SMART CITIES OF BRAZIL

Performance of Brazilian Capital Cities

2022

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BIANCA LIBARDI

SMART CITY PILLARS

Smart Economy
Enhancing productivity and innovation to provide the desired economic outcomes for the city and its residents.

Smart Society
Improving liveability and wellbeing to provide the desired societal outcomes for the city and its residents.

Smart Cities
Enabled by community, technology, and policy to deliver productivity, innovation, liveability, wellbeing, sustainability, accessibility, and good governance and planning.

Smart Environment
Focusing on sustainable urban development and improved accessibility to provide the desired environmental outcomes for the city and its residents.

Smart Governance
Establishing good governance and planning to provide the desired institutional outcomes for the city and its residents.

Smart Technology
Providing good connection structures and services to foster innovation as well as facilitating citizens' access to information and knowledge.

Park of Redenção - Porto Alegre

Smart cities are cities committed to sustainable urban development and digital transformation, in its economic, environmental, and socio-cultural aspects, that act in a planned, innovative, inclusive, and networked way, promote digital literacy, governance, and collaborative management, and use technologies to solve concrete problems, create opportunities, provide services efficiently, reduce inequalities, increase resilience and improve the quality of life of all people, ensuring the safe and responsible use of data and information and communication technologies.

Brazilian Charter for Smart Cities, Ministry of Regional Development, 2021.

SUMMARY

Cristo Redentor / Pão de Açúcar - Rio de Janeiro

EXECUTIVE SUMMARY

This report is an outcome of close collaboration between the Australia-Brazil Smart City Research and Practice Network's member institutions. The report focuses on understanding the smartness levels of the Brazilian capital cities through the lens of a smart city performance assessment framework.

This report focuses on Brazilian cities to develop an evaluation model for smart cities and bring metrics that contribute to public managers seeking balance and smartness in the life of their cities.

The smart city concept in this report concerns of smart economy, smart society, smart environment, smart governance, and smart technology domains that seek community-enabled technology and policy to deliver productivity, innovation, livability, well-being, sustainability, accessibility, and good governance and planning.

This report informs public managers, through the indicators of productivity and innovation, liveability and well-being, sustainability and accessibility, governance and planning, and connectivity and innovation, on the smartness performance and levels of their cities. The report highlights strengths and weaknesses of Brazilian capital cities in becoming internationally renowned smart cities.

The analysis based on the smart city assessment framework revealed the following city types: the leaders, the followers, and the developing ones. Cities identified as leaders have a strong innovation ecosystem, with legislation for developing entrepreneurship and training of skilled labor and generating knowledge-based economic development, and facilitating fast and reliable internet access.

One of the most critical challenges on the journey to smartness of the Brazilian cities is connectivity. The internet needs to be available, affordable, reliable and fast in all regions of the country for all people. This way the digital inclusion problems could be avoided. The broadband and 5G internet are considered by many experts as a social right, and hence should be included a citizen's basic right to the Brazilian Constitution.

The arrival of the Covid-19 pandemic disrupted Brazilian cities but at the same time gave them the opportunity to develop a mobile workforce and attract brilliant minds, including internationally, especially as the concept of anywhere offices becomes increasingly present in the life of cities and contributing to their knowledge-based economic development.

Access to open data is another essential element for city smartness and can promote innovative entrepreneurship and the development of new technologies, governance, transparency, and impact on citizen quality of life. For this reason, municipalities should focus their efforts on collection of local data and their responsible use.

This report is relevant and strategic for the government to guarantee fair, ethical, effective, efficient and progressive public policies. It also offers an invaluable opportunity for the authorities to consider the adoption of the indicators used in this report in assessing their smart city performance and progress. We believe this report will inform smart city policy and practice in Brazilian cities.

Lençóis Maranhenses National Park - Maranhão

1. INTRODUCTION

CITY SMARTNESS MATTERS

The sustainability concept has become a prevalent policy underpinning both developed and developing countries' planning agendas [1]. This is mainly the result of externalities - e.g., climate change, non-renewable resource depletion, air, water and land pollution, pandemics, rapid and sprawling urbanization, and social inequalities - that are often not considered until they reach the level, where disregarding consequences of these externalities may jeopardize the overall wealth and wellbeing of citizens [2]. The trend of growing urban population and associated citizen needs has highlighted the importance of actions, which should be taken to reach the goals of sustainable communities and cities [3].

Popularity of the sustainability concept has led to the formation of a new development type, sustainable urban development [4]. The sustainable urban development term is a self-contradictory one consisting of words that have completely different meanings - an oxymoron. Sustainability refers to maintaining the existence of the ecosystem and its services, while also providing for human needs, whereas, in contrast, urban development refers to any activity that improves the quality of life by depleting natural resources and devastating natural areas. Nonetheless, while urban development cannot be fully sustainable, in general sustainable urban development refers to a less harmful or intrusive development type to the natural ecosystems [5].

Since the turn of the century, when the impacts of global climate change have become more catastrophic, advance information and communication technologies (ICTs) are started to be seen as a potential panacea to, somehow, reverse or ease the impacts of our unsustainable urbanization, industrialization and consumerism practices [6]. Particularly, advance ICT applications' potentials in environmental decision-making is widely recognized. Due to the technological offerings many governments—at local, regional, state, national, and supra-national levels—across the globe jumped on the technology solution bandwagon—this has given birth to the 'smart city' concept [7].

Over the past decade, smart urban technologies, as part of the smart city agenda, have begun to blanket our cities with an aim of forming the backbone of a large and intelligent infrastructure. Along with this development, dissemination of the sustainability ideology has had a significant imprint on the planning and development of our cities. Today, the smart city concept is viewed as a vision, manifesto or promise aiming to constitute the 21st century's sustainable and ideal city form. In other words, smart city is an efficient, technologically advanced, green, and socially inclusive city. This is to say, smart city applications place a particular technology focus at the forefront of generating solutions for ecological, societal, economic, and management challenges [8].

Despite the criticisms on technocentricity of smart cities, there is a general sense among the scholars that rethinking our cities' planning and development paradigms and processes in the age of digital disruption and climate change is a good thing. This has turned the notion of smart city into an important urban innovation agenda [9]; [10]. In this sense, smart cities actively embraces new technologies seeking to achieve desired urban outcomes. The most common smart city outcomes include productivity, sustainability, accessibility, wellbeing, livability, and good governance [11].

Today, many cities around the globe are developing smart city agendas. As smart city transformation requires costly investment, being 'smart' about smart city development is the key to success in such transformation. This is to say, understanding the smart city transformation readiness is critical [12]. This forms the raison d'etre of this report entitled 'Smart Cities of Brazil: Performance of Brazilian Capital Cities'. The report places 27 Brazilian capital cities under the smart city microscope to understand their performances and potentials in becoming a truly smart city. The findings of this report helps policymakers of investigated Brazilian capital cities in making informed decisions on transforming their cities into smarter ones.

Florianópolis - Santa Catarina

2. BACKGROUND

UNDERSTANDING SMART CITIES

Cities are made by people, for people, with the search for a balance between economic development, environmental responsibility, and social justice [13]. Urban planning becomes indispensable with activities such as identifying conditions of population density and demand for housing, infrastructure, energy and mobility. With the continuous growth of the urban population on the planet, cities need to develop solutions to deliver public services, to achieve social equity, and to improve the quality of life. It is exactly at this moment that technology has become the tool to increase efficiency and optimize the proposed solutions [14].

The various definitions of smart cities present in the literature include the use of technology to improve communication between companies, collectives, institutions, and individuals; for environmental solutions like waste management and energy production; to improve access to services health, educational services, transport, expanding the operational functioning of the network, as well as to increase efficiency in the way services are provided and controlled [15].

Cities face such complex challenges that the call for innovation in all aspects of policymaking and public service reflects this need to seek new solutions. These challenges demand a transformative change in the way society works, lives, and builds a new future, which, in turn, imposes a special burden on those who have the responsibility to govern such processes with an optimal use of available public resources [16].

Aiming to contribute to this transformation, the International Standardization Organization (ISO) is developing a new series of international standards designed to focus on a holistic and integrated approach to sustainable development and city resilience.

Since the ISO international technical standards are adopted by several countries, the Brazilian Association of Technical Standards (ABNT) created a Technical Committee on Sustainable Development in Communities ABNT/CEE 268, mirror of the Technical Committee TC 268 that is responsible for improving the existing standards and developing new ones if requested, reflecting a global focus on indicators in harmony with the Sustainable Development Goals and the legislation in force in Brazil.

Cities need indicators to measure their performance management of urban services and quality of life over time and also share good practices between them [17]. According to the Technical Standard of ABNT NBR ISO 37122 (International Organization Association, 2019), a smart city is one that increases the pace at which it provides social, economic, and environmental sustainability outcomes.

Figure 1: Fundamental smart city themes

Smart cities respond to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how they engage society, apply collaborative leadership methods, work across disciplines and city

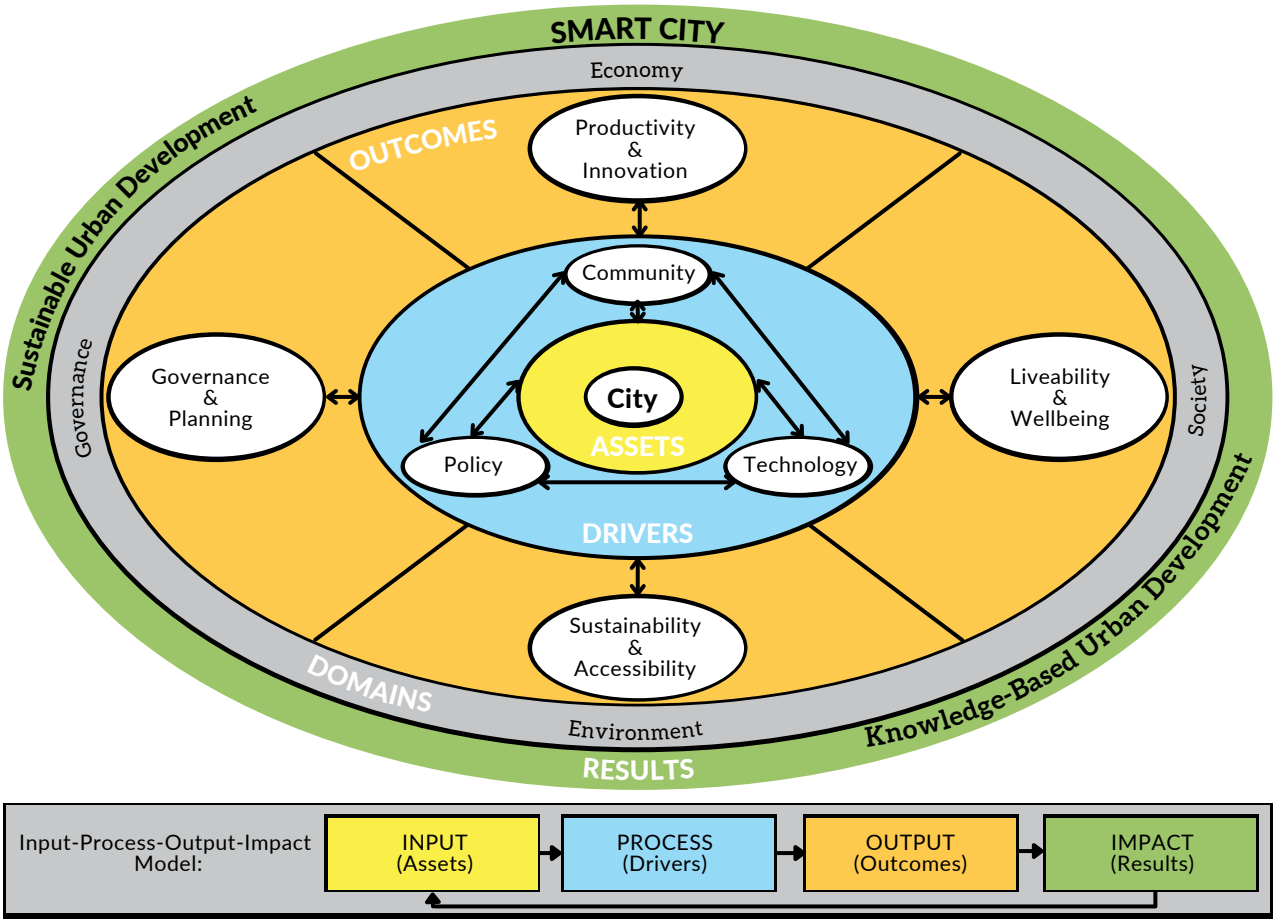
systems, and use data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment.

There is also an important document entitled "Brazilian Charter for Smart Cities", which presents its own definition of Smart Cities, as follows: cities committed to sustainable urban development and digital transformation, in their economic, environmental, and sociocultural aspects, which act in a planned manner, innovative, inclusive and networking. They also promote digital literacy, collaborative governance and management, and the use technologies to solve concrete problems, create opportunities, offer services efficiently, reduce inequalities, and improve the quality of life of all people, ensuring the safe and responsible use of data and ICTs [18].

