Brazilian Smart Cities: Using a Maturity Model to Measure and Compare Inequality in Cities

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ABSTRACT
Nowadays there are several publications on smart cities and improvements offered to the routine of its inhabitants and resource optimization, however, there is still no agreement about the definition of "Smart Cities", their domains and indicators. The lack of a clear and widely usable definition and such as delimitation areas and indicators makes it difficult to compare or measure cities in this context. This paper compares some of the Brazilian capital indicators and presents a maturity model called br-SCMM (Brazilian Smart City Maturity Model) developed to allow extracted indicators of public databases may be used to assist city managers.

Categories and Subject Descriptors
J.1 [**Computer Applications**]: Administrative Data Processing – Government.

General Terms
Measurement, Documentation, Economics, Standardization.

Keywords
Smart City, Smart Government, Maturity Model, Public Data.

1. INTRODUCTION
According to Brousell [1] the concept of Smart Cities is still without a clear definition. Although the author suggests to use scenarios related to transportation, technology, infrastructure, sustainability and governance, there are other authors as [2,3,32] referring to the term "Smart Cities", with different nomenclatures, contexts, domains and meanings. The term "Smart Cities" presents an evolutionary history that began in the 90s, when [4] presented the idea that a Smart City was seen as the virtual reconstruction of a city, or a "Virtual City". After that, the term has been used such as a "digital city", the "information city", "connected city", "tele-city", "knowledge-based electronic community", "e-community" space among other terms.

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One of the difficulties in establishes clear indicators that guide the definition of a smart city is based on regional socio economic differences that characterize the cities.

The creation of extraction methods and public data comparison can help not only the characterization of these cities, but also in the creation of public policies that aims a more equal society.

The purpose of this paper is to present a method that uses public data to define indicators to measure how smart a city can be, and thus propose mechanisms that assist managers to improve social and economic policies.

To achieve the expected results, this paper revisited some authors in order to find more updated definitions of Smart Cities (Section 2). In Section 3 are presented the Domains and Indicators used to compare the Brazilian cities based on public data mining. For this we used some concepts inherent in the Systematic Mapping method. This Section is also displayed the maturity model called br-SCMM (Brazilian Smart City Maturity Model) and held a discussion on the results obtained from the comparison of data and the validation of the model. Section 4 concludes this paper proposing solutions for the future citizens use these indicators to achieve greater equality in living conditions in smart cities.

2. SMART CITIES: A BRIEF SURVEY
The term "Smart Cities" may have originated the term "Smart Growth" which was proposed in the book of Bollier [52], which evoked new political practices for better urban planning.

Almost ten years later, Komninos [53] presented a new definition for the term "Smart Cities". In this work he claimed that these cities are constructed as multi-dimensional clusters, combining three main dimensions: People (intelligence, inventiveness and creativity), Collective Intelligence (knowledge and innovation) and Artificial Intelligence (infrastructure and communication).

Chourabi [4] proposed a framework which was identified eight critical factors: management and organization, technology, governance, political environment, people and communities, economy, built infrastructure, and the natural environment. These factors form the basis of an integrated framework that can be used to examine how local governments are predicting initiatives aimed at creating a smart city.

The Centre of Regional Science [8] made a list where points 70 medium-sized European cities that meet the requirements specified in your Smart City model. This model is divided into six characteristics and consist sets of factors that detail Competitiveness capacity, social aspects, public participation in decision making, quality of life, transport and human resources.

The "Wheel of Smart Cities" proposed by Cohen [6] identifies six key factors for the development of Smart Cities, which are: Smart People, Smart Economy, Smart Environment, Smart Government, Smart Living and Smart Mobility. For each of these key factors, specific indicators were defined aimed at achieving pre-set targets.

The latest initiative, the ISO 37120 created by the International Standards Organization (ISO) [51] was developed to provide 100 different performance indicators for cities which claim to become "Sustainable Cities". Specifically, the ISO 37120 standard consists of 17 themes containing 46 core indicators and 54 indicators of assistance that can help define public policies based on different domains.

The search for a better definition, this work revisited several authors in an attempt to try identification of their difference between cities as usually we know and new cities called "smart". What studies show is that the use of public data on areas (or dimensions) makes possible the creation of indicators to measure the performance. The main indicators refer to optimization of resources, improved public services and greater citizen participation in policy and strategic decisions. The next section presents a number of domains and indicators used to compare smart cities in Brazil.

