

Smart Cities in Latin America

Realities and Technical Readiness

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Abstract. In almost every forum around the world, country leaders are discussing the necessity of creating smart cities. However, even the term “smart city” is diffuse nowadays. Some countries want their cities to become smarter and others want to create smart cities from scratch. Several mappings have been developed around the world to locate the smartest cities. We believe that, since Latin American and Caribbean countries are exploring in the creation of smart cities, a proper mapping and plan is necessary to assure that the efforts in creating smart cities are not a waste. Using a literature review and a survey, we try to determine the state of smart cities development and its technical readiness in the Region.

Keywords: Smart city · IoT technologies · Technical readiness

1 Introduction

Even though several international forums are discussing heavily on the topic, the definition of smart cities is still diffuse [1]. On its basis, smart cities represent an urban development model that utilizes human, collective, and technological capital for the development of urban agglomerations.

Smart cities development should be conceived as a multidisciplinary task that includes socio-economic, governance, and multi-stakeholder aspects [2]. Moreover, it is driven by advances in technology and urban development. Smart cities use information and communication technologies (ICT) to enhance quality of services, reduce resource consumption, and improve communication between citizens and government (to make them efficient, sustainable and attractive to residents and businesses) [3].

Problems associated with urban agglomerations have usually been solved by means of creativity, human capital, cooperation (sometimes bargaining) among relevant stakeholders, and bright scientific ideas: in a nutshell, ‘smart’ solutions. The label ‘smart city’ should therefore point to clever solutions allowing modern cities to thrive through quantitative and qualitative improvement in productivity [4].

European and North American cities dominate the list of the 50 smartest cities in the world according to [5]. Buenos Aires, Argentina, is the top Latin American ranked city, occupying the 83rd position on the IESE Cities in Motion Index 2017 [5].

We believe that, since Latin American and Caribbean (LAC) countries are exploring in the creation of smart cities, a proper mapping and plan is necessary to assure that the efforts in creating smart cities are not a waste. In this paper, we try to determine the state of smart cities development and its technical readiness in the LAC region.

The structure of this paper is as follows. Section 2 describes Smart Cities and its dimensions. Section 3 describes the quality of life in Latin American and the Caribbean (LAC) cities. Section 4 shows evidence of smart cities in LAC. Section 5 describes the methodological approach followed on this research. Sect. 6 presents the results of the survey conducted and Sect. 7 our conclusions.

2 Smart Cities Definition

There are several definitions of smart cities. However, for the purpose of this paper a city would be considered “smart” if it applies ICT based solutions to problems in these six dimensions: governance, quality of life and essential services, transportation (mobility), economy, people, and environmental issues.

The *governance* dimension considers all forms of social coordination and patterns of rule. ICT solutions are applied in this domain to provide citizens with easy access to government services, enable information-based decision-making and increase transparency [6].

As for the *quality of life* or *living* dimension, a smart city must of course consider ICT-enabled life styles and consumption. It should stimulate healthy regimes for its population and assure safety, provide quality housing and accommodations. It would be expected of a smart city to provide decent cultural and education facilities and to have touristic attractiveness. Finally, a high degree of social cohesion would be expected, although this might not be the result of this dimension alone [7].

The *mobility* or transportation dimension includes integrated transport and logistics systems (i.e., interconnected trams, buses, trains, metros, taxis, among others). Moreover, smart cities should provide accessible and efficient ways for pedestrians and other vehicles to mobilize (e.g., smart traffic lights and signals). Besides, non-motorized means of transportation should be prioritized.

In the *economical* dimension, a smart city will be expected to have e-business and e-commerce support, ICT-driven manufacturing, delivery of services and innovation.

The essence of a city is its *people*. In the people dimension, a smart city should provide inclusive education and training that fosters creativity and innovation. Access and use of communication technologies should also be supplied [8].

