Session 7.7: Innovations Driving for Greener Policies and Standards – Smart Initiatives

Smart Cities: Selection of Indicators for Vitória

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ABSTRACT

Since 2007, urban cities have become the main living environment of humanity, as opposed to rural areas. Thus, with the increase of urban areas, it is appropriate to develop techniques for the orderly and integrated growth of the cities. The concept of Smart City arises in this context. Considering the particular challenges of each city to become a Smart City, it is necessary to select specific indicators to meet these different requirements. This article aims to select the most adequate indicators to measure Vitória's performance as a Smart City. The European Smart Cities assessment tool was selected and studied to serve as a reference for the selection process of indicators. Afterwards, the indicators were selected based on suitability, clarity and availability criteria, and weights were assigned by their relevance, based on their compliance with the strategic goals of the city. This study suggests the indicators to measure Vitória's performance and reveals the need to improve the tool with the addition of indicators that are more suitable to local needs.

Keywords: smart city, indicators, green rating tool

1. INTRODUCTION

In 2007, the world's urban population surpassed the rural population for the first time in history. Currently, 54% of the world population live in urban areas, and the forecast is that by 2050 this figure will reach 66%. In Brazil, the urbanization rate is even higher. Currently, 85% of the Brazilian population lives in cities, and it is estimated that by 2050 this figure will reach 91% (United Nations, 2015). Increasing urbanization inflicts obstacles to cities, as it contributes for the emergence of infrastructure, mobility, and environmental problems, and consequently affect the quality of life of the population. In this context, the Smart City concept arises, as an urban planning model aimed at the development of cities through a combination of human and technology capital (Angelidou, 2014).

Although there is no consensus about its definition, it is widely held that Smart Cities are characterized by the use of Information and Communication Technologies (ICT) in order to help cities to make better use of its resources (Neirotti *et al.*, 2014). However, despite the importance of technology, there is a need for investment in human capital for the development of an efficient strategy for Smart Cities. (Angelidou, 2015; Monfaredzadeh and Krueger, 2015). The adopted Smart City concept is based on Caragliu *et al.* (2011), who state that a city is considered to be smart "when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance".

According to Neirotti *et al.* (2014) there is some difficulty in establishing worldwide definitions and trends for Smart Cities, since the initiatives are implemented under different contexts and realities. The Smart indicators of the cities should consider specific variables that capture particular characteristics, such as local culture, political leadership, population density, economic development and climate conditions. Therefore, it is noteworthy that each city faces specific challenges, hence its Smart indicators must be particularized. In this context, the focus of this research is on the city of Vitória, Brazil. The choice of this subject matter is because this municipality has a 100% urbanised territory and a high population density, with more than 3,000 inhabitants/ km² (Oliveira *et al.*, 2014).

This study aimed to select and assign weights to assessment indicators for Vitória, according to the Smart City concept. This set of indicators should measure the city's progress and be periodically updated. Thus, it is assumed that it is possible to evaluate Vitória's evolution in relation to the selected indicators, by providing data to the government assisting the development of specific policies and guiding investments. It is therefore expected that

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the local population be positively affected, since the Smart City attributes are aimed at sustainable development and the improvement of the population quality of life.

2. METHODOLOGY

After a literature review to establish the state of the art theme, this research was developed in three main stages. The initial stage consisted of select an assessment tools, based on specific criteria, which served as reference for the choice of indicators for Vitória (Tab. 1). The selected tool was thoroughly studied, seeking a clear understanding of its conceptual guidelines, specific goals and methodologies associated with the indicators. In the second stage, the reference tool indicators were selected, based on suitability, clarity and availability criteria. In the third stage weights were assigned to the selected indicators, judging their relevance based on their compliance with the strategic goals of the city.

There is currently no unanimity on a methodology or indicators to assess a city in relation to the Smart City concept. In order to select the reference tool for choosing Vitória's indicators, the main urban area assessment systems were identified, specific for Smart Cities or related to the sustainability concept. The score was given by evaluating the relevance of the criteria for the research and suitability of the tool to the criterion. For each tool, the values assigned to the evaluated items were added up, and the one with the highest score was selected as reference for the research, according to Table 1.