We have adopted a conceptual smart city framework, which bases itself on an input-process-output-impact model that is a widely used model in urban and regional planning (Figure 2). This framework was used in the report "Smart Cities Down Under: Performance of Australian Local Government Areas" and it advocates the importance of a smart city as an organic whole of a network that may benefit from technologies and innovation, but do not depend exclusively on them [19].

We highlight that these definitions bring this discussion closer to the Right to the (Smart) City and encompass an alignment of the perspective of smart cities with the development of the city's social functions in the search for a convergence between them, reinforcing the understanding that technology must be used to achieve more human development and guarantee that no one is left behind.

Figure 2: Smart cities conceptual framework



3. METHODOLOGY

MEASURING SMART CITIES

This research adopted the 'Smart City Assessment Model' that builds a metric system based on the conceptual smart cities' framework. The model is a quantitative performance analysis model, or more correctly an index, that evaluates the smart city achievements of cities and urban regions based on a large multivariable indicator base. It embraces the conceptual perspective presented in Figure 2. One of the distinctive characteristics of this index is that it is specifically tailored for each case study context based on local circumstances, comparison and benchmark characteristics. It provides a flexible weighting opportunity for the sensitivity analysis of the results and additional statistical procedures for better interpretation of the results and findings. The steps of the methodology are presented in Box 1. This methodology was adopted in 2020 to analyze cities in Australia and proved to be valid for evaluating the performance of smart cities in relation to the proposed set of indicators [20].

Considering the theory of knowledge-based development and its focus on smart cities, with an approach centered on the citizen, bibliographical research was conducted about the theme as well as a documental analysis about the context of Latin-American cities aiming towards an adaptation of the selection of indicators. The analysis of the information and the choice of the indicators was made by a group of Brazilian and Australian researchers, in order that the final selection reached the idiosyncrasies while remaining within the project's focus.

As a result, the Smart City model that was originally used in the context of Australia is now adapted to a Latin-American Smart City model, with a selection of indicators befitting with the reality that enables the creation of reliable and authentic portraits of the cities. Considering Brazil's singularities and the country's challenges, the chosen methodology includes a dimension of technologies and new indicators in the existing dimension, such as: slum areas, sanitation and education.

Box 1: Methodology steps

Methodology steps

1. Adapting an indexing framework for smart city assessment
2. Determining indicators of the framework
3. Determining the weightings of the indicators
4. Collecting data via primary and secondary data collection techniques
5. Using statistical techniques to scale and normalise data for comparison
6. Conducting statistical and descriptive analyses of the findings

Table 1: Index structure and indicator descriptions used in the studies

Composite Indicator	Indicator Category	Indicator Area	Indicator	Australia	Brazil
Smart City	Economy	Productivity & Innovation	Economic Productivity	Median income in $	Gross domestic product (GDP) per capita at current prices
			Labour Force Participation	% in labour force population (15-85+)	% of formal workers in working population
			Talent pool	% of labour forces as knowledge workers (i.e., professionals & managers)	% of labour force with university education
			Innovation Industries	% of industries categorised as knowledge intensive	% of companies categorised as knowledge-intensive
			Income		Average monthly salary of formal workers
	Society	Liveability & Wellbeing	Health Status	% of taxable population with private health insurance	% of the population covered by a heath insurance according to data from National Health Agency
			Education		Basic education development Index (IDEB) score
			Safety and Security	Offence per 100,000 people	Deaths from external causes (i.e., accidents, violence) per 100,000 people
			Housing Affordability	% of households that pay less than 30% of household income as rent	% of households in irregular settlements
			Socioeconomic Progress	% of individuals categorised as low income	% of individuals categorised as low income
	Environment	Sustainability & Accessibility	Sustainable Commuting	% of workforces using public transport for commuting	Bus fleet per 100.000 people
			Sustainable Vehicles	% of private vehicles categorised as electric or hybrid	% of vehicles categorised as electric or hybrid
			Sustainable Energy	Household solar power and hot water installed per 100,000 people	Installed power of solar radiation per 100.000 people
			Sustainable Buildings	National Australian Built Environment Rating System (NABERS) rating of 4+ per 100,000 people	Buildings with sustainability certifications per 100.000 people
			Sanitation		Basic sanitation index (i.e., water, sewage, solid waste) score
	Governance	Governance & Planning	Smart policy	No official smart city policy=0, Official smart city policy in discussion= 1, Official smart city policy in place=2	Existence of municipal smart city or urban innovation policy
			Sustainable policy		Existence of municipal sustainable development policy
			Participation	Urban sprawl index value	Urban civil associations per 100.000 people
			Research support		Research and development (R&D) funding (FINEP)
			University		International ranking of the most prestigious university (QS World University Rankings 2022)
	Technology	Connectivity & Innovation	Broadband Internet	% of area covered by the National Broadband Network (NBN)	Broadband internet coverage
			Public Wi-Fi	Free Wi-Fi spots per 100,000 people	Free Wi-Fi spots per 100.000 people
			Innovation		Patents registered per 100.000 people
			Research capacity		Research grants per 100.000 people (PQ-CNPq)
			Media		Local digital press media per 100,000 people

The indicators are selected from the prominent smart city literature on the basis of the following key principles: measurability; analytical soundness; comparability; geographic coverage; data availability, and; relevance and suitability. The rationale behind the selection of these indicators are listed in Table 1, and supported with relevant references listed in Table 2. The model, as its default, uses an equal weighting for its indicators.

In this report, all 25 indicators in Table 1 were equally weighted at 0.04 (25 of them adding to 1). Alternate weighting assignment is also possible within the model. Table 1 illustrates the model structure and indicator descriptions.

The last column of Table 2 includes studies that used or advocated using the same or similar smart city indicators and concepts to those used by this study. In addition to this, we further elaborate on the section of some of the indicators. Regarding the indicators shown in Table 1, the following section outlines additional information on the indicators used in this study on Brazilian Capital Cities. Based on the Smart Cities Assessment Model, a dimension related to technology was included in this study, focusing on Connectivity and Innovation.The indicators adopted were related to: Broadband internet coverage; Free Wi-Fi spots per 100,000 people; Patents registered per 100,000 people; Research grants per 100,000 people (PQ-CNPq); Local digital press media per 100,000 people.

In measuring the housing affordability, % of residences in subnormal agglomerations on total residences has been applied. These houses are characterized by an irregular urban pattern and lack of basic sanitation. This favela is an indicator of urban chaos, which has existed for decades, due to social, economic, territorial, environmental and political inequalities which are the result of the way in which Brazilian cities are produced and characterize the local idiosyncrasies which remain a key challenge for smart city transformation.

Regarding the table of indicators adopted in the preliminary study of Australian cities, the set of indicators adopted for the analysis of Brazilian Capital Cities can be seen in Table 1.

Following the same procedure carried out in 2020c, once the raw indicator values have been attained, the 'Smart City Assessment Model' normalises the values so they can be used in the index. This procedure has already been adopted in studies on Knowledge Cities in Brazil converting raw indicator values to a standard scale (ranges between 0 and 1). The index uses the 'min-max normalisation' technique to reflect the specific distribution of the indicator values and presents a relative scale according to the best and worst performers. The min-max normalisation of indicator values is calculated in accordance with the following formula:

$$I\,new = \frac{I\,raw \;-\; I\,min}{I\,max \;-\; I\,min}$$

It corresponds to the indicator value; new, raw, min and max subscripts denote standardised (transformed), original, minimum and maximum scores of each indicator, respectively.

After all subject cities are ranked by their composite indicator scores, three performance categories (or clusters) are formed through a quantile method—i.e., by dividing the frequency distribution into three equal groups. These three performance categories/clusters are labelled as:

(a) Leading, including the best performing cities;
(b) Following, including the cities with achievements and potential, but not as high as the best performing cities, and;
(c) Developing, including the cities with some progress and potential, but not as substantial as in the other two category cities.

Table 2: Indicator descriptions and references used in the Brazilian study

Indicator Area	Indicator	Description	Unit of measurement	Rationale / Reference
Productivity & Innovation	Economic Productivity	Gross domestic product (GDP) per capita at current prices	R$ / inhabitant	To make smart cities more effective to higher economic development, macroeconomic factors must be linked with regular urban policies [21].
	Labour Force Participation	% of formal workers in working population	%	Smart cities provide increased employment opportunities in knowledge and service sectors [22].
	Talent pool	% of labour force with university education	%	Highly-educated workers are the backbone of smart cities in stimulating economic growth and vibrancy [23].
	Innovation Industries	% of companies categorised as knowledge-intensive	%	Innovation industries form the economic core of smart cities [24].
	Income	Average monthly salary of formal workers	R$	Smart cities are claimed to be prosperous locations generating wealth and disposable household income [25].
Liveability & Wellbeing	Health Status	% of the population covered by a heath insurance according to data from National Health Agency	%	Smart cities develop and implement policies to increase health conditions of their residents [26].
	Education	Basic education development Index (IDEB) score	Index	For Smart Cities the need for educating all citizens is the bacis element of development [27].
	Safety and Security	Deaths from external causes (i.e., accidents, violence) per 100,000 people	Deaths / 1.000 people	Digital security, health security, and infrastructure and personal safety are integral elements of smart cities [28].
	Housing Affordability	% of households in irregular settlements	Average %	Housing affordability is a critical element facilitating the varied skill-sets that support sustainable innovation economy of smart cities [29].
	Socioeconomic Progress	% of individuals categorised as low income	%	Smart economy of smart cities should be socially inclusive to address the urban inequity issue [30].
Sustainability & Accessibility	Sustainable Commuting	Bus fleet per 100.000 people	Buses / 100.000 people	Smart cities aim to develop innovative services for sustainable transport and mobility [31].
	Sustainable Vehicles	% of vehicles categorised as electric or hybrid	%	Mobility strategies of smart cities promote cleaner mobility options [32].
	Sustainable Energy	Installed power of solar radiation per 100.000 people	kW / 100.000 people	In realising the energy supply of a smart city, it is essential to maximise the use of renewable energy sources [33].
	Sustainable Buildings	Buildings with sustainability certifications per 100.000 people	Buildings / 100.000 people	Smart cities contain buildings that are designed, built, and utilised to consume less energy, and facilitate efficient building operation [34].
	Sanitation	Basic sanitation index (i.e., water, sewage, solid waste) score	Index	Smart Cities need to find a creative, innovative, and useful way to expand infrastructure (water & sanitation, energy, transportation, housing, information, and communications) [35].
Governance & Planning	Smart policy	Existence of municipal smart city or urban innovation policy	No official smart city policy=0, Official smart city policy in discussion= 1, Official smart city policy in place=2	A smart city policy is necessary to establish a shared democratic approach to engage leaderships from local institutions and to prioritise local issues [36].
	Sustainable policy	Existence of municipal sustainable development policy	No official sustainable development policy=0, Official sustainable development policy in discussion= 1, Official sustainable development policy in place=2	a smart city affects sustainable planning through changes in urban infrastructure (energy, land-use, water, sanitation & waste management and transportation) and the structure of urban governance [37].
	Participation	Urban civil associations per 100.000 people	Civil associations / 100.000 people	A smart city listens and gives voice to everyone [38].
	Research support	Research and development (R&D) funding (FINEP)	R$ / inhabitant	Public R&D is important because it can create advances in the underlying technologies of smart cities that all smart city stakeholders can benefit from [39].
	University	International ranking of the most prestigious university (QS World University Rankings 2022)	Universities	The universities have a diverse influence on the development of the society. Today this also includes countless smart city and community initiatives all over the world [40].
Connectivity & Innovation	Broadband Internet	Broadband internet coverage	Accesses / 100 Households	World-class broadband provides opportunities for inclusion in the innovation economy that is the core economic activity of smart cities [41].
	Public Wi-Fi	Free Wi-Fi spots per 100.000 people	Free Wi-Fi spots per 100,000 people	Smart cities offer public Wi-Fi networks to increase the connectivity and access to smart services [42].
	Innovation	Patents registered per 100.000 people	Patents / 100.000 people	Policy makers need efficient and effective tools to measure and monitor the innovation related performance so that they develop new measures, policies, and evaluate current approaches [43].
	Research capacity	Research grants per 100.000 people (PQ-CNPq)	Reseach grants / 100.000 people	universities act as knowledge intermediaries, knowledge gatekeepers, knowledge providers, and knowledge evaluators for smart cities [44].
	Media	Local digital press media per 100,000 people	Media / 100.000 people	a smart city listens and gives voice to everyone [45].

4. CONTEXT

BRAZILIAN CAPITAL CITIES

Brazil is a federation of three levels, encompassing the Union at the national level, the states at the regional or state level, and the municipalities at the local level. There are 26 states and 5,570 municipalities in Brazil. The Federal District, where Brasília—the country's national capital—is located, accumulates both state and municipal competences. The 26 cities that host the states' political and administrative centres are designated "state capitals". The 26 state capitals—which are the object of this report, alongside the national capital, Brasília—are regional centralities of political, institutional, and economic importance, but they have the same legal status and competences as any Municipality in Brazil.