3. MEASURING BRAZILIAN CITIES

This section presents the definition of domains and indicators used to compare the smart cities. To make a comparison, it was necessary to adapt the methodology used in systematic mappings [34], to achieve a cross qualitative and quantitative information:

- **Planning:** a protocol aiming to collect data in scientific articles and public databases to answer the research question was defined: (**RQ1**) What are the criteria for measuring and comparing smart cities? For the answer we created a query in the form of text string that was held in some scientific search engines for the population data needed to extraction and quality criteria;
- **Progress:** after application of the quality criteria, extraction and evaluation, the review resulted in studies and databases shown in Table I of this work and
- **Presentation and data analysis:** to answer the research question (RQ1) the first topic of this list, the results were compiled, and resulted in the following section, which details the definition of smart cities and the origin of the evaluated public data.

3.1 Defining Domains and Indicators

For the UN [9], the minimum number of inhabitants to be a considered and to become city, have to be a human group with more than 20,000 inhabitants.

The definition of the size for the cities was given by the International Conference of Statistics in 1887 and is maintained by the International Statistical Institute (ISI) [8]. According to the ISI, cities with a population over 100,000 inhabitants are considered large cities.

However, establish criteria defining only based smart cities in the number of inhabitants can lead to misconceptions by not considering regional characteristics, political, social and economic of these cities. Therefore, this work considered different jobs that raised areas and areas of Smart Cities around the world, that they might be suitable to the Brazilian reality.

According to the Global Index ranking of Open Data 2014, produced by the Open Knowledge [54] Brazil occupies the twenty-sixth position among the countries that have adopted the philosophy of sharing open public data. The intention of this work is, in the future, expand the comparison between smart cities of the countries belonging to the BRICS, which respectively occupy positions: Brazil (26), Russia (45), India (10) China (57) and South Africa (36). However, among the countries of this group, Brazil was chosen because it has more public transparency initiatives, such as the one created by Transparency Brazil [55].

Thus, we arrived to a model consisting of 10 domains called "Domains Basic" where each domain has its respective "Basic Indicator". The main objective of these domains and basic indicators is to understand the scenario in which the city is inserted, and thus understand the structural weaknesses that need further attention to the city to be comparable to a smart city. Are shown in Table 1 these domains and their basic indicators.

Table 1. Basic Domains and their Indicators

Domains	Basic Indicators	Papers	Data Sources
Water	Piped water	[4,6,31]	[10,36,40]
Education	HDI–Education	[19,25,28,30]	[10,39,18,12]
Energy	Access to energy	[6,17,27,29]	[10,41]
Governance	HDI/Employment	[5,12,30]	[11,35,38]
Housing	Private residence	[5,6,25]	[10,46,12]
Environment	Garbage collected	[14,12,25]	[24]
Health	HDI – Health	[16,22,23]	[10,12,37,44]
Security	Homicides/1000	[18,27,30]	[10,43,45]
Technology	Computers/home	[5,25,31]	[10]
Transport	Mass transport	[6,12,30]	[25,42]

To develop the domains and their indicators were considered the studies surveyed both in Section 2 and in the field of Smart Cities. The intersection of the domains presented various studies made it possible to create this list containing 10 domains.

To create the list of indicators for each of the domains presented in Table I, were considered two important factors: the availability of public information for the measurement and the compatibility of local data with the same set of data collected in other cities around the world.

These indicators are called basic indicators and for each of them, there are also two secondary indicators associated to the domain. Although mathematically, there is no difference in the calculation of ranking among the cities, this paper presents only the basic indicators and the definition of secondary indicators is being created according to the criteria used for the primary indicators.

Please find below each of the areas, their indicators and how these indicators are calculated to compose the concept of Smart City proposed by this article.

3.1.1 (A) Water – Piped water

The Water domain was appointed in the works of [4,6,31] as essential to the understanding of Smart Cities. However, the reality found in Brazilian cities can become unviable the full their classification, because between the 5570 Brazilian municipalities, only three have all households supplied by piped water and sanitation while 2147 municipalities had an index less than 90% of supply residential water.

Compare this scenario with the reality of European or North American countries may hinder the planning of public policies to expand the network of water and sewage in the country. Currently, according to the IDEC (Brazilian Institute of Consumer Protection) for failures in governance, mega cities like São Paulo and Rio de Janeiro face problems such as waste and lack of water supply. [47]

As stated in the estimation of water from UNICEF [14] report, access to piped water increased from 83% in 1990 to 92% in 2010, while access to sanitation increased from 71% to 75%. So this domain will make use of indicator that quantifies the percentage of households served with piped water in the municipality assessed.