Finally, in the *environment* dimension, renewable energy, smart electric grids, green buildings, efficient use of resources and several other strategies must be addressed and worked on to consider a city environmentally smart [9]. Table 1 shows a summary of cities indicators of “smartness” proposed by Cohen [10] for the six dimensions previously mentioned.

Table 1. Summary of cities indicators of “smartness” (source: Smart City Index [10])

Dimension	Working areas
Government	Online services/Infrastructure/Open government
Living	Culture and well-being/Safety/Health/Technology infrastructure
Mobility	Efficient transport/Multimodal access/Technology infrastructure
Economy	Entrepreneurship & innovation/Productivity/Local and global connection
People	Inclusion/Education/Creativity
Environment	Smart buildings/Source management/Sustainable urban planning

3 Quality of Life in Latin American and the Caribbean Cities

LAC is the region with the largest proportion of the population concentrated in megacities, that is, cities with more than 10 million inhabitants [11]. In 2016, 12.7% of the total population of the region lived in 5 megacities, but this percentage will rise to 14.3 when Bogotá reaches this city category, estimated to happen in 2030 [11].

Cities drive LAC economies, but disparities are a constant. Informal labor plays a very important role in LAC economies, but at the same time contribute to inequality [12]. Cities in LAC are the most unequal in the world, which undermines urban prosperity and can affect personal security and safety [12, 13].

Public security remains as the weakest point of LAC urban life [14, 15]. This region has one of the world’s highest rates of victimization (robbery). Lack of security and personal safety limits “freedom, mobility, productivity and public interactions” [13], which decreases quality of life. Therefore, the financial burden of crime is high, ascending, in some cases, up to 25% of the gross domestic product (GDP) of the country, for example, in Colombia and El Salvador.

Quantity and quality of dwelling houses is not sufficient to warranty adequate conditions to LAC city inhabitants [13]. Access to electricity is practically universal in urban areas (95%). Access to running water is high (85%), but the region is very heterogeneous because some cities have serious shortages and others do not face this problem [14]. Cell phones and fixed lines are widespread in LAC cities [13]. The cell phone sector contributes significantly to the region’s public finances and economy.

Problems in LAC cities are: persistent deficit in dwelling of quality, insecurity, traffic congestion, lack of public space, and severe economic segregation [14].

LAC cities are expanding their area at a higher rate than the increase of their population [12]. This is unsustainable in the long term and causes physical and social fragmentation. The region needs to develop territorial policies for making better use of the available space and preventing environmental disasters due to degradation of the ecosystem [12].

Despite health services, roads, air quality, water quality, and traffic flow are deficient, when LAC citizens were asked about their degree of satisfaction with the city they live in, these aspects did not have significant impact in their quality of life [14]. Particularly interesting is the traffic congestion issue. LAC has the highest motorization rate of all developing regions, with the consequence of less use of public transport [13]. Lack of

security and physical expansion of cities are two of the triggers of high motorization. Traffic congestion is the most important infrastructure deficiency in LAC cities [13].

Governments do not pay attention to the creation and maintenance of public spaces, such as parks. Shopping malls are the new socialization spaces [12].

LAC cities face environmental problems [13]. Sanitation is not adequate in many cities. Waste management is a major problem in some of them [12]. The environmental situation creates health and environmental hazards.

Urban governance is a topic that requires attention. There is a significant progress in democratization and decentralization, but it does not mean that resources and capabilities have been transferred to local governments [12]. More active citizen participation has to be encouraged in order to strengthen more transparent governance processes. A taxation culture has to be established, so that local governments can work with effectiveness, efficiency, and equality [16].

E-government must become a priority for local governments. Successful experiences in Colombia, Uruguay and Panama show that political support of the project, qualification of human resources, and availability of financial resources are key factors [16]. All governments in LAC face the challenge of providing high broadband connectivity to remain competitive.