According to the 1988 Brazilian Constitution [46], urban planning is essentially a local, or municipal, issue. As such, municipalities have exclusive powers to approve their own Master Plans, following the guidelines set by the National Statute of the City. The Constitution also grants municipalities the powers to provide access to culture, education, science, technology, research, and innovation at the local level.

The National Statute of the City, approved by a national law edited in 2001 [47], only refers to technology as applied to civil construction, by recommending the use of sustainable technologic solutions to reduce environmental impacts in the city. In contrast, the National Science, Technology, and Innovation Code, edited in 2016 [48], foresees the creation, implementation, and consolidation of innovation promoting environments such as technology parks, centres and incubators by municipalities, as a means to foster technological development, competitiveness and interaction between the private sector and scientific, technologic and innovation institutions at the local level.

Many municipalities have approved local regulations on innovation and technology encompassing not only incentives and fiscal grants but also the application of new technologies in urban planning, disasters management, resource management, mobility, climate change adaptation, and so on. Numerous smart cities projects and initiatives have been developed by large and medium-sized cities in the country, to attract investors and enhance urban quality of life.

In this sense, it is noteworthy to mention the Connected Smart Cities (CSC) Ranking, an annual report, published by the private consultancy Urban Systems, that ranks Brazilian cities according to 70 indicators, distributed in 11 sectors: mobility, environment, urbanism, innovation and technology, health, public safety, education, entrepreneurship, energy, governance, and economy. Currently in its 7th edition [49], the CSC Ranking has consolidated its position as a national reference on smart city development in the public, private and third sectors.

In 2018, the Federal Decree n. 9612 [50] determined the creation of a Smart Cities Program within the Ministry of Science, Technology, and Innovation (MCTI), to be developed in coordination with the National IoT Plan and the National Cities 4.0 Chamber, in substitution to the former Digital Cities Program. A cooperation agreement was established between MCTI and the Ministry of Regional Development, to set up a national strategy on sustainable and smart cities. In 2020, this national strategy was published under the form of a Brazilian Charter for Smart Cities [51], a political document which provides a public agenda for the digital transformation of Brazilian cities, based on eight strategic

objectives and policy recommendations.

However, data pertaining to internet connectivity in Brazil for the year of 2019 shows a huge sociotechnical gap that needs to be bridged [52]. Around 17.3% of the country's households, an estimated 12.6 million, are not connected to the internet. Lack of interest in connectivity (32.9%), digital illiteracy (25.7%) and high prices for services and equipment (25.7% and 5%) were the main reasons appointed by these households for their lack of internet connectivity. Only 6.8% of the households reported service unavailability as the main reason for their lack of connectivity. Regional disparities are also an important factor: the country's North and Northeast regions presented the highest percentages of households without internet access (24% and 25.7%).

Coherently to the country's huge socio-economic inequities and regional disparities, the Brazilian Charter for Smart Cities is strongly positioned in favour of promoting equality and social inclusion through the digital transformation of Brazilian cities, as it points out the characteristics of the smart cities it aims to implement: diverse and just, alive and for people, connected and innovative, inclusive and welcoming, safe, resilient and self-regenerative, economically fertile, environmentally responsible, articulating different notions of time and space, aware, independent in the use of technologies, attentive and responsible with its principles. Hopefully, these same goals will be incorporated in the National Policy for Smart Cities, currently under discussion in the Brazilian Parliament (Bill n. 976/2021) [53].

São Paulo City - São Paulo

The Brazilian Charter for Smart Cities aims to position Brazilian cities to succeed in the global knowledge and innovation economy by stimulating the role of smart solutions and advanced tecnhnologies in building cities. It aims to provide guidelines and principles to future policy programs and plans.

Brazilian Charter for Smart Cities, Ministry of Regional Development, 2021.

Botanical Garden - Curitiba

5. RESULTS

COMPARATIVE PERFORMANCE OF BRAZILIAN CAPITAL CITIES

5.1. LOCATIONAL PERFORMANCE VARIANCES

A three-cluster solution was developed by examining results of comparative performance of Brazilian Capital Cities (BCCs) smart city performance analysis. Table 3 places 27 BCCs under one of the relevant three clusters—i.e., Leading, Following, and Developing—based on their performed achievements as of 2020-2021 datasets used. Smart and sustainable city policy was based on a search of the relevant Council websites completed 31 October 2021. Furthermore, for each region a separate map is prepared to visualize the locations and performance categories of the investigated BCCs (Figure 2).

As it is shown in Table 3 all Leading BCCs are predominantly in the southern area. Two of the nine cities are in the central area. The best performing BCCs in Brazil are metropolitan cities with higher population densities. Therefore, BCCs located in the north and northeast areas showcase lower performances—concerning the 'Smart City Assessment Model' indicators (Table 2). Other key factors explaining the high performance in these BCCs include:

- Employment opportunities and income;
- Knowledge intensive companies and innovation results (patents);
- Basic education development;
- Health;
- Existence of municipal sustainable development policy.

Point bus - Curitiba

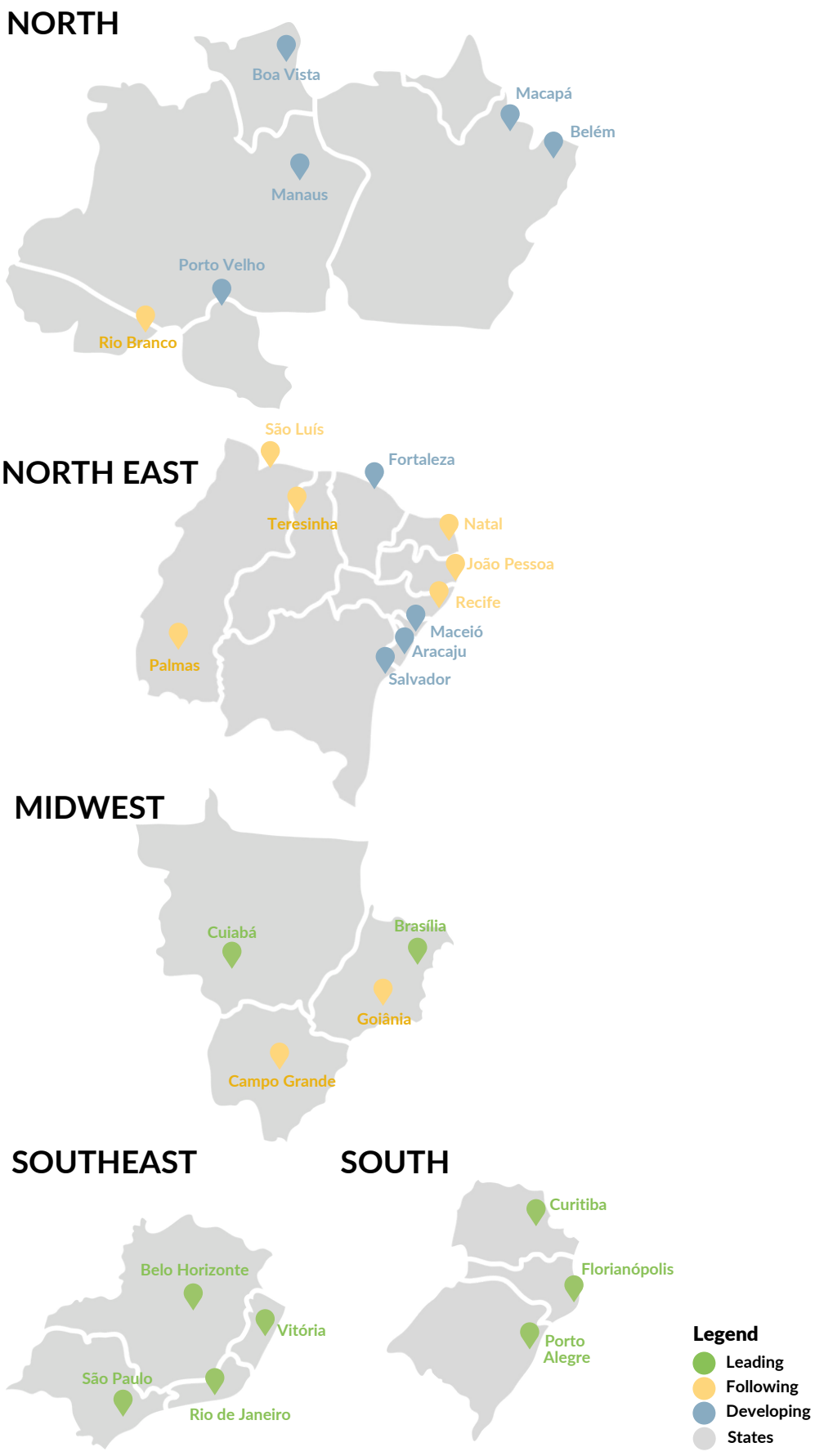
Table 3: Smart City performance clusters of BCCs

Name	State	Region	Population	Score	Cluster
Florianópolis	Santa Catarina (SC)	South	508826	0,72	Leading
São Paulo	São Paulo (SP)	Southeast	12325232	0,60	Leading
Vitória	Espírito Santo (ES)	Southeast	365855	0,59	Leading
Curitiba	Paraná (PR)	South	1948626	0,58	Leading
Porto Alegre	Rio Grande do Sul (RS)	South	1488252	0,56	Leading
Brasília	Distrito Federal (DF)	Midwest	3055149	0,51	Leading
Belo Horizonte	Minas Gerais (MG)	Southeast	2521564	0,47	Leading
Rio de Janeiro	Rio de Janeiro (RJ)	Southeast	6747815	0,46	Leading
Cuiabá	Mato Grosso (MT)	Midwest	618124	0,45	Leading

Name	State	Region	Population	Score	Cluster
Palmas	Tocantins (TO)	North	306296	0,44	Following
Goiânia	Goiás (GO)	Midwest	1536097	0,41	Following
Campo Grande	Mato Grosso do Sul (MS)	Midwest	906092	0,38	Following
João Pessoa	Paraíba (PB)	North East	817511	0,34	Following
Recife	Pernambuco (PE)	North East	1653461	0,31	Following
São Luís	Maranhão (MA)	North East	1108975	0,31	Following
Natal	Rio Grande do Norte (RN)	North East	890480	0,31	Following
Teresina	Piauí (PI)	North East	868075	0,30	Following
Rio Branco	Acre (AC)	North	413418	0,28	Following

Name	State	Region	Population	Score	Cluster
Fortaleza	Ceará (CE)	North East	2686612	0,27	Developing
Aracaju	Sergipe (SE)	North East	664908	0,26	Developing
Macapá	Amapá (AP)	North	512902	0,24	Developing
Boa Vista	Roraima (RR)	North	419652	0,24	Developing
Porto Velho	Rondônia (RO)	North	539354	0,23	Developing
Salvador	Bahia (BA)	North East	2886698	0,22	Developing
Belém	Pará (PA)	North	1499641	0,22	Developing
Maceió	Alagoas (AL)	North East	1025360	0,21	Developing
Manaus	Amazonas (AM)	North	2219580	0,18	Developing

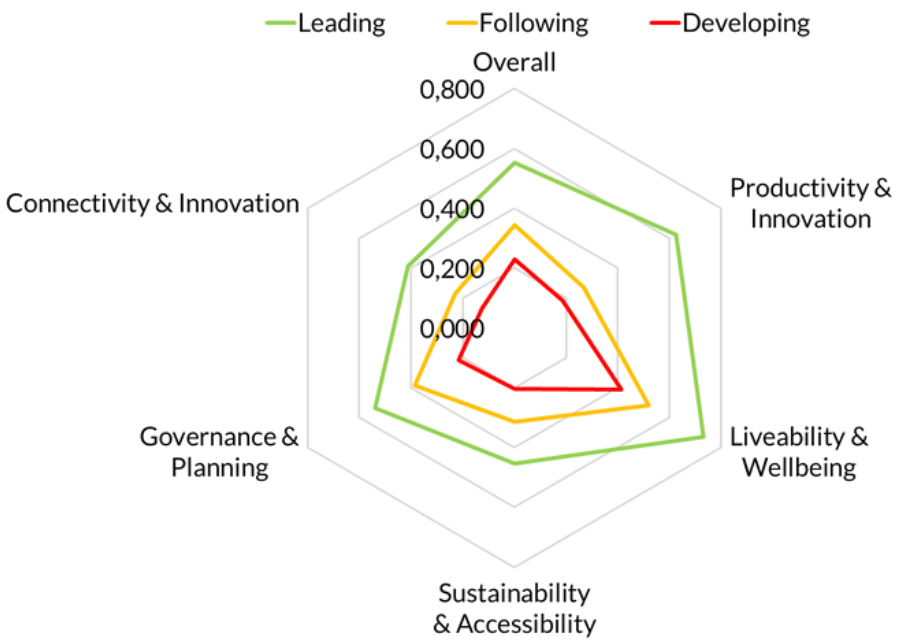
Figure 2: Locations and performance categories