3.1.2 (B) Health – HDI Health

To calculate the indicator that represents the health of a city, we used the HDI (Human Development Index) as an indicator. This index was developed in the 90s and has been used by UN member countries, which are classified as developed, developing or underdeveloped according to the Human Development Report (HDR).

This index was rebuilt in 2010 and started to use a new method of calculation that is based on the calculation of three different variables. The first variable is the result of the equation obtained with life expectancy (1), which in Brazil is about eighty-three.

$$LE = \frac{LE-20}{83{,}2-20} \quad (1)$$

The second variable is the result of Education Index (EI) (2), which considers mean years of schooling (MYSI) and expected years of schooling (EYSI).

$$EI = \frac{MYSI+EYSI}{2} \quad (2)$$

The third variable considered the result of the equation obtained with the income index (3). This income is calculated based on the gross domestic product per person with parity by purchasing power, indexed by the dollar, the calculated location.

$$IR = \frac{(GDPpc)-In(163)}{\mathrm{In}(108.211)-\mathrm{In}(163)} \quad (3)$$

Finally, in possession of these three variables, HDI is calculated as the arithmetic average of the values obtained. (4)

$$HDI = \sqrt[3]{\mathrm{LE \times EI \times IR}} \quad (4)$$

This domain will therefore make use of the HDI indicator to measure the quality of municipal health evaluated because it is an indicator of international reach and used for both municipalities and countries.

3.1.3 (C) Education – HDI Education

From the social point of view, Education can be seen as responsible to increase many other indicators, therefore, to the extent that a society becomes more educated, it also becomes more healthy and safe.

In Brazil, the MEC (Ministry of Education) [17] uses different quality measuring instruments of education depending on the educational level that need to be measured. One is the IDEB (Basic Education Index) was created in 2007 is responsible for providing data on the quality of basic education (Figure 1). The index is measured every two years and the aim is that the country, from the reach of state and local targets will achieve a grade equal to 6, which corresponds to the quality of basic education in developing countries. [18].

Figure 1. Target for the Basic Education Index (IDEB) in Brazilian municipalities. [17]

Like other indicators from this work, the IDEB was chosen because it has similar tools used in other countries, thus allow comparisons with the targets achieved by other cities and countries around the world.

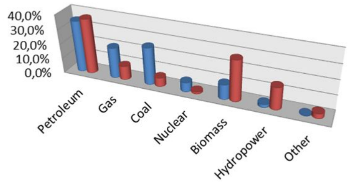
3.1.4 (D) Energy – Access to energy

The papers of [6,17,27,29] shows the primary energy supply as main Smart Cities indicators when they have ways to manage their resources and optimize their use.

Initiatives such as the SGMM (Smart Grid Maturity Model) developed by SEI (Carnegie Mellon University's Software Engineering Institute) [27] points to a model that consist eight domains, which contains incremental indicators with intelligent network features that represent the strategic aspects of the organization, implementation and operation of these networks.

In Brazil, the Ministry of Mines and Energy [26] is responsible for managing the data on the electricity distribution services in cities. In a survey conducted by the ministry, was explicit the need in country to seek new forms of renewable energy production to balance its energy matrix. This type of national survey can be used locally as a good indicator for growth and financial and political municipalities involved in energy generation projects.

The comparison of the Brazilian energy matrix with the world can be seen in Figure 2 and reveals a large dependency on hydropower. As described in the water domain, Brazil is going through a water crisis that has direct impact on power generation.



	Petroleum	Gas	Coal	Nuclear	Biomass	Hydropower	Other
World	35,0%	20,7%	25,3%	6,3%	10,0%	2,2%	0,5%
Brazil	37,4%	9,3%	6,0%	1,4%	27,8%	14,9%	3,2%

Figure 2. Comparison of the energy mix of Brazilian and global cities. [26]

The indicator used for this work considers the percentage of households served by the distribution of electricity in the city. It is important to remember that the population density in some regions of Brazil is very low, given the characteristics of terrain and vegetation.

3.1.5 (E) Governance – HDI Income / Employment

The models proposed by [23,19,20] use the Governance among the policies for the definition of Smart City. With different definitions and indicators, Governance can be summarized as a set of processes, policies, laws, regulations and institutions that regulate the way that public resources and services are managed.