Perceived impediments to the prosperity of LAC cities are, on descending order of importance: poor governance and weak institutions, high incidence of slums and poverty, high levels of crime, corruption, high cost of doing business, inadequate infrastructure, and low levels of human capital [13]. LAC cities face these great challenges to become smart. However, these impediments can also constitute opportunities to improve quality of life, which could be addressed through “smart” initiatives driven by ICTs.

4 Latin-American and the Caribbean Smart Cities

According to our literature review, the number of cities with smart initiatives in LAC is relatively very low compared with the number of large cities (more than one million inhabitants) in the region. They constitute only one percent of all smart cities in the world [17]. According to [18], the eight smartest cities in LAC are:

- | | |
|-----------------------------|----------------------------|
| 1. Santiago (Chile) | 5. Rio de Janeiro (Brazil) |
| 2. Mexico City (Mexico) | 6. Curitiba (Brazil) |
| 3. Bogotá (Colombia) | 7. Medellín (Colombia) |
| 4. Buenos Aires (Argentina) | 8. Montevideo (Uruguay) |

These cities have developed very diverse projects. Most of them have focused on transport (e.g.: public bicycles and bus corridors). Environment, more efficient energy use, and security are some of the aspects that have also been addressed. Other cities in the region that have started at least one “smart” initiative are Lima (Perú), Quito (Ecuador), Monterrey (México), Panama City (Panama), Santo Domingo (Dominican

Republic), Sao Paulo (Brazil), Paraná (Brazil), Juarez (Mexico) and Nassau (Bahamas) [17, 18]. LAC cities characterized as smart still face great challenges and have a long way before they become truly smart cities.

Mexico is developing the project called IQ Smart City for building the first smart city of the country, Ciudad Maderas [19]. The idea was proposed to the local government by the cluster of information and communication technologies of the State of Querétaro. The project includes building a smart energy grid. Juan Carlos Coronado, director of the project, believes that thinking about a large city becoming smart requires a larger investment in infrastructure than building a new relatively small smart city. The Ciudad Maderas project could be replicated in LAC.

The case of Ciudad Maderas illustrates what Lucas Lanza says *“The challenge for a city to turn “smart” ... is a process that requires developing a capacity to reach agreements and a global consensus about the best interfaces between public and private actors and a balance between technology and politics”* [20].

Some urban developments in LAC are still oriented to creating isolated communities, a tendency during the last decades with the goal of achieving security. For example, Ciudad Cayalá, near Guatemala City, is a private real estate development that includes dwelling and commerce facilities for high income class residents and is surrounded by a wall [21]. Though Ciudad Cayalá could be considered a smart city because of the use of technology, it does not lead to the inclusion of all urban social groups.

LAC is a heterogeneous region. No rules can be applied to all cities. Each LAC city wanting to become smart has to analyze its weaknesses and establish priorities, since financial resources are limited. Understanding citizen concerns and needs is crucial for success.

5 Methodological Approach

In this paper, we propose a methodological approach to discover and assess the realities and technical readiness for Smart Cities in LAC. This proposal is driven by the fact that several smart cities in LAC are being proposed; however, most of them lack (or at least there is no academic evidence) of a proper assessment of the current status of “smartness” in the main cities or proposed cities in the region. We believe that technical readiness and a diagnosis are necessary to reassure that smart cities will be successful both within themselves and interconnecting among them.

The desk research approach has been applied in several projects with the goal of mapping smart cities. Our proposal does not escape from this reality since the first step was to **conduct a literature review** including academic sources, national reports and plans. Unfortunately, this documentation is not always available in all LAC countries or it is not updated. During a brief review, we found that the main sources of information easily findable about smart cities in LAC were news or media reports (most of them lacking a systematic approach).

A review of smart cities, initiatives and projects was conducted. For the purpose of this paper, a city becomes smart if a series of initiatives (different dimensions) are carried, and an initiative is composed of projects (same dimension). Information at this

level was not found in literature or web browsing. Therefore, a deeper search in LAC countries national archives and smart cities proposals should be performed.