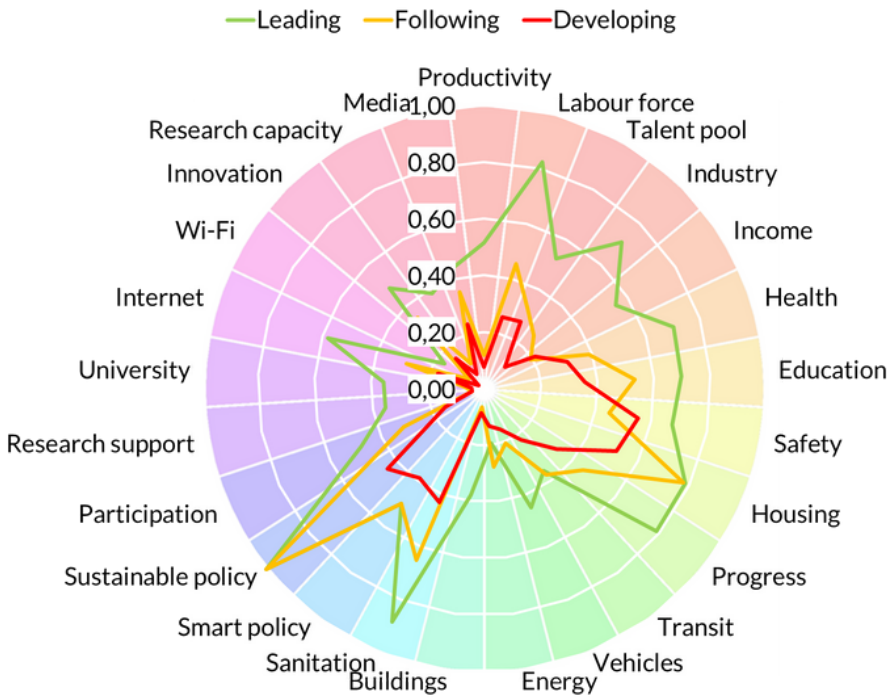


5.2. OVERALL FINDINGS

The smart city performance levels (cluster averages) of the three clusters are illustrated in Figure 3 - against the five indicator areas and overall performance (at the top), and 25 indicators (at the bottom).

Figure 3: Overview of BCC smart city performances





Overall findings suggest a relatively stronger performance of Leading BCCs in Livability & Wellbeing (particularly in progress and housing) areas and Productivity & Innovation (particularly in labor force and knowledge intensive companies) areas. The analysis points out a general weakness in Connectivity & Innovation (particularly in research capacity and free wi-fi spots) and Sustainability & Accessibility (particularly in sustainable energy and sustainable commuting/transit) areas across all the investigated BCCs. The study highlights a stronger high contrast in Productivity & Innovation (particularly in Industry— existence of knowledge intensive companies and economic productivity - GDP per capita) between Leading BCCs and the following and developing BCCs as these two clusters are closer in the performance of indicators in this area.

There are two key findings that need further elaboration. The first one concerns the increase in the number of favelas in Brazil. The number of favelas in Brazil has doubled in the last decade, according to IBGE data. Between 2010 and 2019, the number of subnormal agglomerations, such as slums and stilts, went from 6,329 in 323 municipalities to 13,151 in 743 cities. These houses are characterized by an irregular urban pattern and lack of basic sanitation. The favela presence is an indicator of urban disruption, which has existed for decades, due to social, economic, territorial, environmental, and political inequalities. These inequalities are the result of the way in which Brazilian cities are produced and characterize the local idiosyncrasies which remain a key challenge for smart city transformation.

The second issue relates to Connectivity & Innovation scores. This indicator area was included in the Smart City assessment model for the study carried out in the BCCs due to the specific context of LatinAmerican cities pointed out by Marchetti et al. (2019). The study found that this was the area with the lowest scores in all clusters (normalized values for Leading = 0.411, Following = 0.230, developing = 0.703).

5.3. LEADING VS FOLLOWING

Leading BCCs (normalized index score of 0.551), in general, have a statistically significant higher performance compared to the Following BCCs (normalized index score of 0.343). In agreement with that, Figure 3 illustrates that the performance levels of Following BCCs are significantly lower in all categories (Productivity & Innovation, Livability & Wellbeing, Sustainability & Accessibility, Governance & Planning and Connectivity & Innovation) compared to the Leading BCCs.

Nevertheless, the Following BCCs are not necessarily performing poorly in all of the indicators compared to the Leading BCCs. For instance, Following BCCs average cluster performance is higher in sustainable energy (normalized score of 0.227 against the Leading BCCs 0.193) and sustainable commuting (0.374 vs 0.357) indicators compared to the best performing BCCs. This difference partly reflects the low incentives for the use of renewable energy and the deficiencies in public transportation that still exist in the best performing BCCs (Leading).

It is important to note that in the case of similar performances of two BCCs, the combined effect of relatively weaker performance, in one or more areas, could place one of the BCCs in the Following cluster (e.g., at the top of the Following cluster), where the other one could be located in the Leading cluster (e.g., at the bottom of the Leading cluster). For instance, Cuiabá (MT) was categorized as Leading and Palmas (TO) as Following despite having a similar indexed score with almost negligible performance differences. Hence, the findings of this study should not be taken as an ultimate success or failure in the smart city transformation journey, rather it should be considered as a guide to highlight the higher, average and lower achievements across the 25 indicators of the 'Smart City Assessment Model' index. This approach will assist the BCCs identify strategies and opportunities to address the weaknesses and sustain the strengths.

5.4. FOLLOWING VS DEVELOPING

Following BCCs (normalized index score of 0.343), in general, have a statistically significant higher performance compared to Developing BCCs (normalized index score of 0.229). Nonetheless, the BCCs that are identified and located in the Developing cluster do not necessarily perform poorly in all categories compared to those in the Following cluster. As Figure 3 demonstrates, performances of Developing BCCs are relatively closer to Following BCCs in four categories (Productivity & Innovation, Livability & Wellbeing, Sustainability & Accessibility, and Connectivity & Innovation). The gap between Following and Developing BCCs clusters are a bit wider in Governance & Planning area—as this is the weakest performance area for Developing BCCs. One of the possible reasons for the lag behind in Governance & Planning could be the low investment in science and technology, which is also reflected in the weak international recognition for universities from the north and northeast regions of the country. Developing a smart city strategy could help BCCs engage their communities to priorities and plan smart city initiatives in line with local needs (weaknesses) and assets (strengths). There are three individual indicators that Developing BCCs marginally outperform the BCCs in the Following cluster.

These are socioeconomic progress, safety and security and sustainable buildings. This is due to the fact that two cities in the developing cluster, Salvador and Fortaleza, perform better than all the following BCCs in the sustainable building indicator. In addition, in the socioeconomic progress, safety and security areas, the city of Recife (Following cluster) has a relatively low performance in the indicators of violent deaths and in the basic education indexes in relation to Developing BCCs. And finally, all the Following BCCs are below the average of the GDP per capita indicator, while in the Developing Cluster there is one city, Manaus, which is above the average in this indicator.

National Congress - Brasília

6. CONCLUSION

TOWARDS SMARTER CITIES

Buying on the smart city's premises, today, many cities around the globe are developing smart city agendas [54]. Nevertheless, there is a big gap between theory and practice. What smart cities are claimed to be is quite different from what they actually are in reality [55]. Hence, it is imperative to undertake empirical studies to understand what makes a city smart city, and what are the existing performance and hidden potentials of a locality to transform itself into a smarter one. In order to address these important questions, this report adopted a smart city conceptual model and its metrics, previously applied to Australian city context, [56] to evaluate smart city performances of Brazilian cities.

This report entitled 'Smart Cities of Brazil: Performance of Brazilian Capital Cities' explored the smart city performance and potentials of 27 Brazilian Capital Cities. The clustering of the investigated cities under the Leading, Following and Developing smart cities categories reveled the following insights into smart city transformation readiness of Brazilian cities. First, the Leading cluster is mainly made of Southern and Southeastern Brazilian Capital Cities, where some Midwest capital cities have made their way into the Leading cluster. The other Midwest capital cities are in the Following cluster. North and Northeastern capital cities are scattered through the Following and Developing clusters. This clearly points out to a regional divide in Brazil. Cities of South and Southeast of the country leads the smart city development agenda, where Midwest is catching up and North and Northeast far behind.

Second, across in all investigated cities the highest category of performance was Livability & Wellbeing. This is the indication of unique Brazilian culture, nature and lifestyle that shapes the social sphere of the Brazilian smart cities as a critical asset. Studies [57-59] also highlighted sociocultural assets of Brazilian cities as a core strength of vibrancy in the city.

Third, in all clusters the weakest performance was in the Sustainability & Accessibility areas. This is a major challenge for achieving truly smart city development in Brazil. As cities cannot fully achieve their smartness goals without becoming sustainable. In other words, Brazilian cities need to seek ways to develop a sustainable urbanism approach to transform their cities into and create new ones that are truly smart and sustainable.

Last but not least, the analysis shed light on the Governance & Planning and Connectivity & Innovation issues and challenges of the investigated Brazilian cities. In terms of Connectivity & Innovation, only a limited number of Brazilian cities managed to build a functional innovation ecosystem, such as Florianopolis and Sao Paulo [60,61]. There exists a major socioeconomic disparity between the cities have a sound innovation ecosystem and the others that have not. Additionally, while a strong creativity potential exists in Brazil, the cities seem to be not tapping into the creative industry opportunities as the other country cities do [62]. In terms of Governance & Planning, the main issue is the lack of, or limited, good and effective governance. This problem is not only unique to Brazil, but widely common across all developing nations.

In conclusion, we echo Betz et al.'s [63] following considerations for Brazilian cities: (a) Smart cities which focus only on technology seldom work; (b) Local governments should adopt the role of facilitator; (c) Risks need to be shared with the private sector; (d) Local governments should be open to new innovations and learn from mistakes; (e) Smart cities should focus on inclusivity; (f) Consumption of resources must be considered—particularly regarding the longevity of technological infrastructure; (g) Long-term sustainability is dependent on renewable resources, and; (h) Smart cities require a smart community that is knowledgeable, conscious, forward-thinking, engaged, united and active.

We also note that, this report has been prepared to assist public organizations, including the Brazilian Local, State and Federal Governments, in designing and improving smart city policies for their localities and communities. It is a quantitative analysis based on indices developed by Brazilian and Australian researchers and academics with expertise in this area. However, it does not factor in various local contextual and unique characteristics that play an important role in assessing the progress of the localities and their communities. Therefore, this report should not be relied on by itself or be used to rank or compare performances of cities, but instead be used in conjunction with other relevant sources of information and assessments. This report does not necessarily reflect the official policy or position of Brazilian government agencies.

Pelourinho - Salvador

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DATA SOURCE ACRONYMS

a. IBGE: Brazilian Institute of Geography and Statistics
b. CAGED: General Register of Employed and Unemployed
c. ANS: National Supplementary Health Agency
d. INEP: National Institute of Educational Studies and Research
e. DATASUS: IT department of the Unified Health System in Brazil
f. Portal Brasileiro de Dados Abertos: Brazilian Open Data Portal
g. SENATRAN: National Traffic Department
h. ANEEL: National Electric Energy Agency
i. Leed GBC Brasil: Leadership in Energy and Environmental Design – Brazilian Green Building Council
j. IPEA: Institute of Applied Economic Research
k. QS TOP UNIVERSITIES: Quacquarelli Symonds Top Universities
l. ANATEL: National Telecommunications Agency
m. Local Council Websites: BCC government websites
n. INPI: National Institute of Industrial Property
o. CNPq: National Council for Scientific and Technological Development
p. Atlas da Notícia: Independent website Atlas da Notícia