One way to measure the quality of governance of cities is to measure its gross domestic product (GDP) and thus know the economic activity of a region. GDP is the sum (in monetary terms) of all finished goods and services produced during a given period.

Models that aims to define Smart Cities use management and policy issues to assess the governance capacity of a municipality, so if a municipality does not have its GDP growth, this may be a clear indicator that action is needed to resumption of growth.

The consulting firm PricewaterhouseCoopers [22] developed a ranking of the 100 cities and / or its richest metropolitan areas in the world by GDP. From this list, Brazil has five cities: São Paulo, Rio de Janeiro, Brasilia, Porto Alegre and Belo Horizonte respectively occupying the positions: 10, 31, 57, 89 and 91 of this ranking. Previous studies show that cities such as Porto Alegre, Rio de Janeiro, Recife and Brasilia seek to achieve targets for building smarter cities.[49,50]

However, the production capacity of a municipality is tied directly to their ability to manage and optimize their productive resources. Thus, this work is not limited to only measure the nominal GDP, but considers its growth over previous periods, favoring this way also the smaller municipalities.

3.1.6 (F) Housing – Private residence

The Housing Domain was set from a basic indicator commonly used by local governments: the own homes index. In Brazil, this index is measured by the IBGE and published by sites such as IPEA [11] and the Portal MDGs [12].

Among the studies conducted municipalities, smaller feature greater facilities in the acquisition of own residence ranging from encouraging residential own credit policies until federal government grants to purchase homes. [13]

The results of a survey released by the Applied Economic Research Institute (IPEA) show a reduction of the housing deficit in the country. Based on the National Survey by Household Sample (PNAD-2012), the study shows that 10% of the total deficit of Brazilian households recorded in 2007 dropped to 8.53% in 2012, representing 5.24 million of homes. [48]

3.1.7 (G) Environment – Garbage treatment

Although the term Smart Cities have multiple definitions, it is almost a consensus that is included the related domain to the environment. [14,12,25]

One way to measure the impact of the cities on the environment is to assess whether the city has mechanisms to neutralize the production of damaging effects on nature. According to the Ministry of the Environment [24] the municipalities are responsible for the daily production of approximately two hundred thousand tons of waste per day, totaling seventy two million per year of household waste.

To compose this indicator was considered the percentage of households served by the collection and treatment of household waste service. The percentage found in both large and small cities almost in its entirety rates reach more than ninety-five percent of waste collected and treated.

3.1.8 (H) Security – Homicides per thousand

By choosing the Security indicator was determined by calculating the number of deaths per thousand inhabitants, this indicator is called the Homicide risk. According to WHO (World Health Organization) studies in Homicide risk can be classified by age, gender or race. [15,16]

The Homicide risk is an index used specifically to measure violence in the cities. The number is collected dividing the deaths caused by third parties by the population of the studied area; afterwards they made their equivalence per 100 thousand inhabitants.

Among the 50 most violent cities in the world, 16 are held in Brazil (Table II), according to the ranking made by experts from non-governmental Mexican organization Citizen Council [28]. Safety based on the figures of world cities in homicides over 300 thousand inhabitants. In spite of the northeast region of Brazil concentrates small towns whose indices are well above the national average which demand urgently control violence policies.

Table II. Ten most violent cities in Brazil. [28]

Position	City	Index
5	Maceió	79,76
7	Fortaleza	72,81
9	João Pessoa	66,92
12	Natal	57,62
13	Salvador	57,51
14	Vitória	57,39
15	São Luís	57,04
16	Belém	48,23
25	Campina Grande	46,00
28	Goiânia	44,56

In Brazil there is a great difficulty in obtaining these data on safety, because there is no institution to centralize state data. Thus, each state board (in the country are 27 departments) they responsible for collect and disseminate data on public safety. Thus, each State Security Bureau determines how and when to make the data available, hence there is a clear need to establish a Big Data with centralized information about public safety.

3.1.9 (I) Technology - Computers at home

The work of [19,20,21] considers technology as a key factor for the development of Smart Cities. Both point to technology as necessary domain, to act integrating the other domains and also to achieve the expected results for smart cities.

A city can be considered technologically advanced when it makes use of computational in order to improve their processes and manage their resources optimally. Make use of technology will create a better environment to the citizens enabling them to become part of the processes and monitoring the optimization resources.

To compose the domain score studies consider the number of households with computer. The indicator described above is most recent one was created ten years ago.