Parallel to the literature review, an updated *assessment of the smartness of cities* in their current state became necessary. A *cross-sectional study* could allow the identification of patterns when comparing cities characteristics and their level of smartness in the region. To assure that the smartness of cities is measured systematically, a the *Smart City Index Master Indicators Survey* [10] has been proposed by the literature as *evaluating instrument*.

We designed an on-line survey using Lime Survey, and used its categories, to try to assess the level of smartness in the LAC region. The survey included:

- Information on the city the interviewee lives in (name, type of city, and size, based on the categorization proposed by Doxiadis Konstantinos [22].
- Data of the interviewee: his/her area of your expertise and knowledge on the concept of smart cities and on the following technologies used
 - interaction with the environment
 - sensors, actuators
 - Internet of Things (IoT) service architecture
 - data storage
 - open data, ontologies, taxonomies, and data integration
 - cloud computing
 - decision making
 - data analytics, data visualization, and big data
 - domain specific modeling
 - crowdsourcing and collaborative decision making
- Data on the interviewee's perception on the city's state of smartness, and on the potential benefits of and the viability of becoming smart, for each of the specific Smart City dimensions presented in Table 1.
- An open question for comments participants wanted to make about the topic.

An online questionnaire was designed mainly with closed questions to ease its analysis. It was distributed using the institutional representatives and divulgation mailing lists of CLEI (Latin American Center for Informatics Studies) augmented by the Central American mailing list of WITFOR 2016 (World Information Technology Forum). People receiving the questionnaire link were invited to share the survey among colleagues. Anonymity was offered and an open space for suggestions or general comments was provided.

6 Results

The following subsections describe the demographic data on participants and results obtained about Smart City technical readiness and smartness of LAC cities, as reported by participants.

6.1 Demographic Data of the Survey

The questionnaire remained open until the last week of April 2017. We received 154 complete valid responses.

Figure 1 shows the distribution of respondents per country. Although it is not evenly distributed amongst LAC countries, most countries are represented, except small and insular countries in the Caribbean. Participants' areas of expertise are Computer Science (76%), Electrical Engineering (13%), other engineering (7%), and other 4%.

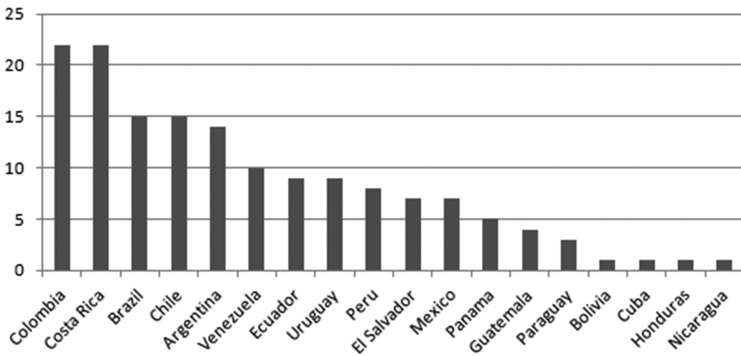


Fig. 1. Number of responses per Country

Respondents were asked to typify the smart city situation of the city they lived in. Figure 2 categorizes the response frequency per size of city. Almost half of the responses correspond to metropolis (26%) and large cities (23%). Moreover, many of the largest cities are also represented, conurbation (15%) and megapolis (8%). Smaller urban areas are also represented by cities (15%), large towns (10%) and towns (3%).