8. APPENDIX

Table A1: Indictator and data sources

Indicator Category	Indicator Area	Indicator	Data source and year	Data source link
Economy	Productivity & Innovation	Economic Productivity	IBGE CIDADES 2018	https://cidades.ibge.gov.br/
		Labour Force Participation	Novo CAGED 2020	https://app.powerbi.com/view?r=eyJrIjoiNWI5NWI0ODEtYmZiYy00Mjg3LTkzNWUtY2UyYjIwMDE1YWI2IiwidCI6IjNlYzkyOTY5LTVhNTEtNGYxOC04YWM5LWVmOThmYmFmYTk3OCJ9
		Talent pool	Novo CAGED 2020	https://app.powerbi.com/view?r=eyJrIjoiNWI5NWI0ODEtYmZiYy00Mjg3LTkzNWUtY2UyYjIwMDE1YWI2IiwidCI6IjNlYzkyOTY5LTVhNTEtNGYxOC04YWM5LWVmOThmYmFmYTk3OCJ9
		Innovation Industries	IBGE CONCLA 2021	https://concla.ibge.gov.br/
		Income	IBGE CIDADES 2019	https://cidades.ibge.gov.br/
Society	Liveability & Wellbeing	Health Status	ANS 2020	http://www.ans.gov.br/anstabnet/cgi-bin/tabnet?dados/tabnet_br.def
		Education	INEP 2019	http://ideb.inep.gov.br/resultado/resultado/resultado.seam?cid=11669178
		Safety and Security	DATASUS 2019	https://datasus.saude.gov.br/mortalidade-desde-1996-pela-cid-10
		Housing Affordability	IBGE 2019	https://www.ibge.gov.br/geociencias/organizacao-do-territorio/tipologias-do-territorio/15788-aglomerados-subnormais.html?=&t=o-que-e
		Socioeconomic Progress	Portal Brasileiro de Dados Abertos 2019	https://dados.gov.br/dataset/cadastro-unico-familias-pessoas-cadastradas-por-faixas-de-renda/resource/26fd54a8-a26a-412f-b22e-3a2dac63b83b
Environment	Sustainability & Accessibility	Sustainable Commuting	SENATRAN 2021	http://dados.infraestrutura.gov.br/pt_PT/dataset/frota-de-veiculos
		Sustainable Vehicles	SENATRAN 2021	http://dados.infraestrutura.gov.br/pt_PT/dataset/frota-de-veiculos
		Sustainable Energy	ANEEL 2021	https://app.powerbi.com/view?r=eyJrIjoiZjM4NjM0OWYtN2IwZS00YjViLTllMjItN2E5MzBkN2ZlMzVkIiwidCI6IjQwZDZmOWI4LWVjYTctNDZhMi05MmQ0LWVhNGU5YzAxNzBlMSIsImMiOjR9
		Sustainable Buildings	Leed GBC Brasil 2021	https://www.gbcbrasil.org.br/certificacao/certificacao-leed/#:~:text=O%20LEED%20(Leadership%20in%20Energy,e%20a%20manuten%C3%A7%C3%A3o%20do%20mesmo.
		Sanitation	IBGE PNSB 2017	https://www.ibge.gov.br/estatisticas/multidominio/meio-ambiente/9073-pesquisa-nacional-de-saneamento-basico.html?=&t=o-que-e
Governance	Governance & Planning	Smart policy	Local Council Websites 2021	Accessed Jun 2021 from 27 Local Council Websites. Search completed on 31 Jun 2021.
		Sustainable policy	Local Council Websites 2021	Accessed Jun 2021 from 27 Local Council Websites. Search completed on 31 Jun 2021.
		Participation	IPEA 2021	https://mapaosc.ipea.gov.br/
		Research support	INEP 2021	https://www.gov.br/inep/pt-br
		University	QS TOP UNIVERSITIES 2022	https://www.topuniversities.com/university-rankings/world-university-rankings/2022
Technology	Connectivity & Innovation	Broadband Internet	ANATEL 2021	https://dados.gov.br/dataset/densidade_banda_larga
		Public Wi-Fi	Local Council Websites 2021	Accessed Jun 2021 from 27 Local Council Websites. Search completed on 31 Jun 2021.
		Innovation	INPI 2021	https://www.gov.br/inpi/pt-br
		Research capacity	CNPq 2021	https://www.gov.br/cnpq/pt-br
		Media	Atlas da Notícia 2019	https://www.atlas.jor.br/plataforma/edicoes/atlas2/estatisticas/

Table A2: Normalised index scores of leading capital cities

Capital	Productivity	Labour force	Talent pool	Industry	Income	Health	Education	Safety	Housing	Progress	Transit	Vehicles	Energy	Buildings	Sanitation	Smart policy	Sustainable policy	Participation	Research support	University	Internet	Wi-Fi	Innovation	Research capacity	Media	Index Score
Florianópolis	0,334	0,960	1,000	0,816	0,692	0,557	0,857	0,848	0,901	1,000	0,420	0,686	0,105	0,322	0,779	0,500	1,000	1,000	1,000	0,200	1,000	0,168	0,966	1,000	0,813	0,717
São Paulo	0,582	0,884	0,415	0,831	0,538	0,762	1,000	1,000	0,788	0,757	0,395	0,425	0,000	1,000	0,967	0,500	1,000	0,299	0,414	1,000	0,548	0,050	0,330	0,265	0,338	0,603
Vitória	0,813	1,000	0,687	1,000	0,462	1,000	0,643	0,085	0,413	0,810	0,169	1,000	0,209	0,064	0,851	1,000	1,000	0,739	0,127	0,000	0,545	1,000	0,579	0,414	0,219	0,593
Curitiba	0,376	0,976	0,545	0,888	0,423	0,821	0,857	0,683	0,907	0,878	0,338	0,308	0,029	0,649	1,000	0,500	1,000	0,358	0,342	0,400	0,680	0,137	0,677	0,261	0,540	0,583
Porto Alegre	0,480	0,935	0,514	0,949	0,538	0,654	0,500	0,693	0,811	0,831	0,296	0,394	0,085	0,346	0,941	0,500	1,000	0,446	0,555	0,400	0,568	0,052	0,470	0,596	0,474	0,561
Brasília	1,000	0,574	0,560	0,549	1,000	0,441	0,571	0,867	0,904	0,523	0,450	0,459	0,161	0,284	0,911	0,500	1,000	0,506	0,173	0,200	0,413	0,018	0,203	0,193	0,330	0,512
Belo Horizonte	0,241	0,932	0,215	0,708	0,269	0,782	0,786	0,694	0,815	0,756	0,340	0,231	0,098	0,121	0,910	0,500	1,000	0,325	0,125	0,200	0,655	0,037	0,657	0,331	0,095	0,473
Rio de Janeiro	0,516	0,547	0,235	0,307	0,577	0,724	0,786	0,611	0,670	0,792	0,129	0,172	0,052	0,504	0,892	0,500	1,000	0,266	0,387	0,800	0,327	0,000	0,372	0,295	0,160	0,465
Cuiabá	0,277	0,621	0,548	0,332	0,462	0,589	0,286	0,608	0,847	0,747	0,676	0,377	1,000	0,114	0,713	0,000	1,000	0,371	0,060	0,000	0,482	0,022	0,138	0,089	1,000	0,454

Table A3: Normalised index scores of following capital cities

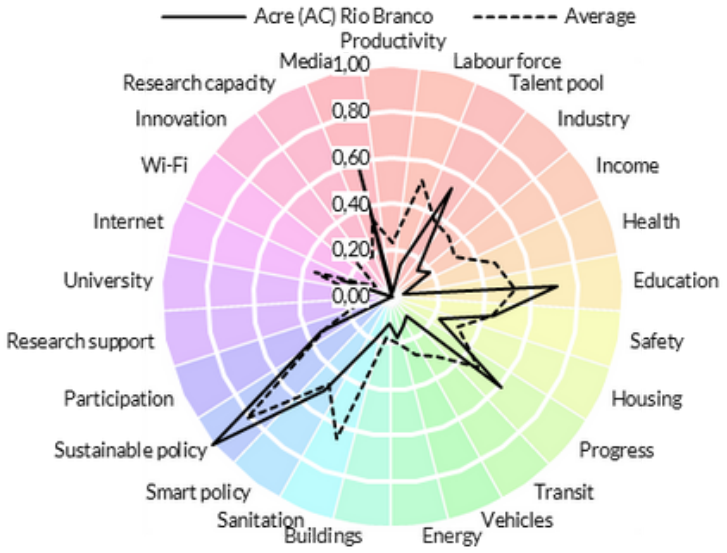
Capital	Productivity	Labour force	Talent pool	Industry	Income	Health	Education	Safety	Housing	Progress	Transit	Vehicles	Energy	Buildings	Sanitation	Smart policy	Sustainable policy	Participation	Research support	University	Internet	Wi-Fi	Innovation	Research capacity	Media	Index Score
Palmas	0,172	0,466	0,566	0,368	0,500	0,211	0,786	0,365	0,887	0,424	1,000	0,054	0,599	0,000	0,789	0,500	1,000	0,848	0,052	0,000	0,162	0,019	0,276	0,049	0,999	0,444
Goiânia	0,183	0,684	0,325	0,415	0,231	0,521	0,857	0,330	0,981	0,865	0,501	0,156	0,246	0,122	0,875	0,500	1,000	0,259	0,071	0,200	0,485	0,002	0,281	0,125	0,141	0,414
Campo Grande	0,182	0,415	0,258	0,110	0,308	0,393	0,714	0,760	1,000	0,773	0,179	0,184	0,349	0,078	0,887	0,500	1,000	0,398	0,011	0,000	0,350	0,080	0,224	0,089	0,326	0,383
João Pessoa	0,060	0,377	0,103	0,134	0,000	0,431	0,214	0,489	0,796	0,458	0,215	0,193	0,159	0,057	0,872	0,500	1,000	0,235	0,003	0,200	0,493	0,359	1,000	0,000	0,173	0,341
Recife	0,168	0,686	0,380	0,430	0,231	0,587	0,071	0,000	0,666	0,221	0,143	0,540	0,047	0,057	0,578	0,500	1,000	0,181	0,199	0,200	0,000	0,086	0,401	0,283	0,108	0,311
São Luís	0,147	0,458	0,250	0,212	0,154	0,331	0,571	0,547	0,427	0,203	0,431	0,276	0,147	0,021	0,535	0,500	1,000	0,302	0,018	0,000	0,276	0,002	0,326	0,053	0,539	0,309
Natal	0,092	0,458	0,186	0,231	0,115	0,532	0,286	0,573	0,786	0,451	0,250	0,160	0,224	0,079	0,600	0,500	1,000	0,056	0,024	0,000	0,387	0,010	0,395	0,221	0,103	0,309
Teresina	0,049	0,403	0,263	0,253	0,000	0,451	0,571	0,430	0,665	0,280	0,549	0,160	0,546	0,054	0,509	0,500	1,000	0,199	0,010	0,000	0,198	0,020	0,178	0,073	0,177	0,302
Rio Branco	0,017	0,146	0,535	0,157	0,192	0,048	0,714	0,556	0,774	0,388	0,100	0,131	0,174	0,113	0,195	0,500	1,000	0,341	0,003	0,000	0,234	0,013	0,000	0,014	0,609	0,278

Table A4: Normalised index scores of developing capital cities

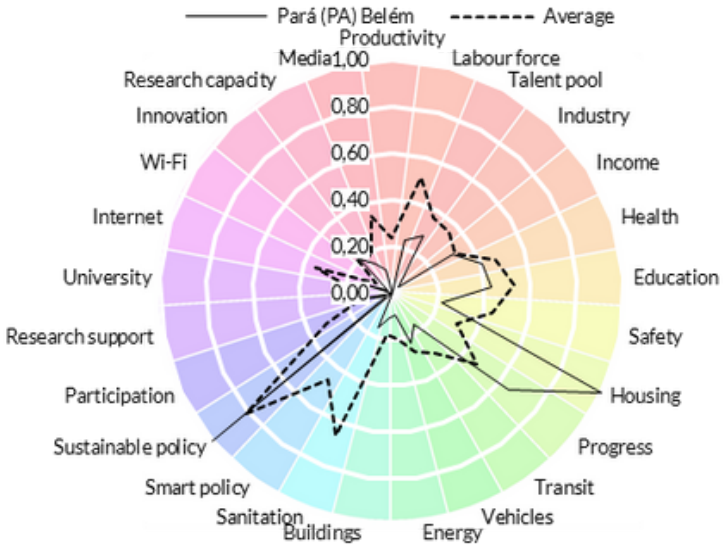
Capital	Productivity	Labour force	Talent pool	Industry	Income	Health	Education	Safety	Housing	Progress	Transit	Vehicles	Energy	Buildings	Sanitation	Smart policy	Sustainable policy	Participation	Research support	University	Internet	Wi-Fi	Innovation	Research capacity	Media	Index Score
Fortaleza	0,065	0,496	0,047	0,198	0,000	0,507	0,214	0,599	0,591	0,433	0,154	0,160	0,141	0,201	0,541	0,500	1,000	0,106	0,040	0,200	0,240	0,001	0,180	0,139	0,000	0,270
Aracaju	0,084	0,485	0,000	0,331	0,115	0,532	0,214	0,318	0,735	0,357	0,391	0,220	0,235	0,070	0,705	0,500	0,000	0,211	0,016	0,000	0,286	0,006	0,322	0,022	0,304	0,258
Macapá	0,015	0,000	0,980	0,015	0,500	0,060	0,714	0,533	0,580	0,000	0,000	0,073	0,113	0,000	0,044	0,500	1,000	0,251	0,000	0,000	0,219	0,104	0,077	0,009	0,239	0,241
Boa Vista	0,086	0,076	0,510	0,000	0,308	0,000	0,786	0,489	0,966	0,402	0,141	0,000	0,144	0,056	0,661	0,000	1,000	0,168	0,026	0,000	0,006	0,031	0,000	0,006	0,156	0,241
Porto Velho	0,168	0,178	0,127	0,074	0,269	0,168	0,500	0,569	0,776	0,513	0,384	0,051	0,201	0,087	0,000	0,000	0,000	0,441	0,020	0,000	0,285	0,027	0,022	0,006	0,782	0,226
Salvador	0,016	0,324	0,131	0,079	0,269	0,384	0,143	0,528	0,253	0,481	0,259	0,397	0,041	0,138	0,809	0,500	0,000	0,054	0,047	0,200	0,067	0,003	0,155	0,081	0,032	0,216
Belém	0,000	0,235	0,279	0,038	0,308	0,408	0,429	0,783	0,000	0,345	0,166	0,232	0,097	0,109	0,156	0,000	1,000	0,030	0,152	0,000	0,133	0,024	0,205	0,145	0,102	0,215
Maceió	0,015	0,304	0,261	0,054	0,000	0,384	0,000	0,590	0,706	0,237	0,117	0,142	0,124	0,023	0,563	1,000	0,000	0,114	0,028	0,000	0,022	0,010	0,294	0,077	0,229	0,212
Manaus	0,237	0,252	0,086	0,167	0,154	0,327	0,214	0,575	0,039	0,229	0,385	0,106	0,107	0,095	0,394	0,500	0,000	0,000	0,062	0,000	0,293	0,008	0,064	0,030	0,268	0,184

