure.
2. Construction of a model for the operation of urban furniture, lighting lamps, power poles, soil and subsoil for companies of network neutrals and infrastructure exploitation.
3. Use of investments and exploitation of connectivity by telecommunications companies (CSPs, ISPs, NHNs).
4. Creation of commitment in the exploitation of connectivity solutions that meet the needs of Smart Cities.





**Public Safety as A Great Promoter of Social Welfare:** Promoting public safety as a promoter of wellbeing and quality of life, but also of attractiveness of companies and new investments for municipalities.

1. Facilitation and simplification in licensing for the viability of investments in wireless broadband.
2. Search for new sources of funding through the creation of new business models and partnerships.
3. Use of synergies in consolidated projects, such as Public Lighting, for public safety. E.g. Surveillance camera in luminaires;
4. Realization of municipal partnerships for the creation of integrated Command Centers.
5. Integration of Command Centers.
6. Use of applications that seek the engagement of society and community;

### Second Step

The Second Step is characterized by reorganization of mechanisms for funding and enabling smart cities. **Creation of a public concession model for high tech services and investments** can attract new investors for a smart city by bringing legal certainty and a long-term services exploitation.

The interoperability of smart city applications promotes the synergy and innovation. The first step is **Standardization of data access** where existing and new applications can use the same database.

The **Innovation Environment** is also already adopted by several cities by taking advantage government incentives of existing Laws for attracting companies and investors, such as: Startups' Law; Informatica's Law; and others.



**Exclusive Public Concession Model for The Intelligent City's Exploitation of Services:** Evolution of concession models to host the combination of profitable, high-cost and essential services.

1. Creation of a comprehensive concession model, of federal level, for applicability to all Brazilian municipalities.
2. The Concession model should consider horizontal and long-term exploitation for Smart Cities services.
3. The Concession model may consider multiple municipalities – similar to telecommunications operating models.
4. The model should consider counterparts and service obligations to contemplate services of interest to society, but of lower economic attractiveness.



**Promotion and expansion of Public-Private Partnerships:**

Consolidation of PPPs as a means for enabling smart cities, bringing several benefits, such as: investments, guarantee of service management and maintenance, technological evolution, dishonoring the municipality in the complex task of creating skills and technological investments.

1. Exploring new partnership and investment models –Figure 19
2. Promotion of PPPs for the exploitation of other services for Smart Cities in addition to Public Lighting.
3. Promotion of Notices that include multiple municipalities to improve the attractiveness of private investors.
4. Creation of Notices that include more than one service for Smart Cities.



**Creating an Environment for Development and Innovation:** Creating an innovation environment through integration with industry, academia, startups and etc.

1. Creation of innovation programs (edicts) aimed at solutions that solve the problems of cities and involving society, academic community, entrepreneurs, investors, etc.
2. Use of levers brought by the framework of existing laws and exemption policies: Computer Law, Law of Good, Marco das Startups, City Statute.
3. Inclusion in innovation programs mechanisms that promote training and engagement: events for dissemination of knowledge; courses, training and specialized schools; viability of incubators with the academic sector; feasibility for the creation of techno parks; hackathons, etc.
4. Promotion for the popularization of knowledge of technologies associated with Smart Cities, through distance training programs.
5. Viability of collaborative spaces and experimentation of new solutions such as: Open Labs, living labs etc.



**Standardization of a data access and unification model:** Search for the standardization of Smart Cities starting with the standardization of access to data of all services.

1. Creation and standard to ensure data interoperability and synergy of services.
2. Adoption in public notices of this standard for the public services of Smart Cities.
3. Promoting the evolution of technologies and solutions already deployed to adhere to the standard and interoperability.

### Third Step

This final stage and motivated by the complexity of implementation of the suggested actions. The **Standardization of Architecture for Smart City as innovation platform** has a big impact, however it needs a long discussion with industry for establishing a model that makes sense of the Brazilian environment. Also, **Standardization in digital service public management** can have impact with growth of synergies among services, but it needs discussion with public agents in all public spheres for alignments and having the same approach. The most complex action is **Coordination and visibility of Public Policies in all spheres of public power (municipal, State and Federal)**, where it needs a long and complex discussion, but it can solve problems around clarity of legal environment and certainty, bringing associated benefits.



**Standardized Architecture:** Standardizing the architecture for digital platforms and access to associated services.

1. Creation of the standard for the architecture of the digital platform (interfaces, access to data and some enabling elements) for the provision of smart cities services.
2. Adoption in public notices of this standard for the public services of Smart Cities.
3. Promoting the evolution of technologies and solutions already implemented to adhere to this standard.



**Standardization in digital public management:** Standardization and standardization of processes for common public services.