This research is based on the first version of the tool European Smart Cities, released in 2007. The assessment system was created in order to assess European medium-sized cities, with populations between 100,000 and 500,000 people, comparing them and identifying their strengths and weaknesses. It presents a total of 74 indicators, divided into six key features: economy, people, governance, mobility, environment and living (Giffinger *et al.*, 2007). According to Giffinger *et al.* (2007), the indicators have their values standardised by z-transform. The score of each domain is given by the simple average of the corresponding indicators. The same goes for the key features, obtained by the simple average of the domains. Thus, the indicators have equal weights.

Assessment Tool	Selection Criteria					
	Developed for assessment of Smart Cities	Free access to assessment methodology	Developed in Brazil	World-wide recognition	Academic relevance	Total sum
European Smart Cities	6	3	1	1	1	12
Connected Smart Cities	6	1	3	0.5	0.5	11
CASBEE for Cities	4	3	1	1	1	10
AQUA Bairros	2	3	3	1	1	10
Green Star Communities	2	3	1	1	1	8
LEED ND	2	1	1	1.5	1.5	7
BREEAM Communities	2	1	1	1.5	1.5	7
HQE UPD	2	1	1	1	1	6

Keys:

- 6 — Very relevant criterion and very adequate tool
- 4 — Very relevant criterion and adequate tool
- 3 — Relevant criterion and very adequate tool
- 2 — Relevant criterion and adequate tool
- 1.5 — Irrelevant criterion and very adequate tool
- 1 — Irrelevant criterion and adequate tool

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2 Very relevant criterion and inadequate tool	1 Relevant criterion and inadequate tool	0.5 Irrelevant criterion and inadequate tool

Table 1: Selection of reference tool

In the second stage of the research, the reference tool was used as a source for the acquisition of indicators for Vitória's Smart assessment. Each item proposed by the structure was analysed according to the following criteria:

- Suitability – considers whether the indicator is adequate to assess Vitória;
- Clarity – evaluates whether the purpose of the indicator or data related to its acquisition is understandable;
- Availability – amongst the defined research sources – IBGE and City of Vitória websites – it identifies if there are similar available data.

The indicators that not fulfilled simultaneously these criteria were not eligible for the following step. After the selection of indicators for Vitória, it was deemed necessary to assign weights in order to provide a hierarchical reading of the items, facilitating the analysis in investment decisions. Thus, in the third stage of the research, the proposed system classifies each indicator according to its relevance, which is based on the relationship with the strategies presented in the 2008-2028 Agenda of the City of Vitória. Each indicator is evaluated under the perspective of the Agenda themes, and its relevance is judged based on the type of relationship they establish with them, whether direct or partial.

The Agenda is the third revision of the strategic plan drawn up according to the 1992 Rio Summit, and it was developed by a multidisciplinary technical team and representatives from various social sectors of the city. The population participated in the Agenda development through debates in seminars and surveys, signalling their main demands and expectations to the City. Thus, the document proposes strategic goals in line with the local reality. The strategy is based on three main themes that steered the plan's guidelines (Agenda Vitória, 2016):

- Economy – involves issues related to the dynamics of labour and production, productive investments, Science and technology, innovation, workforce qualification, specialized activities, labour market, ports and airports;
- Urban-Environmental – prioritizes issues related to the environment and urban infrastructure, such as mobility, sanitation, housing, clean energy and urban planning legislation;
- Sociocultural – addresses areas related to citizenship, human rights, social welfare, culture, education, health, security, employment and income and population dynamics.

Considering the above-mentioned criteria, weights were assigned to the indicators. First, we evaluated the relationship of each indicator with the Vitória 2008-2028 Agenda themes, considering its direct or partial affinity (Eq. 1). Then, its weight was calculated in contribution percentage for the scoring of each key feature (Eq. 2).

$$CM_i = ADR_i \times 2 + APR_i \times 1$$

Equation 1

where ADR_i = sum of the amount of themes directly related to indicator i; APR_i = sum of the amount of themes partially related to indicator i

$$IW_i = \frac{CM_i}{\sum_{i}^{n} CM}$$

Equation 2

where $\sum_{i}^{n} CM$ = sum of CM of all indicators of the key feature.