Figure A1: Performance diagrams of capital cities

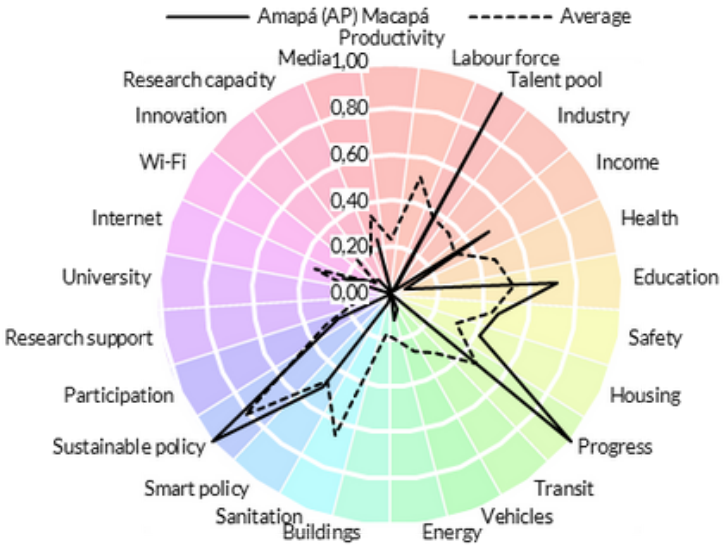
Rio Branco



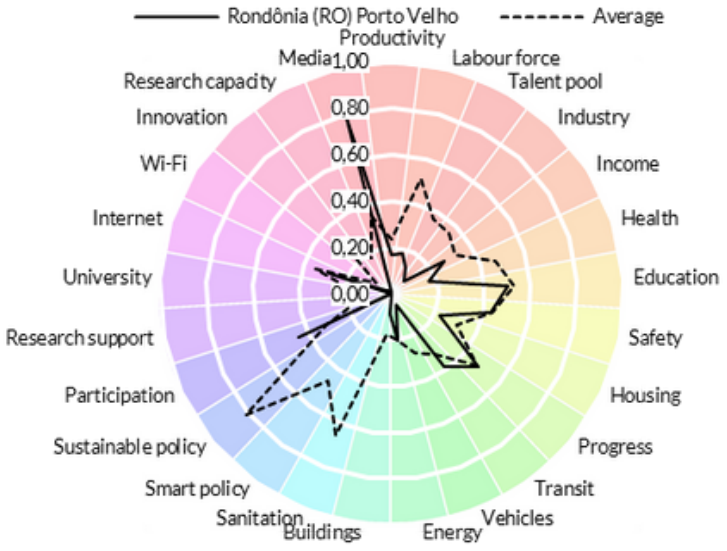
Belém



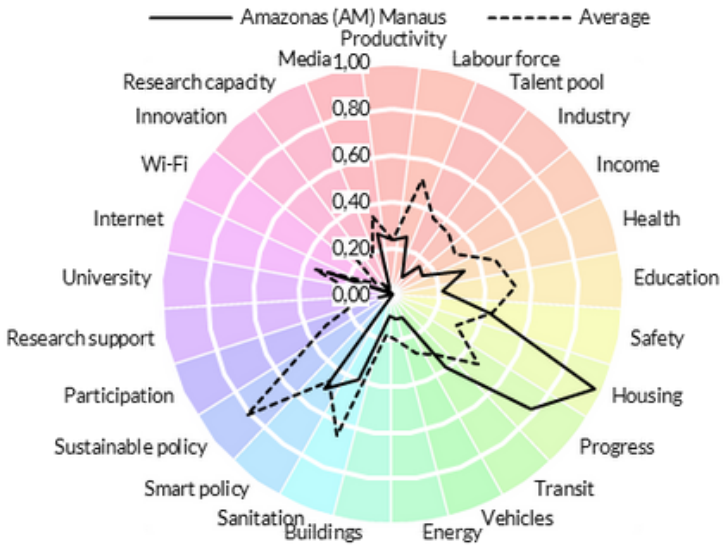
Macapá



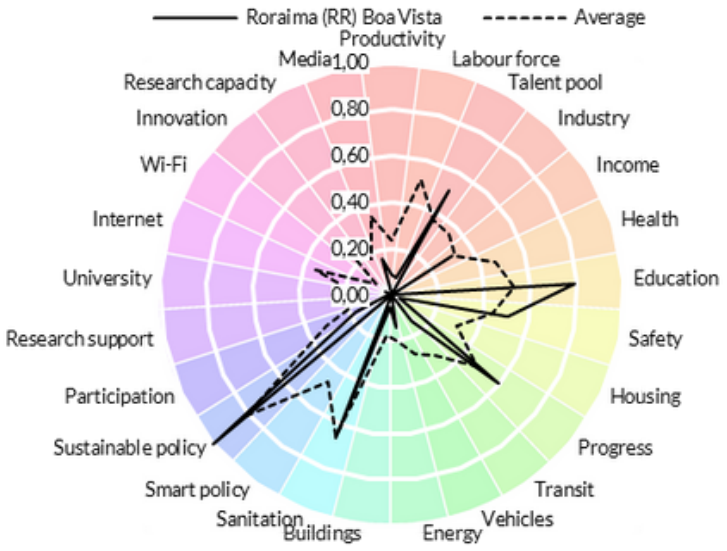
Porto Velho



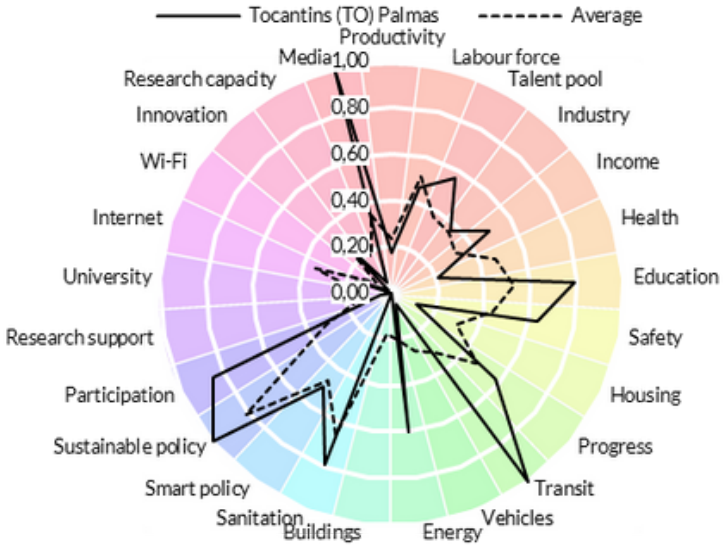
Manaus



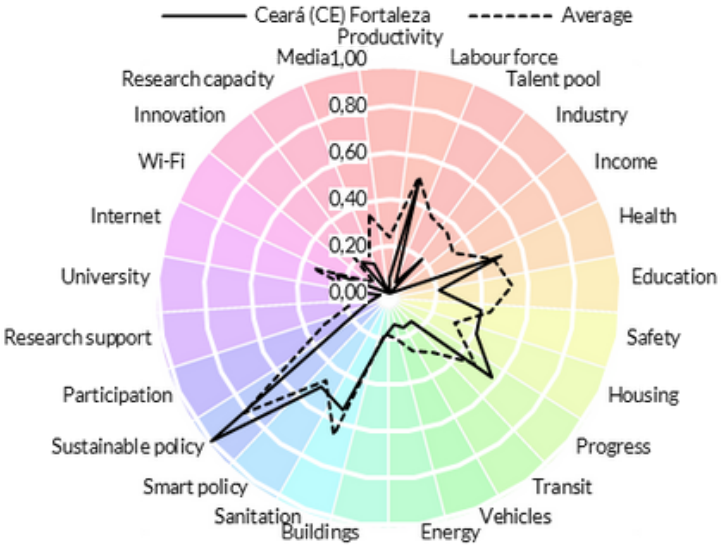
Boa Vista



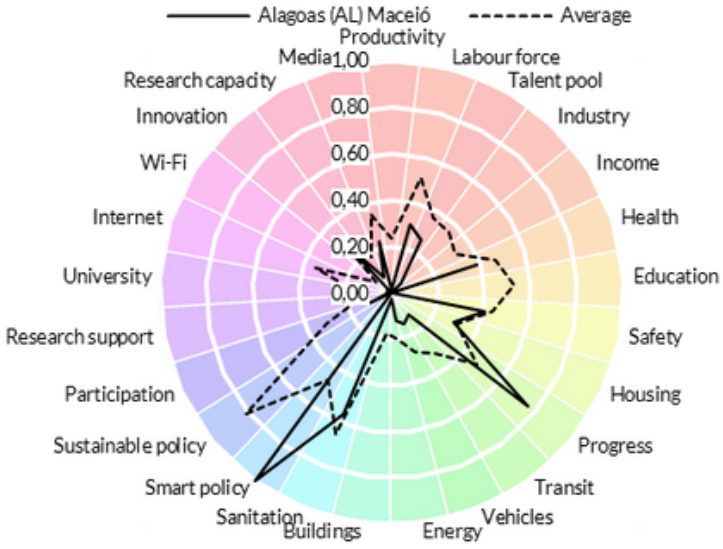
Palmas



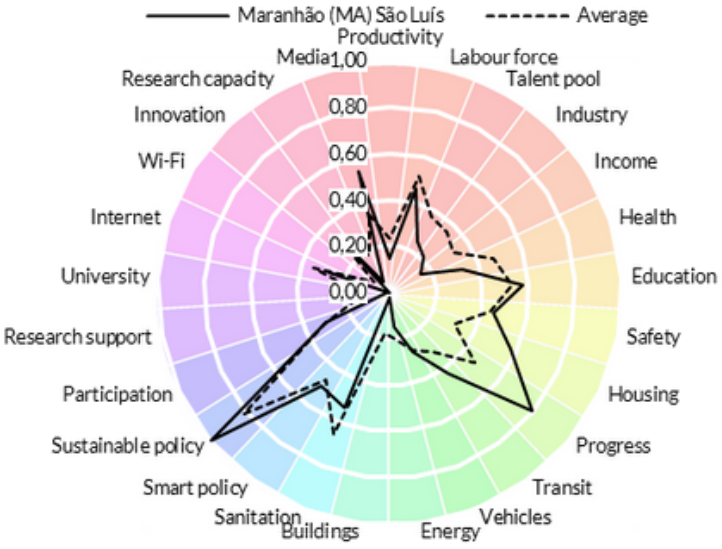
Fortaleza



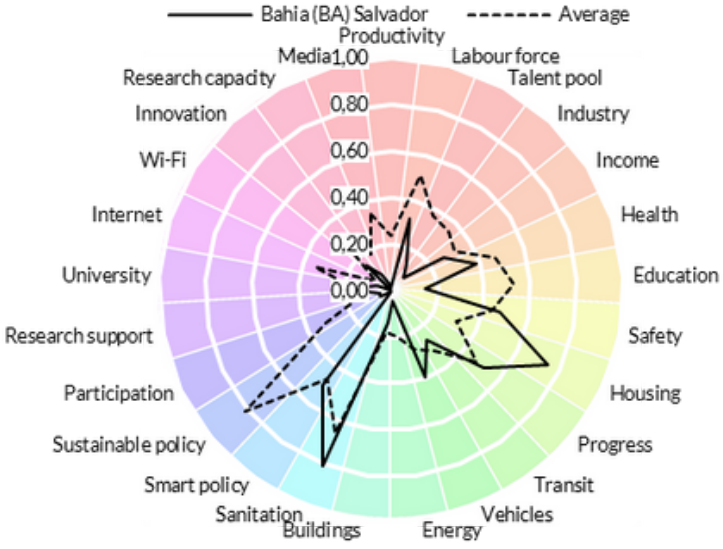
Maceió



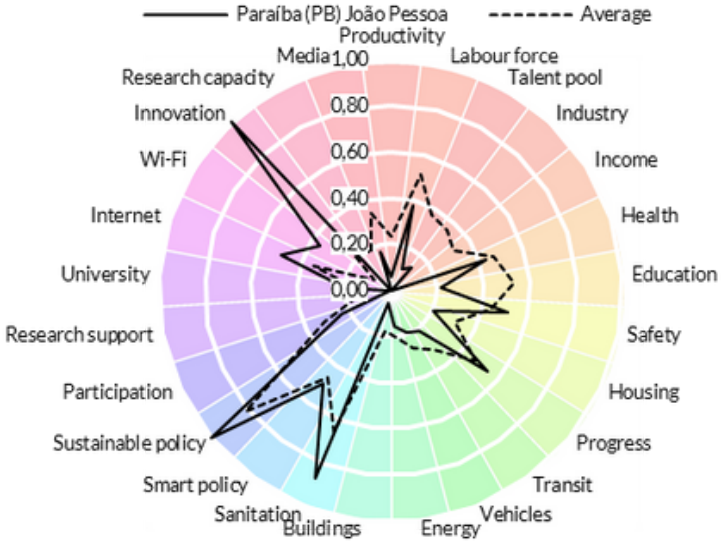
São Luís



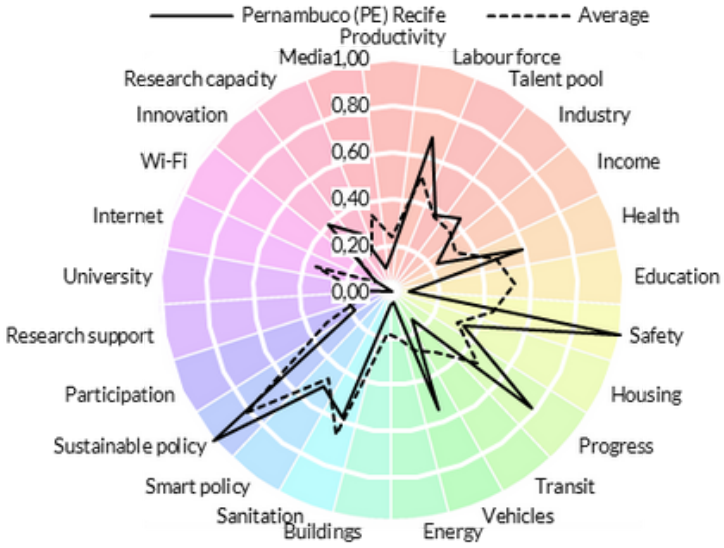
Salvador



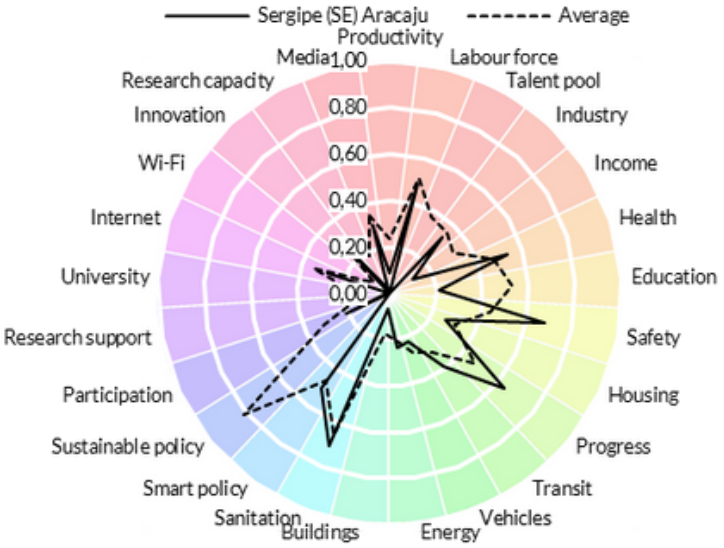
João Pessoa



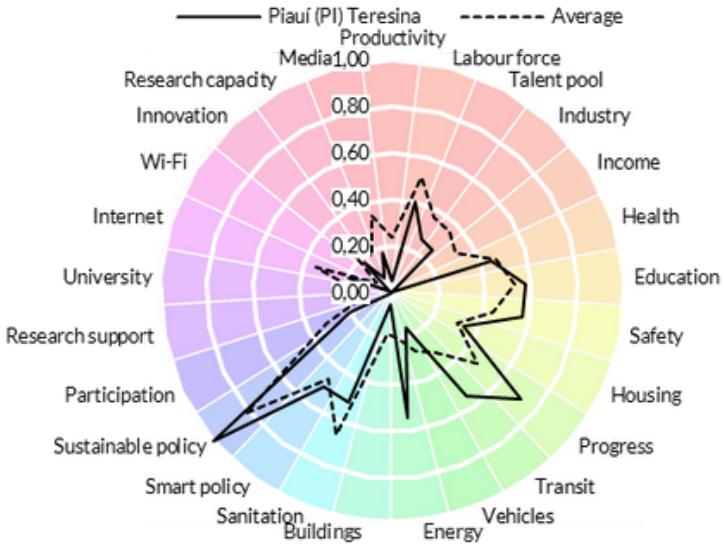
Recife



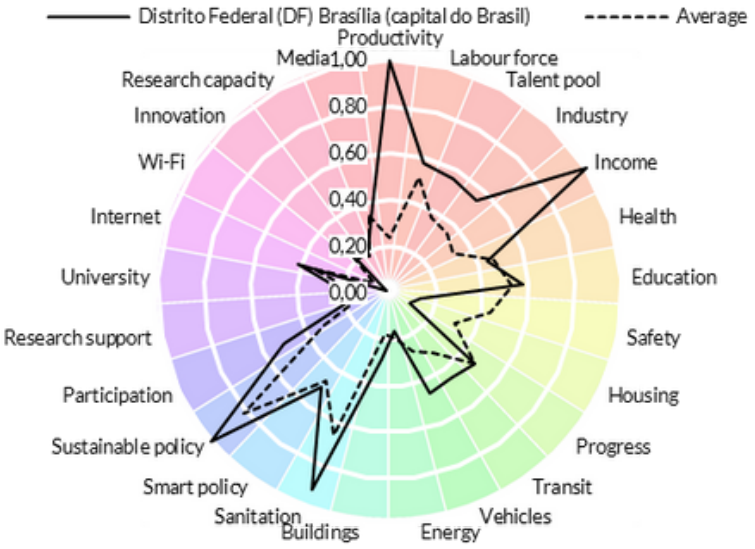
Aracaju



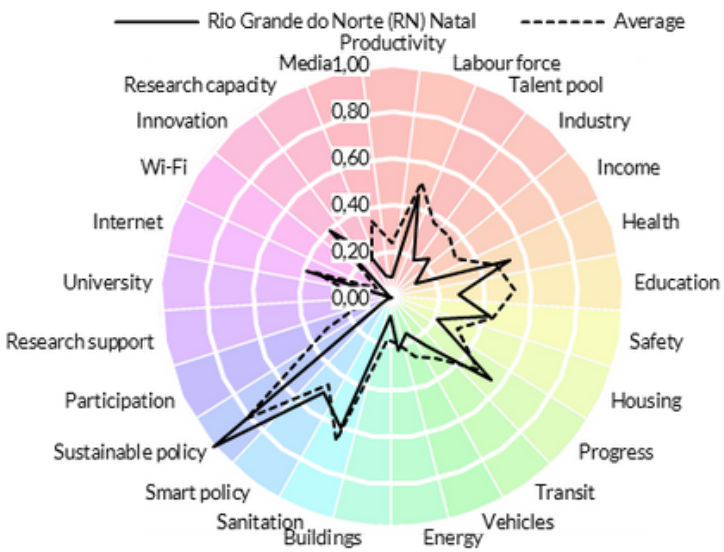
Teresina



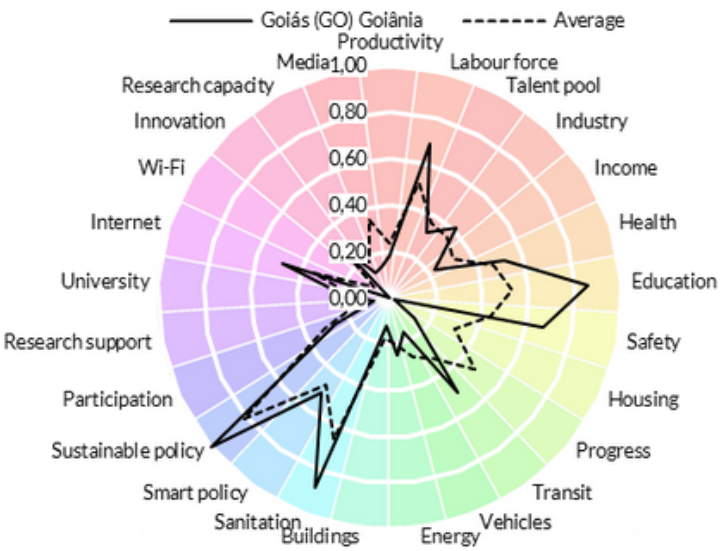
Brasília



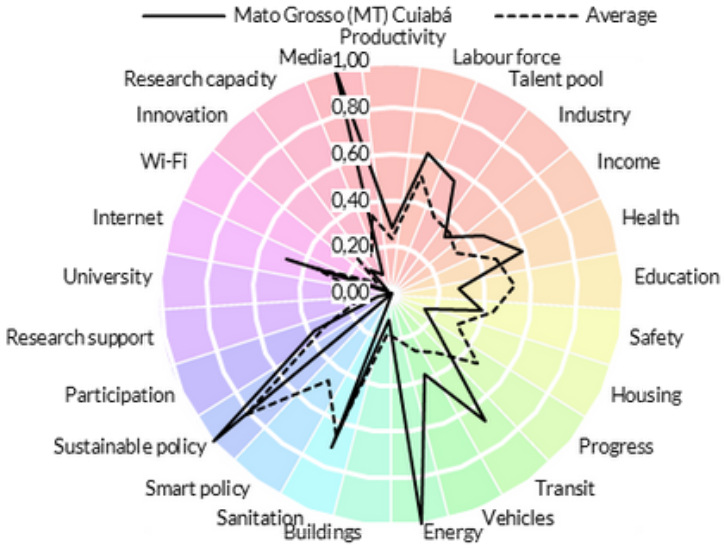
Natal



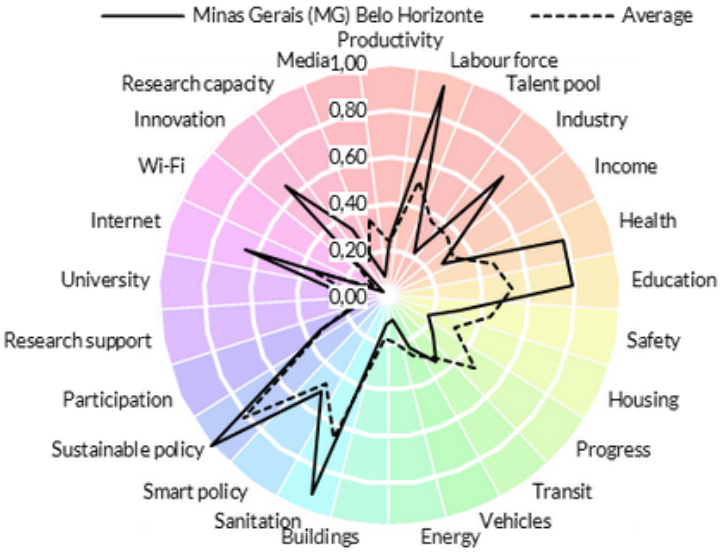
Goiânia



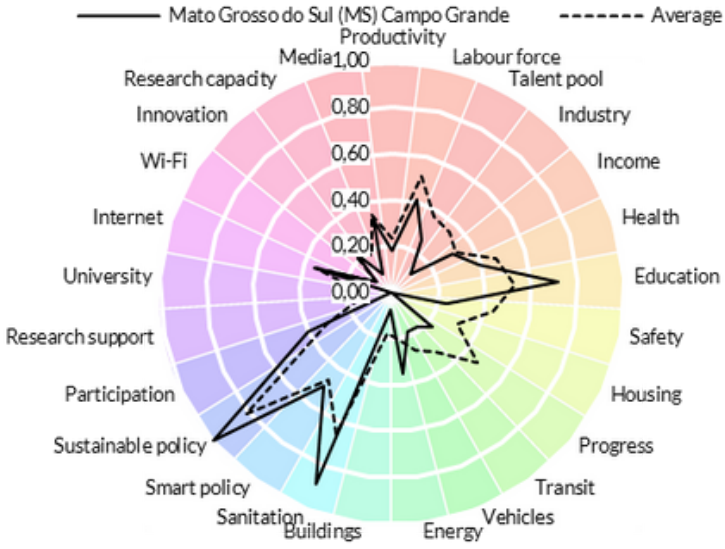
Cuiabá



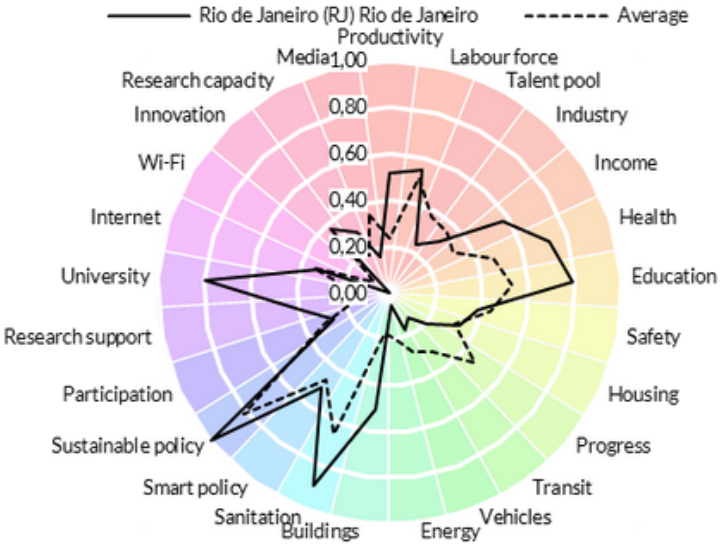