Apparently the north and northeast regions of Brazil have a technological deficit in relation to the south and southeast regions, as demonstrated in Figure 3, which have attracted many digital inclusion projects in these regions.

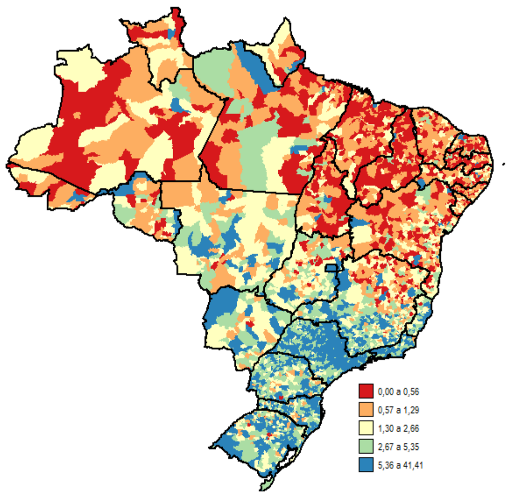


Figure 3. Percentage of households with computer in Brazil according to the IBGE [10].

3.1.10 (J) Transport – Mass transportation

Urban mobility of cities is generally associated with the ability of production flow and mass public transport supply. Thus, it appears that the most developed municipalities also have the best transport indicators.

According to the Brazilian Ministry of Transport [25], road transport prevailing in the country, which has 1.03 kilometers of paved road per capita and 7.35 km of unpaved road. The Midwest region stands out in this indicator, having, respectively, 1.74 and 14.85.

Mato Grosso do Sul state has greatest indicator for both paved roads and for unpaved: 2.56 and 34.18 respectively, because it has low density housing with a vigorous economy. Among the regions, the highlight was the South Region, which has 1.46 and 10.68 respectively.

In addition to the road indicators, it is necessary to measure the municipality's ability to manage the daily mass transportation. The National Land Transportation Agency (ANTT) [26] is the competent body for the award and monitoring of permits and authorizations for the public transport service operation. For this indicator, the data made available by this agency confirms that road transport by bus is the main mode in the collective movement of users in Brazilian cities were used.

3.2 Br-SCMM (Smart City Maturity Model)

In this section we propose a Brazilian maturity model developed to measure and compare the different levels that cities can reach and lead towards a smarter city.

Maturity models generally aims to make organizations to measure and optimize the progression of skills and competences developed in a particular area.

According to [CMMi 2002] the CMMI maturity model (Capability Maturity Model Integration) is a model that uses generic and specific practices and is designed to standardize and measure the quality of corporate improvement process, integrating different models and disciplines.

Regional models were developed based on the model established by CMMi. The MPS.BR or Brazilian Software Process Improvement is a maturity model used to expand the quality system production process while serving the reality of the market, and is compatible with CMMi. [MPS-Br 2009]

The model proposed in this work was called Br-SCMM (Brazilian Smart Cities Maturity Model), and uses the domains and indicators presented throughout this section to measure the first level on a scale from 1 to 5 in order to identify possible areas for improvement before the following levels are adopted.

The indicators had to standardize data and mathematically equated to meet this scale (5). For calculation, we used the method proposed in [33] that transforms all the values of the indicator on standardized values with a mean of 0 and standard deviation 1. These methods offer the advantage of considering the heterogeneity within groups and keep your metric information.

$$Z_i = \frac{x_i - x}{s} \quad (5)$$

The initial level of this model (Level S) was established by considering the following levels (management levels) can only be achieved in a work of improvement of the basic indicators of provision of public services such as Education, Water and Health.