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3. INDICATORS FOR VITÓRIA'S SMART ASSESSMENT

The second stage of the research has resulted in the identification of 39 indicators (Tab. 2). Among the excluded indicators, it is noteworthy that about 63% received a negative response only to the data availability criterion, which was the main cause of exclusion of indicators.

The third stage of the research consisted in assigning weights to the selected indicators based on the strategic themes of the Vitória Agenda. We highlight the indicator Social Welfare Return Index (Índice de Retorno de Bem-Estar à Sociedade - IRBES), which stands out with the highest relative weight in the context of its category (Governance dimension), with 46.15%. This indicator compares the tax burden to the Human Development Index (HDI), thus is directly related to the three strategic themes of the Agenda and establish a direct relationship with them. Next, with the relative weight of 27.27%, are the indicators Ratio of Students Enrolled in High Quality Courses, Percentage of Population with 13 or More Years of Schooling, and Ratio of Workers in STEM Occupations, components of the People dimension.

Table 2 presents the set of indicators for Vitória's Smart Assessment, their adaptation based on locally available data and respective weights.

	Factor	Indicator	Adapted Indicator	DR	A DR	PR	A PR	CM	IW
ECONOMY	Innovative spirit	R&D expenditure in % of GDP	State government investment in C&T/State budget	E	1	S	1	3	13.64 %
		Employment rate in knowledge-intensive sectors	Proportion of workers in STEM occupations (Science, Technology, Engineering, Mathematics)	E	1	S	1	3	13.64 %
	Entrepreneur-ship	Patent applications per inhabitant	Patents registered in ES year/100,000 Inhabitants	E	1	-	0	2	9.09%
		Self-employment rate	Self-employed workers/Total workers	E	1	-	0	2	9.09%
		New businesses registered	New companies registered	E	1	-	0	2	9.09%
	Productivity	GDP per employed person	GDP per capita	E	1	-	0	2	9.09%
	Flexibility of labour market	Unemployment rate	Unemployment rate	E+S	2	-	0	4	18.18 %
	International embedded-ness	Air transport of passengers	Embarked and disembarked passengers/Year.	E	1	-	0	2	9.09%
		Air transport of freight	Participation in national freight handling (t)/Year	E	1	-	0	2	9.09%
MOBILITY	International accessibility	International accessibility	Existing ports and airports	E	1	U+S	2	4	23.53 %
	Availability of ICT-Infra-structure	Computers in households	Households with computers	E+S	2	-	0	4	23.53 %
		Broadband internet access in households	Percentage of households with access to broadband internet, compared to total households	E+S	2	-	0	4	23.53 %
	Sustainable, innovative and safe transport systems	Green mobility share (non-motorized individual traffic)	Motorization rate (Vehicles/100 Inhabitants)	U	1	-	0	2	11.76 %

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	Factor	Indicator	Adapted Indicator	DR	A DR	PR	A PR	CM	IW
		Traffic safety	Total number of traffic accidents (with or without victims)	U	1	S	1	3	17.65 %
ENVIRONMENT	Attractivity of natural conditions	Sunshine hours	Annual solar radiation (hours)	-	0	U	1	1	7.14%
		Green spaceshare	Total square meters of green area per capita (annual measure)	U	1	-	0	2	14.29 %
	Pollution	Particulate matter	Annual daily average of PM10 concentrations (µg/m³)	U	1	-	0	2	14.29 %
		Fatal chronic lower respiratory diseases per inhabitant	Number of deaths from respiratory diseases per 10,000 inhabitants	S	1	U	1	3	21.43 %
	Sustainable resource management	Efficient use of water (use per GDP)	Average estimated water consumption in m³/ inhabitant, per month	U	1	E	1	3	21.43 %
		Efficient use of electricity (use per GDP)	Average consumed electricity, in kwh/inhabitant, per month	U	1	E	1	3	21.43 %
PEOPLE	Level of qualification	Importance as knowledge centre (top research centres, top universities, etc.)	Ratio of students enrolled in high-quality courses (4 and 5 ENADE scores)	S	1	E	1	3	27.27 %
		Population qualified at levels 5-6 ISCED	Percentage of population with 13 or more years of schooling	S	1	E	1	3	27.27 %
	Social and ethnic plurality	Share of foreigners	Foreigners living in the state/10,000 Inhabitants	-	0	S	1	1	9.09%
		Share of nationals born abroad	Naturalised foreigners living in the state/10,000 Inhabitants	-	0	S	1	1	9.09%
	Creativity	Share of people working in creative industries	Ratio of workers in STEM occupations (Science, Technology, Engineering, Mathematics)	E	1	S	1	3	27.27 %
LIVING	Cultural facilities	Theatre attendance per inhabitant	Audience of the National Theatre Festival of Vitória/1,000 Inhabitants	S	1	-	0	2	8.70%
	Health conditions	Life expectancy	Life expectancy at birth	S	1	-	0	2	8.70%
		Hospitals beds per inhabitant	Inpatient beds in public and private health facilities/1,000 Inhabitants	S	1	-	0	2	8.70%
		Doctors per inhabitant	Number of doctors/10,000 Inhabitants	S	1	-	0	2	8.70%