Belo Horizonte



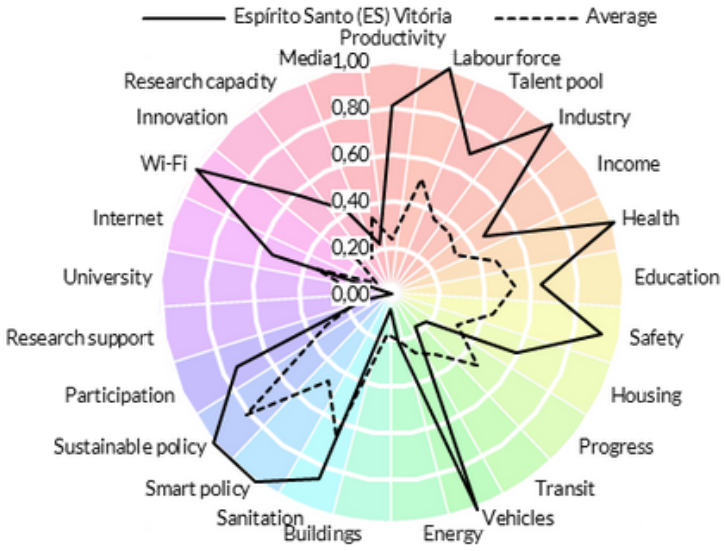
Campo Grande



Rio de Janeiro



Vitória



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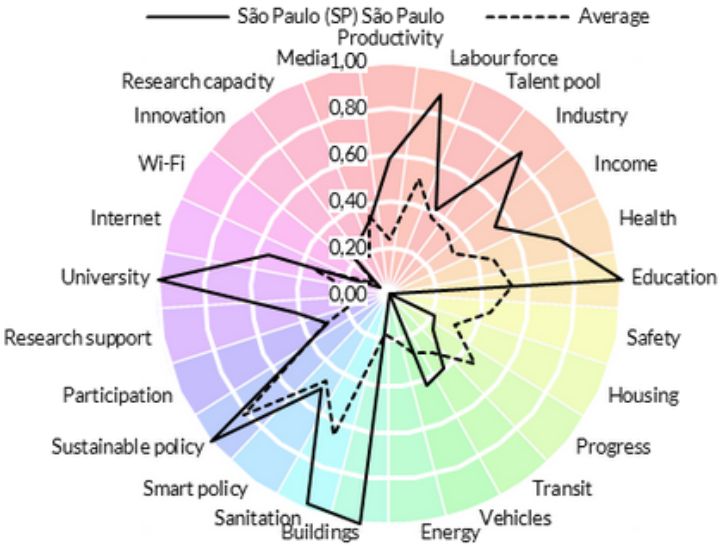

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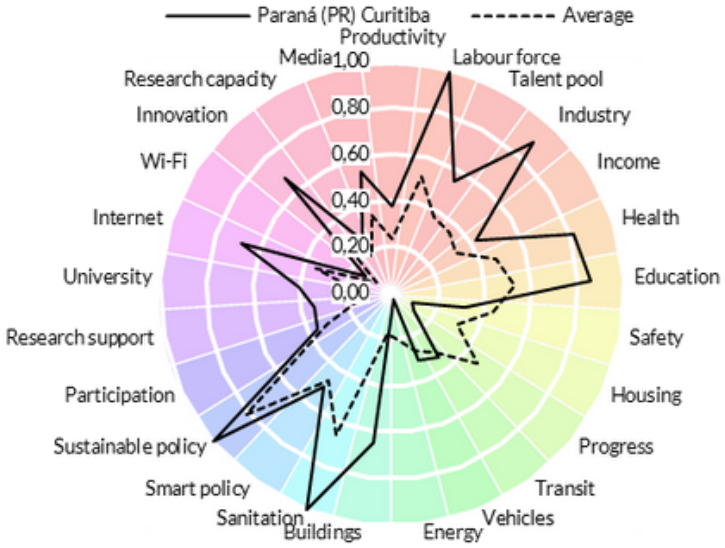

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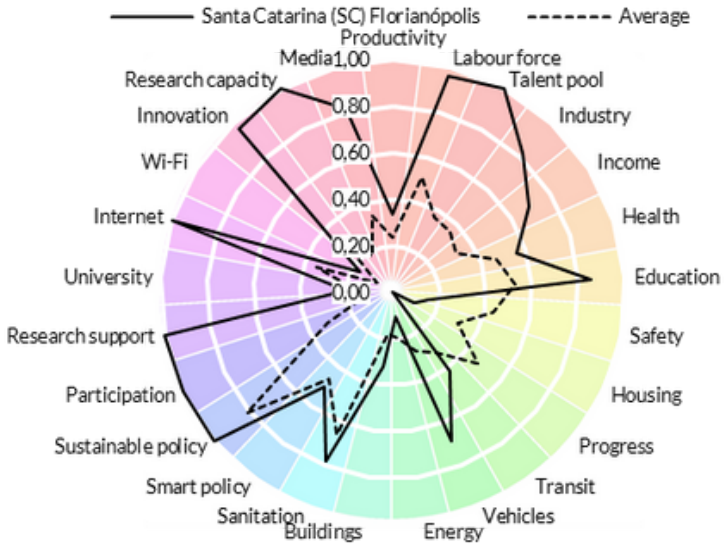

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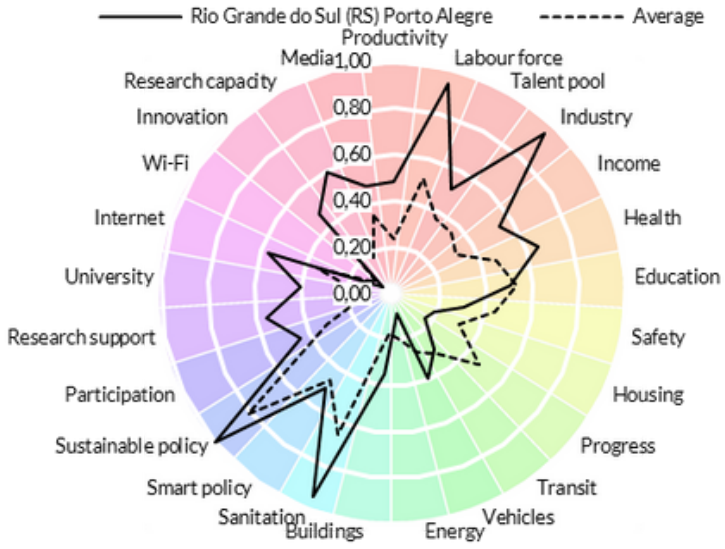

Fernando de Noronha - Pernambuco

OUR TEAM: CITYLIVINGLAB

Through a new vision of the academic world combined with the expertise of an internationally recognized faculty, the Graduate Program in Administration at the University of Caxias do Sul (PPGA) established the CityLivingLab that also houses the Brazilian Observatory for Knowledge Based Development (OBDC). In order to establish a balance between the academic world and the business world, the OBDC acts as a platform for the dissemination of research and studies. It aims to interact with the public and private sector, generating learning and values, capable of being applied to different contexts related to the development of Brazilian cities and businesses.