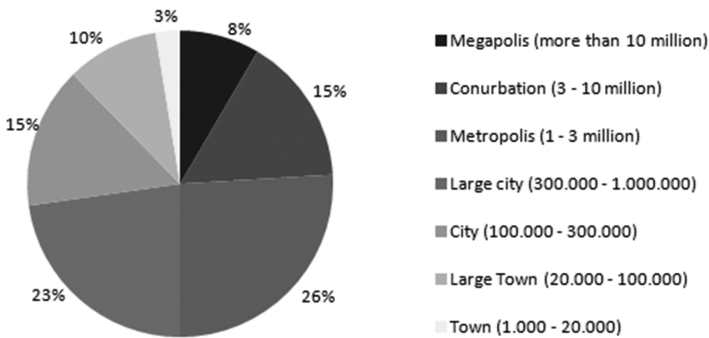


Fig. 2. Percentage of responses per city size

Responses were also categorized by type of city. The resulting distributing was 41.9% Capital city of the country, 48.4% Capital of province or department, and 9.7% other type of cities. Responses were tabulated by city size and by type of city. Results

by city size are considered more interesting and therefore are reported in Sect. 6.3 using this categorization.

6.2 Smart City Technical Readiness as Reported by Respondents

As can be seen in Fig. 3, the understanding of the Smart City concept is normally distributed among respondents. One third of the respondents report they have very good or excellent knowledge; one third report having good knowledge; and finally, one third report having poor or fair technical knowledge of the concept of smart cities.

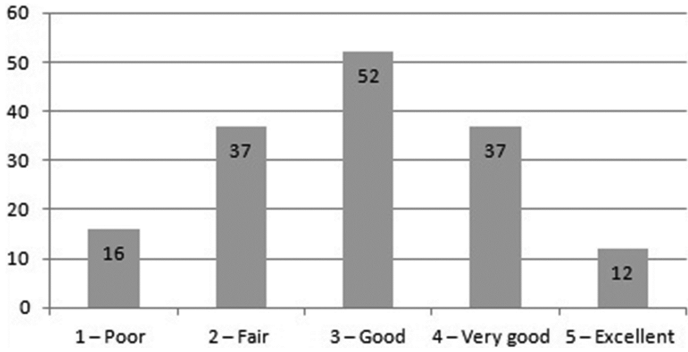


Fig. 3. General knowledge of the concept of Smart Cities of respondents

Figure 4 displays the average level of knowledge reported by respondents on the different technologies used to develop smart city applications. Although small differences exist, the level of average technical expertise is low. It ranges from 2.82 to 3.26, which correspond only to **good**, corresponding to the same scale used in Fig. 3. This situation is especially worrying knowing that the areas of expertise of 96% of participants is Computer Science, Electric Engineering or any other engineering, critical knowledge fields for creating smart cities.

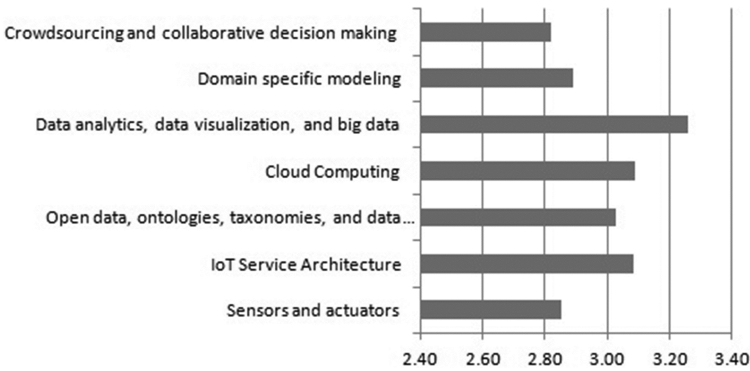


Fig. 4. Average specific knowledge of respondents

The distribution of technical knowledge on specific technologies can be seen on Fig. 5. There are not significant differences among the distribution of knowledge level reported on the seven different technologies. It is worth highlighting that only a small percentage of respondents consider themselves as experts on the subject.