Capitals	Water	Education	Health	Environment	Energy	Transport	Housing	Governance	Security	Technology	Media
Florianópolis	4,95	5,00	4,81	4,95	5,00	4,27	3,85	4,16	4,03	1,68	4,3
São Paulo	4,93	5,00	4,63	4,97	5,00	4,15	3,18	4,22	4,13	1,29	4,1
Rio de Janeiro	4,89	5,00	4,63	4,94	5,00	4,07	3,57	4,17	3,22	1,19	4,1
Brasília	4,72	5,00	4,64	4,91	4,98	4,05	3,11	4,53	3,33	1,19	4,0
Curitiba	4,95	5,00	4,71	4,97	5,00	4,04	3,54	4,06	2,73	1,39	4,0
Porto Alegre	4,89	5,00	4,76	4,97	4,99	4,01	3,30	4,11	2,64	1,40	4,0
Campo Grande	4,79	4,92	4,48	4,91	4,99	3,95	3,51	3,90	3,39	0,68	4,0
Goiânia	4,80	4,90	4,58	4,95	4,99	3,94	3,24	3,92	3,27	0,81	3,9
Cuiabá	4,22	4,94	4,52	4,66	4,99	3,88	3,99	3,86	3,06	0,66	3,9
Belo Horizonte	4,90	4,83	4,61	4,92	4,99	3,93	3,47	3,86	2,53	1,22	3,9
Natal	4,70	4,46	4,33	4,86	4,98	3,89	3,76	3,61	3,59	0,69	3,9
Boa Vista	3,88	4,87	4,28	4,58	4,94	3,79	4,03	3,46	3,72	0,39	3,8
Manaus	3,75	5,00	4,26	4,57	4,95	3,78	4,04	3,56	3,38	0,49	3,8
Vitoria	4,87	4,88	4,71	4,98	4,99	3,89	3,90	3,93	1,23	1,48	3,9
Belém	4,06	4,74	4,43	4,80	4,97	3,79	3,77	3,48	3,29	0,55	3,8
Aracaju	4,64	4,55	4,37	4,80	4,99	3,82	3,62	3,54	3,06	0,81	3,8
Macapá	3,58	5,00	4,25	4,18	4,94	3,68	3,72	3,72	3,39	0,32	3,7
Rio Branco	2,66	4,64	4,15	4,47	4,76	3,58	4,19	3,56	3,45	0,30	3,6
Salvador	4,65	4,57	4,43	4,66	4,99	3,75	3,83	3,42	2,54	0,71	3,8
Teresina	3,88	4,28	4,21	4,51	4,94	3,65	3,69	3,34	3,59	0,42	3,7
Fortaleza	4,43	4,44	4,32	4,75	4,98	3,68	3,23	3,39	2,99	0,62	3,7
Porto Velho	3,57	4,87	4,20	4,30	4,85	3,60	3,96	3,77	2,44	0,41	3,6
Joao Pessoa	4,82	4,36	4,31	4,72	4,99	3,66	3,34	3,51	2,17	0,73	3,7
Palmas	4,21	4,73	4,40	4,74	4,91	3,59	3,06	3,56	2,22	0,46	3,6
São Luís	3,31	4,31	4,28	3,80	4,98	3,49	4,13	3,14	3,08	0,38	3,5
Recife	4,39	4,46	4,38	4,80	5,00	3,47	3,35	3,48	0,63	0,79	3,5
Maceió	4,53	4,17	4,06	4,68	4,98	3,32	3,59	3,24	0,13	0,50	3,3

Figure 4. All Brazilian capitals measures by the model br-SCMM

In addition to the initial level, the model features four levels not incremental, consequently the municipality can choose to evolve in domains which have greater capacity, resources and strategic interests.

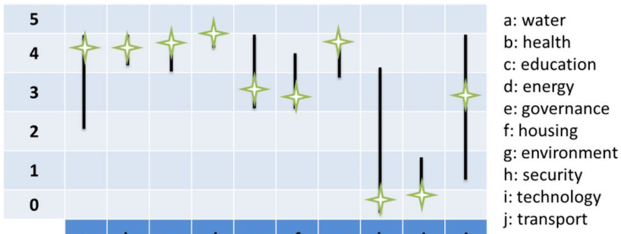
Thus, certain indicators can be selected to be improved, while others can be measured in a second stage or step of the desired strategy by the municipality.

Regardless of the level at which they are, all the capitals of Brazil had collected their public data on the ten proposed domains, and data were mathematically equated to give Figure 4 demonstrating a heat map of municipal indicators.

The levels are divided into five categories and composed the word (SMART), to answer five questions about Smart Cities:

- **Level S** (**Simplified**): Does the city reaches threshold scores for so-called basic indicators?
- **Level M** (**Managed**): Does the city has goals and practices that point to an optimized management of resources?
- **Level A (Applied):** Does the city uses a maturity model to establish public policies?
- **Level R (Measured):** Does the city established strategic indicators and has measurement practices and performance improvement?
- **Level T (Turned):** Does the city reached desired notes in the areas planned in the previous level?