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	Factor	Indicator	Adapted Indicator	DR	A DR	PR	A PR	CM	IW
		Satisfaction with quality of health system	Positive assessment of emergency care at home or hospitalization for 24 hours or more by the public health system (SUS)	S	1	-	0	2	8.70%
	Individual security	Crime rate	Homicides per 100,000 Inhabitants	S	1	-	0	2	8.70%
		Death rate by assault	Armed robbery per 100,000 Inhabitants	S	1	-	0	2	8.70%
	Housing quality	Share of housing fulfilling minimal standards	Percentage of households served by the sanitation system network	U	1	S	1	3	13.04 %
	Touristic attractive-ness	Overnights per year per resident	Hotel occupancy rate	E	1	S	1	3	13.04 %
	Economic welfare	Poverty rate	Incidence of poverty	E	1	S	1	3	13.04 %
GOVERNANCE	Participation in decision-making	City representatives per inhabitant	City Council representatives/ 100,000 Inhabitants	-	0	E+ S+ U	3	3	23.08 %
		Share of female city representatives	City Council female representatives/Total City Council representatives (Percentage)	-	0	S	1	1	7.69%
	Public and social services	Expenditure of the municipal per resident in PPS	IRBES (Índice de Retorno de Bem-Estar à Sociedade – Social Welfare Return Index)	E+S +U	3	-	0	6	46.15 %
		Share of children in day care	Percentage of enrolment compared to demand	S	1	E	1	3	23.08 %

Table 2: Indicators for Vitória's smart assessment

Keys: DR directly related, PR partially related, E economical axis; S sociocultural axis, U urban-environmental axis, ADR amount directly related, APR amount partially related, CM calculation method, IW indicator weighting

4. FINAL CONSIDERATIONS

This article is the first step to develop an assessment tool for Vitória under the Smart City concept. The development of a consistent assessment tool requires the selection of relevant indicators, aligned with the defined goals and targets (Hák *et al.*, 2015). Amid a large number of indicators, it is assumed that the first step in the development of the assessment framework is to define the city's strategy, in accordance with the adopted concept of Smart City and Sustainable Development Goals. The importance of defining city level strategies is stressed, due to the relevance of local characteristics and challenges (Shen *et al.*, 2010). The Vitória Agenda defines the strategy at the local level and displays important diagnostics and considerations. However, it is not clear as to setting goals and targets to be achieved, hindering the selection of indicators.

The main challenge of the research was the access to reliable information, especially at the local level. In some cases, the use of the metropolitan region or state data was accepted, in order to not hinder the work, since the percentage of excluded items for lack of similar data was high. The data sources used for this research are public databases, and their publication, in general, does not occur on an annual basis, which also makes it difficult to obtain updated data.

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The high weight assigned to the indicator IRBES may have occurred because the Governance dimension has a lower amount of items when compared to the others. Thus, for a proper assessment, the need to add new indicators to this dimension is clear, in order to achieve a better balance in the allocation of weights.

By analysing the proposed indicators for the European medium-sized cities, the authors emphasise the difference between their development levels compared to the Brazilian cities. The tool used as reference does not address issues that correspond to recurring problems in Brazil, such as illiteracy and infant mortality. Thus, the need to continue the research is realised, in order to, once again, supplement the list of indicators with new items according to the local reality, grounded on other existing assessment tools.

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