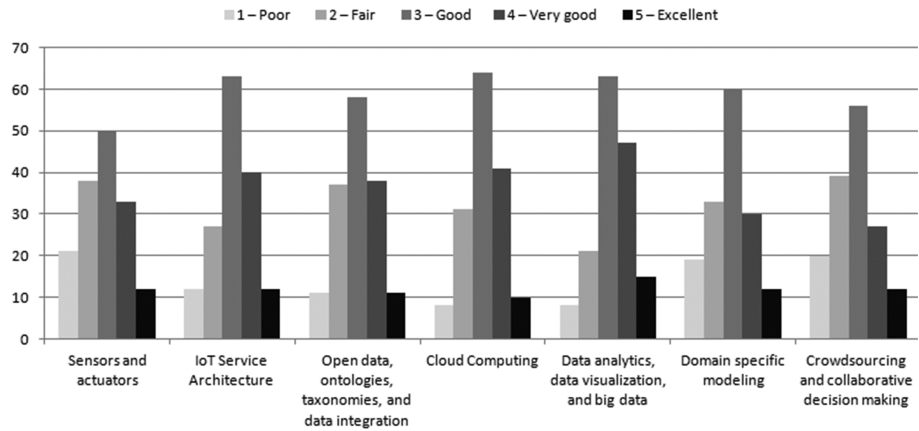


Fig. 5. Distribution of specific knowledge of respondents

6.3 Smartness of LAC Cities

Figure 6 demonstrates the exiting gap between the level of smartness of LAC cities (considerably low), and the perceived potential benefits from the six dimensions of

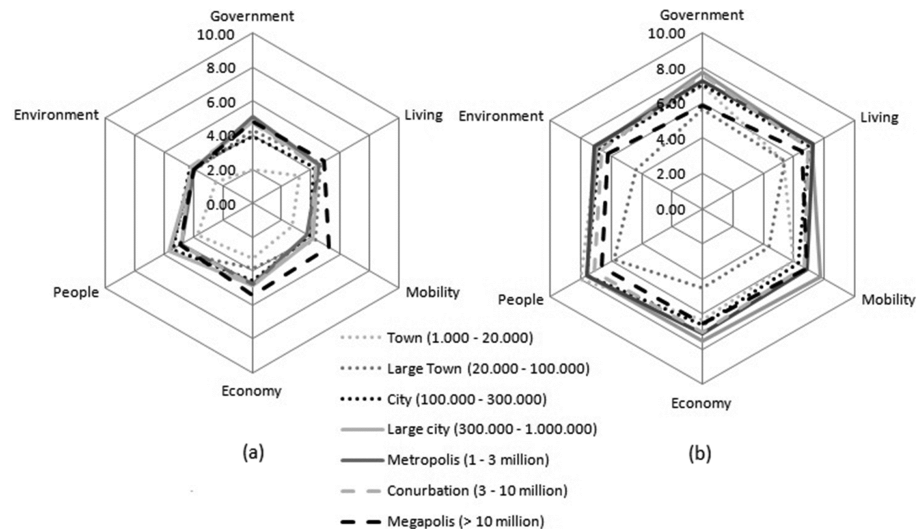


Fig. 6. City degree of smartness (a) and perceived degree of benefits from implementing the six dimensions of Smart Cities (b)

Smart Cities (deemed considerably high). *How Smart is your city?* In each dimension was graded by respondents on a range from 1 to 10. All average grades are below 6 and very few average grades surpass the middle grade of 5. On the other hand, benefits of adding smartness to the city range much higher, with average grades between 6 and 8, except from large towns. Maybe their inhabitants regard automation as unnecessary and value their more relax way of living.

Most cities in the Region face a similar situation. However, some differences exist due to the city size. As expected, towns are the ones that report less technological smartness, and people from Megapolis report a slightly higher effort on using ICT to address their urban needs and problems. Environment smart applications seem to be the least developed, and Government, Economy, and People are the relative strengths regarding smart development in LAC. Mobility on Megapolis has also received attention.