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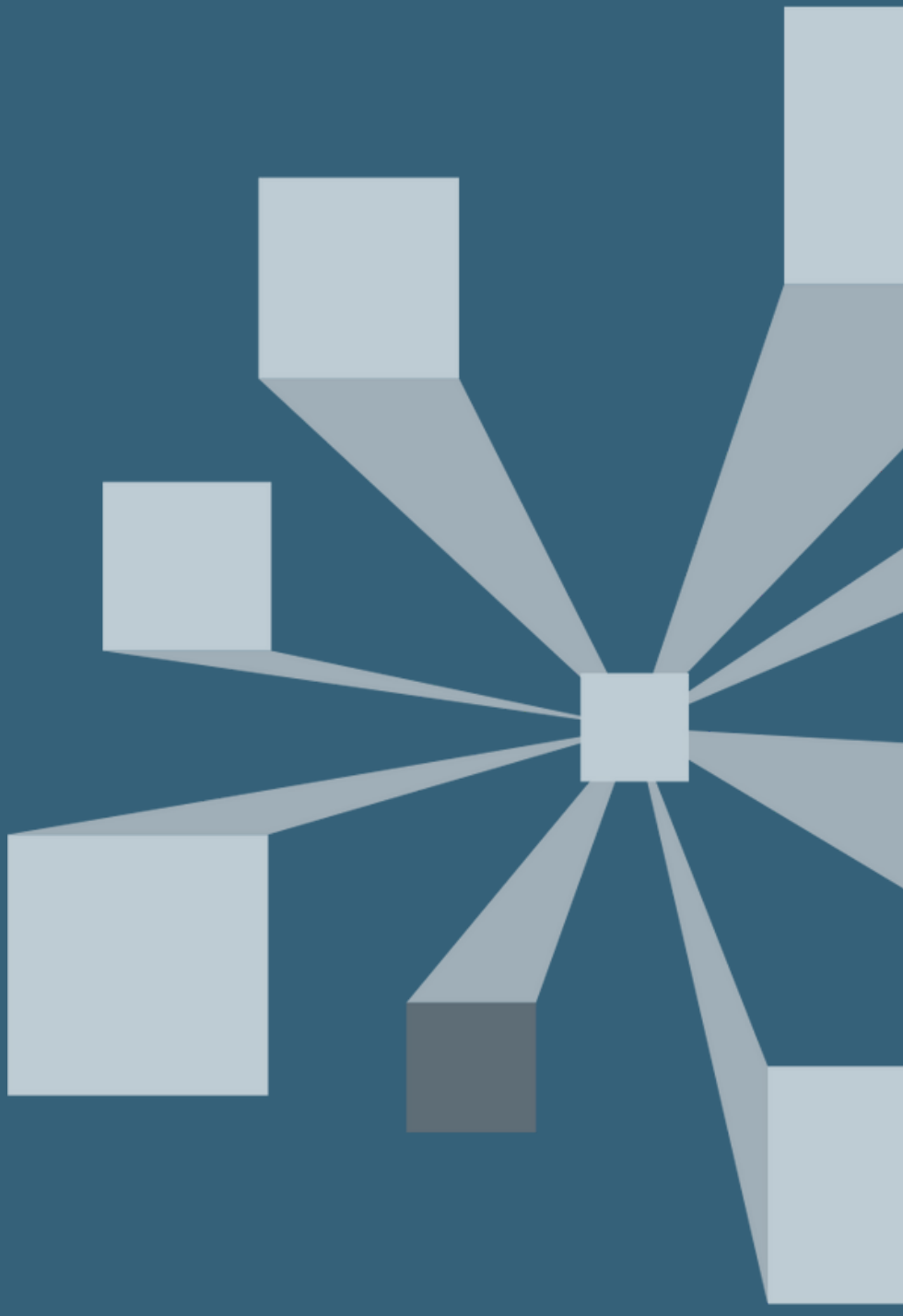
Disclaimer

This report has been prepared to assist public organisations, including the Brazilian, State and Territory, and Local Governments, in designing and improving smart city policies for their localities and communities. It is a quantitative analysis based on indices developed by researchers and academics with expertise in this area. However, it does not factor in various local contextual and unique characteristics that play an important role in assessing the progress of the localities and their communities. Therefore, this report should not be relied on by itself or be used to rank or compare performances of local government areas, but instead be used in conjunction with other relevant sources of information and assessments. This report does not necessarily reflect the official policy or position of the Brazilian Government.



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