All of the 27 state capitals were measured using the level S of this model, and its classification mapped identically to the shown in Figure 5, where individually observe the evaluated domains (a to j), the minimum marks obtained in each domain (Min) , the highest score (Max) and the score given to the municipality assessed (Attrib).



	a	b	c	d	e	f	g	h	i	j
Min	2,7	4,1	4,2	4,8	3,1	3,1	3,8	0,1	0,3	3,3
Max	5,0	4,8	5,0	5,0	4,5	4,2	5,0	4,1	1,7	4,3
Attrib	**4,4**	**4,4**	**4,5**	**5,0**	**3,5**	**3,4**	**4,8**	**0,6**	**0,8**	**3,5**

Figure 5. Recife, located in northeastern Brazil, mapped by the level of the S-Br SCMM..

The assessment of this level allows the evaluator to obtain a large amount of comparative data between indicators and thus guide the municipality on what strategies should be used for increases in levels approaching to the proposed model.

One of the biggest potential of this model is to allow public managers compare their averages in the desired domains and search for policies and initiatives that enhance the basic indicators.

It is possible to compare the marks obtained in the fields of Education, Security and Technology between the five cities with the highest and lowest score, and thus, establish a systematic way a relationship between the need for improvement in educational and technological indicators for reducing violence as illustrated in Figure 6. An example of regional characteristics is implicit in this figure: the city of Victoria has indicators making comparable to city northeast region, although it is located in the Southeast.

In this way, each municipality can develop public policies based on best practices obtained in other cities of the same region, or others that have been successful in this indicator..

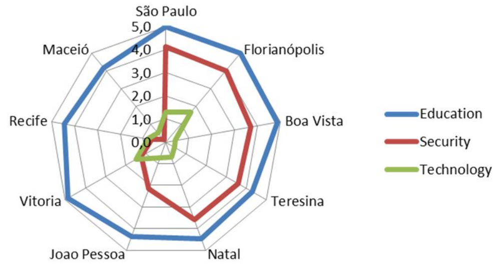


Figure 6. A comparison between domains of the Br-SCMM.

The next level (Level M - Managed) verifies if the cities have adopted policies and administrative practices that indicate interest in optimizing resources. This level, different from the initial level, has few data sources that offer which government strategies of municipalities. Which strategy of municipalities the government should take. To compose this level was necessary to observe the local laws, the style governing for each capital, and verify that they conform to good management practices.

It could be observed that larger cities have become concerned more with the policies of care for basic indicators of education, health and security. The Big cities turned a benchmarking to the small towns that had not yet become priority these actions, now these small cities are changing their organizational behaviors. The next section shows a comparison between some municipalities and were ranked as this maturity model.

3.3 Validating the model br-SCMM

This section is dedicated to compare the results obtained by some municipalities and in particular by those who have adopted policies and administrative solutions to optimize resources and processes. Is shown in Figure 7 a comparison between the Brazilian capitals and their media by level S and the level M.

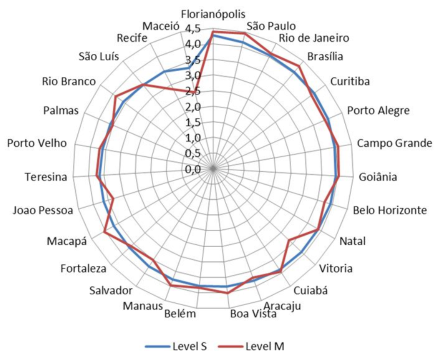


Figure 7. Evaluated Brazilian capitals in S and M levels of br-SCMM.

Cities whose safety indicators are lower than the other cities also have trouble to formulate policies and solutions to this urban problem. On the other hand, cities whose education indicators, health and water are likewise tend to have better solutions for municipal legislation on the other indicators. When viewing Figure 8, it can be seen that there is a clear discrepancy between security and technology indicators. The way the municipality plans its objectives and practices is to be considered to assess it in relation to the level of M Br-SCMM model.

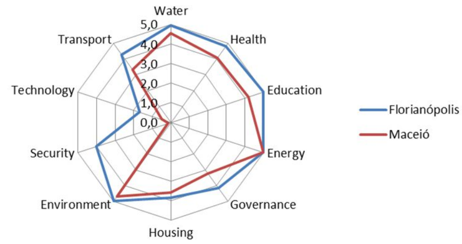


Figure 8. The cities that occupy respectively the first and last position in the Br-SCMM.

The following is a comparison of the objectives established by the ODM for the two municipalities assessed and the results obtained:

A. Goals

1) **Education*:*** Ensure that by 2015 all children complete primary school.