1. Standard creation for service applications and digital public management: services of a similar nature with similar journeys. Example National Electronic Process.
2. Adoption of single access to digital public management and service applications, such as "Citizen Digital Identity".



**Coordination of Policies in all spheres of public power (Municipal, State and Federal).** Guidance for the creation of broader policies, laws and regulations in the three spheres of government.

1. Creation of guideline that bus that clarify the applicability of Laws for the viability of Smart Cities, such as: Statute of the City (Law 10.257/01); Computer Law (Law 13.969/19); Marco Legal das Startups (Law 182/21); National Smart Cities Policy (Bill 976/21); PPPs Law (Law 11.079/04); municipal laws, including those for the establishment of COSIP. Also combining with important documents such as CBCI.
2. Simplification and consolidation of the entire legal and regulatory framework for Smart Cities projects through exclusive law – such as the Law of Antennas in telecommunications.

**Table 12: Strategy Roadmap for Suggested Policies**

1 <sup>st</sup> →	2 <sup>nd</sup> →	3 <sup>rd</sup> →
<ul style="list-style-type: none"> <li>• Long-term Plan</li> <li>• Funding Access for Smart City projects</li> <li>• Public Safety as Great promoter of Social Welfare</li> <li>• Enabling Connectivity Infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>• Creation of a public concession model for high tech services and investments</li> <li>• Creation an Environment for Innovation and Capacity</li> <li>• Promotion and expansion of PPPs</li> <li>• Standardization of data access and unification model</li> </ul>	<ul style="list-style-type: none"> <li>• Standardization of Architecture for Smart City as innovation platform</li> <li>• Standardization in digital public management.</li> <li>• Coordination and visibility of Public Policies in all spheres of public power (municipal, State and Federal)</li> </ul>

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# Glossary

Acronym	Meaning
<b>3GPP</b>	3rd Generation Partnership Project. Standardization body that brings together several other standards organizations that develop protocols for mobile telecommunications from the second generation (2G) to recently the (5G). <a href="https://www.3gpp.org/about-3gpp">https://www.3gpp.org/about-3gpp</a>
<b>4G</b>	4 <sup>th</sup> Generation of Wireless Communication. Defined in ITU-R M.2012 and 3GPP Series 36.
<b>5G</b>	5 <sup>th</sup> Generation of Wireless Communication. Defined in ITU-R M.2150 and 3GPP Series 38.
<b>AI</b>	Artificial intelligence. Systems or machines that seek to reproduce human intelligence in the form of learning and performing tasks and can improve as they process more information.
<b>ANATEL</b>	National Telecommunications Agency (Agência Nacional de Telecomunicações). Regulatory body linked to the Ministry of Communications.
<b>ANTT</b>	National Land Transport Agency (Agência Nacional de Transportes Terrestres)
<b>AR, MR, VR e XR</b>	Augmented Reality. Use of digital devices (smartphones, smart glasses, Heads-Up Display) to provide real-time information related to the location and situation that overlaps the view of the real world.
	Mixed Reality. It is a middle ground between Augmented Reality and Virtual Reality where computationally generated images are superimposed and interact with real-world vision.
	Virtual Reality. Completely replaces real-world vision with a computationally created one, generating an immersive experience in a virtual environment
	eXtended Reality. It is the junction between AR, MR, VR being used simultaneously or not.
<b>Backhaul</b>	It is the network that connects the access networks to the core of the network or <i>backbone</i> .
<b>Big Data</b>	Set of tools and processes of ingestion, treatment and storage of large amounts of data for further analysis.
<b>Blockchain</b>	It is a distributed database or ledger that is shared among the network nodes and facilitates the processes of recording transactions and tracking assets across this network. As a database, a blockchain stores information electronically in digital format.
<b>CBCI</b>	Brazilian Smart City Charter (Carta Brasileira de Cidade Inteligente)
<b>CCTV</b>	Closed Circuit Television
<b>CSP</b>	Communication Service Provider
<b>Digital Twin</b>	They are virtual representations of objects, assets, situations, and real things that can capture the physics of structures and alter internal and external conditions measured by connected sensors. They can perform simulations within the virtual twin to: discover and solve problems; seek improvements through updates of real physical products.
<b>eMTC</b>	Enhanced Massive Machine Type Communication. 3GPP technology for Low Power Wide Area defined in Release 13.
<b>ESG</b>	Environmental, Social & Governance. The environmental component might focus on a company's environmental impact. The social component might focus on the company's relationship with people and society. The governance component might focus on how the company is run.
<b>eMBB</b>	Enhanced Mobile Broadband - performance requirement for 5G (IMT-2020) that establishes download speeds up to 20 Gbit/s. Ex.: streaming video in very high resolution, immersive games, transferring large volumes of data, etc.