The most surprising response is reflected on Fig. 7, to the question *How viable is to add smartness to your city?* Average responses are very optimistic. Except from people living on Cities (100.000–300.000), average responses range from 6 to 8. Large towns regard giving smartness to their cities as less viable. The People dimension is the one reaching the highest punctuation in cities with up to 300000 inhabitants.

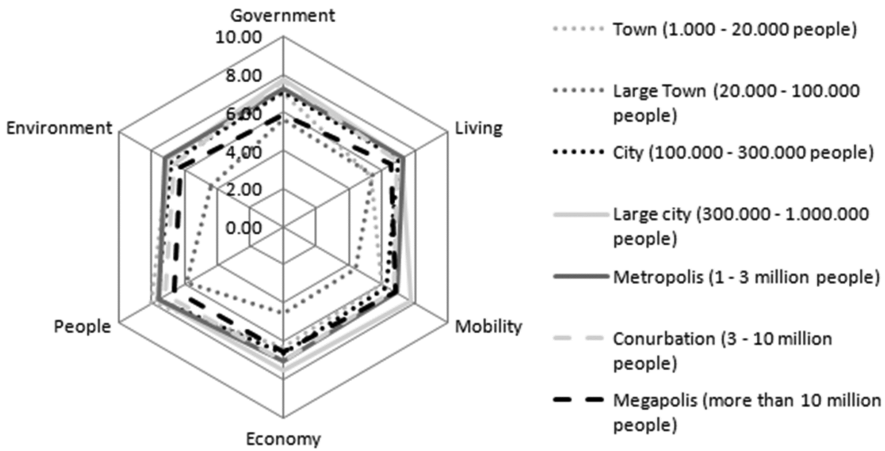


Fig. 7. Degree of viability of implementing the six Smart City dimensions

The viability question is the only one in which participants could decide if they wanted to respond. This decision was driven by the difficulty of the question, since deciding on the technical, economical, and political viability of developing smart applications for most dimensions is very complex. Only 10% of participants felt they could not answer the viability question. We expected a higher rate of *no response*. We suspect most participants answered this question regarding mainly on technical viability.

Some interesting insights of this research are the following:

- “Adding smart features to a city is not just a matter of installing services or devices, it has to be an integral process. People’s needs have to be identified, modeled, understood and then solutions have to be designed and prototypes have to be built.”

- “the main difficult obstacle for smart cities is to reach an efficient articulation between the main actors in city management (local government, academia and industry)”

Another interesting finding in the responses is that, in several cities there are isolated smart city initiatives. However, the lack of a governmental approach prevents the growing of these initiatives.

Finally, some respondents think that university cities and small cities could be used as laboratory settings because there is less resistance to change.

7 Conclusions

Smart cities are a hot topic nowadays and can provide several benefits to the inhabitants of cities around the world. This paper presented the results of a regional survey assessing the viability and technical difficulties of developing smart cities. The goal of this research was to understand the realities and expectations of smart cities in Latin America.

One hundred fifty-five (155) experts in technical areas answered an online survey. Towns and cities ranging from thousands to millions of inhabitants were considered. Moreover, six dimensions of smartness were considered: government, living, mobility, economy, people, and environment.

The perceived level of smartness of cities was average, around 4.5 in a scale (1–10). However, the potential benefits of becoming smart are evident, 8.2 in a scale (1–10), and the perceived level of viability was 6.9 in a scale (1–10).

Despite being so positive about viability, some participants highlighted that the establishment of smart cities is an integral process that requires more than technology. According to participants, a national policy on technological development and articulation of different actors, including the government, industry and people, are necessary in order to implement smart solutions.

LAC cities are growing continuously, and their urban and quality of life problems are also growing fast, especially on the most populated cities. Solutions are more than ever needed. It is our duty to evaluate and propose alternative solutions and accompany our local and federal governments to implement more smartness into our surroundings. Helping get our international academic communities together to address this challenge may be the best result of the research endeavor.

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