2) **Water*:*** To halve by 2015 the proportion of people without sustainable access to safe drinking water.

3) **Health*:*** By 2015, Halt and begin to reverse the spread of the virus of HIV/SIDA.

B. Practices

The practices are defined individually, and represent how municipalities use legal tools to make possible to achieve the established objectives. Table III shows a relationship between the objectives and the results obtained with the practices of these municipalities assessed. Table compares the results obtained by the municipalities that occupy respectively the best and worst place in the ranking of Brazilian Smart Cities.

TABLE III. Objectives and Practices of Smart cities

Objective	*Practice (Maceió)*	*Practice (Florianópolis)*
1 (Education)	The completion rate among young people aged 15 to 17 years, increased to 47.2%.	The completion rate among young people aged 15 to 17 years, increased to 69.3%.
2 (Water)	In this city, in 2010, 72.3% of residents had access to general water network with plumbing in at least one room.	In this city, in 2010, 93.1% of residents had access to general water network with plumbing in at least one room.
3 (Health)	From 1986 to 2011, 2,800 cases of AIDS diagnosed and treated.	From 1986 to 2011, 5,284 cases of AIDS diagnosed and treated.

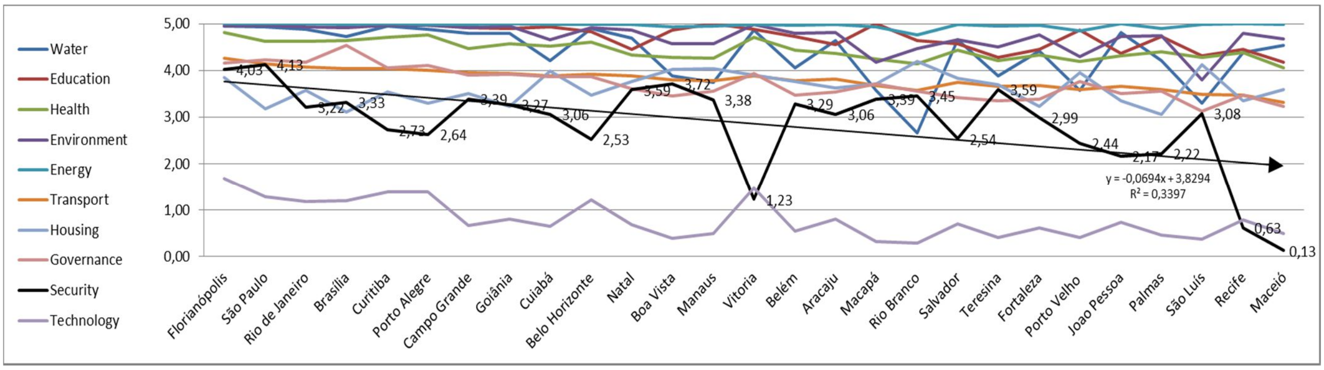


Figure 9. Comparison Chart of domains in capital cities.

Based on the presented results and creating policies for practical solutions to improve basic indicators, the M Level evaluates the cities whose practices present the best performance in order to achieve the targets.

Figure 9 shows a comparison between the 27 capital cities in all specified domains. Between one of the largest national concerns, the public security indicator is highlighted in this Figure. It may be noted that upside values obtained by means of the smart cities are reflected in other indicators.

The following levels have not been tested, because cities need to adapt to the initial levels, and increase its management capacity, therefore they will be able to challenge new levels of the model.

The next section presents some conclusions and the future about the work and how it will be needed to expand the results and improve the model proposed here.

4. FUTURE RESEARCH AND CONCLUDING REMARKS

This paper presented the domains and indicators that could be used to measure the optimization of capacity and improvement of municipal resources and processes.

Thus, it will be offered one practical tool to measure how smart a city can be, and identify which areas, goals and practices may be planned strategically to allow cities to truly be classified according to their skills and capabilities.

To create a maturity model of this kind, it was necessary to perform a severe survey data in government databases, understanding the dynamics of public service and above all, establish indicators that are likely to be achieved, regardless of the size of the city.

This model is being developed in partnership with three Brazilian universities and their researchers are coordinating with the municipalities where these institutions are located so that can implement and test the following levels of this model.

Besides, from now on the next works it is already defined the use of this model for cities in different regions at different sizes in the country.

5. ACKNOWLEDGMENTS

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