<b>ETL</b>	Extract Transform and Load. Extraction, Transformation and Load. It is an example of process and data processing for Big Data.
<b>EIF4SCC</b>	European Interoperability Framework for Smart Cities and Communities
<b>GDP</b>	GDP Gross Development Product
<b>HFC</b>	Hybrid Fiber Coaxial. Cable telecommunications physical medium, which combines optical fiber between the network core to an optical node close to the point of consumption, and coaxial cable between the optical node and the consumer.
<b>ICT</b>	Information and Communications Technology
<b>IDB</b>	Inter-American Development Bank (IDB) is a cooperative bank to help support the economic and social development of Latin America and Caribbean countries.
<b>IMT-2020</b>	International Mobile Telecommunications-2020. Series of requirements defined by the ITU for the 5th generation of mobile telecommunications (5G).
<b>IoT</b>	Internet of Things.
<b>ISO</b>	International Standard Organization
<b>ISP</b>	Internet Service Provider
<b>ITU</b>	International Telecommunication Union. International telecommunications standardization body linked to the United Nations (UN).
<b>JICA</b>	Japan International Cooperation Agency (JICA) is an implementing agency of Japanese official development aid (ODA) for the purpose of supporting the socioeconomic development, recovery or economic stability of developing regions.
<b>MCOM</b>	Ministry of Communication (Ministério das Comunicações)
<b>MCTI</b>	Ministry of Science, Technology and Innovations (Ministério da Ciência, Tecnologia e Inovação)
<b>MDR</b>	Ministry of Regional Development (Ministério do Desenvolvimento Regional)
<b>Metaverse</b>	Originally defined as hypothetical iteration of the Internet as a unique, universal and immersive virtual world. Its development is related to the use of virtual reality technologies and Web3.0.
<b>mMTC</b>	Massive Machine Type Communications - performance requirement for 5G (IMT-2020) that establishes 1 million connected devices per Km2. Ex. mass diffusion of IoT.
<b>NB-IoT</b>	Narrow Band IoT. 3GPP technology for Low Power Wide Area defined in Release 13.
<b>NFT</b>	Non-Fungible Token. Digital representation of certificate of authenticity or possession of digital item, stored in blockchain.
<b>NHN</b>	Neutral Host Network
<b>ODA</b>	Official development assistance (ODA) is defined as government aid that promotes and specifically targets the economic development and welfare of developing countries.
<b>O-RAN</b>	Open RAN. Open RAN architecture, where each of the functions and elements that make up a RAN can be <i>provided by a distinct vendor</i> , in contrast to a proprietary RAN solution where all components must be provided by the same <i>vendor</i> .
<b>PDM</b>	Municipality Master Plan ( <i>Plano Diretor do Município</i> )
<b>RAN</b>	Radio Access Network. 2G, 3G, 4G, 5G wireless communication network, consisting of antennas, radio units, baseband units and controllers.
<b>V2X</b>	Vehicle-to-everything. Direct communication between vehicle and anything else, which could be another vehicle, traffic signs (traffic lights and smart signs), street furniture, cyclists, pedestrians, etc.
<b>USAID</b>	The United States Agency for International Development (USAID) is an independent agency of the U.S. federal government that is primarily responsible for administering civilian foreign aid and development assistance.
<b>Vendor</b>	Company providing solutions.
<b>Wi-Fi</b>	Wireless LAN communication standards defined by IEEE ( <a href="https://www.ieee802.org/11/">https://www.ieee802.org/11/</a> ) and homologated and promoted by Wi-Fi Alliance ( <a href="https://www.wi-fi.org/">https://www.wi-fi.org/</a> )

# Contributors



**Marcia O. Matsubayashi**  
Partner Industry Leader, Technology,  
Media and Telecom  
[mmatsubayashi@deloitte.com](mailto:mmatsubayashi@deloitte.com)



**Marcelo Yamamoto**  
Senior Manager in Strategy,  
Analytics and M and A, Technology,  
Media and Telecom  
[maryamamoto@deloitte.com](mailto:maryamamoto@deloitte.com)



**Jefferson L. Denti**  
Partner Leader in Analytics Cognitive,  
AI and Digital Transformation  
[jedenti@deloitte.com](mailto:jedenti@deloitte.com)



**Tiago Novais**  
Senior Manager and Expert in  
Technology, Media and Telecom  
[tnovais@deloitte.com](mailto:tnovais@deloitte.com)



**Alberto Boaventura**  
Senior Manager in Strategy,  
Analytics and M and A, Technology,  
Media and Telecom  
[aboaventura@deloitte.com](mailto:aboaventura@deloitte.com)



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