

# On the Way to a Smart City: A viability Analysis of the Transformation Process in Latin America

Elías Iván Ramel<sup>1</sup> and Agustina Noelia Mildemberger<sup>2</sup>

Universidad Tecnológica Nacional, 1033 Almafuerde Av., Paraná, 3100, Argentina

**Abstract.** In a globalized world, smart cities are often analyzed as a process that includes certain elements, tasks and requirements. In an effort to develop the conformation, growth and transformation of these cities, those elements will be studied sequentially considering them as the basic foundations, continuing with the construction of the cities and, finally, their way of operating. In addition, this phenomenon will be studied in Latin America, in order to make comparisons and conclusions, but taking into account the economic and political contexts, and the variability in which the countries are involved. It will be possible to have, in this way, a rather important understanding of priorities, inequalities and aspects of specific cities or countries that are on the smart movement, either because they are smart or because they want to be smart.

**Index Terms**—Globalization, ICT, Latin America Smart Cities, Smart Cities, Smart People, Sustainability, OD.

## I. INTRODUCTION

**P**OPULATION growth worldwide has resulted in dense unplanned urbanization. Although it is difficult to change this trend, the notion of smart cities to address this problem comes as the way forward. It is not just a job for a few, but it implies a social, governmental and industrial collaboration in order to look for changes or progress. In this sense, smart cities should be viewed as a process and as a transformative one.

Numerous social, economic and political studies show the relevance of growing smart cities [1], which involve government actions and, logically, according to the above, globalized urban-economic-environmental development. All this comes together within the United Nations 2030 Global Agenda, SDG #11 (Sustainable Cities and Communities: Make cities human settlements inclusive, safe, resilient and sustainable) [2], and the National

Academy of Engineering Challenge #6 (Restore and Improve Urban Infrastructure) [3]. These global frameworks provide the elements that are fundamental when it comes to being or becoming a smart city, but it is interesting to analyze what would happen if this process were happening in Latin America.

The shortcomings and the state of most of the countries that make up South America are widely known. New directions in terms of sustainability and infrastructure resilience need to be set so as to start addressing this issue. It is for this reason that it is necessary to generate knowledge, understanding and awareness regarding what the smart city process requires or needs in order to take place in Latin America.

The purpose of this paper is to provide a general analysis of a smart city as a constructive process, detailing its main key elements. The present paper is organized this way: firstly, the elements of a smart city as such will be described in an introductory way. Secondly, the functioning of all these elements together will be studied to, finally, observe the situation in the place and context of study (Latin America), in relation to its viability and possible development.

## II. THE FOUNDATIONS OF A SMART CITY

Like a civil construction, nothing can be built without first thinking about the bases; that is, the foundations that are needed to start safely. A smart city needs basic elements, key elements, that together help it to be built or transformed.

There are many definitions of what a smart city is, and they are really subjective, but in order to understand them as a set of pieces that work globally (developed in later

<sup>1</sup> Elías Iván Ramel is a Civil Engineering student at UTN FRP: [eliasramel@alu.frp.utn.edu.ar](mailto:eliasramel@alu.frp.utn.edu.ar).

<sup>2</sup> Agustina Mildemberger is a Civil Engineering student at UTN FRP: [agustinamildemberger@alu.frp.utn.edu.ar](mailto:agustinamildemberger@alu.frp.utn.edu.ar).

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sections), one in particular will be used. As Sikora and Fernández indicate:

A smart city is an intelligent city, that can be considered as a territory with great capacity for learning, innovation, and creativity, where there are research and development institutions, higher education centers equipped with digital infrastructure and communication technologies, and a high level management performance. Cities can be defined as smart, if they have human and social capital, communications, infrastructure, both traditional and modern (transport and communication technologies respectively) and their development conform to the theory of sustainable development. Likewise, the citizen participation in its system of government should contribute towards the improvement of the quality of life [4, p. 135-136].

In this way, it is possible to highlight the factors and key elements that characterize these cities and then carry out a coordinated study of them in the next section.

#### A. Information and Communication Technologies

The growth and importance of Information and Communication Technologies (ICT) in today's interconnected world does not need further justification. Nowadays, it is practically impossible to think of a person or society that does not make use of digital communication services: Internet browsing, telephony, television, commerce and electronic market. The "Internet of Things" (IoT) [5] is absolutely a fact.

Smart cities have a comprehensive approach to the processes that outperform large cities in technological infrastructure and respond to national plans of ICT. In a similar vein, smart-to-be cities follow in smart cities' footsteps, by adapting and modifying different aspects.

In this globalized world, it is an indispensable requirement for cities to be interconnected, to improve their energy yields, to anticipate and act on climate change, and, in synthesis, to transform behaviors and social structures to make them interrelated and intelligent. Definitely, ICT applications for the development of innovative, sustainable, and smart cities have become a new model for municipal cooperation between government and corporations [6].

#### B. Efficient Urban and Construction Planning

Urban planning demands a coordinated effort among administrative scales (national-regional-local) that ensure action and management to address problems, to get feedback and play a good role. Therefore, efficiency will be only achieved with combined efforts, perseverance, methods and organization.

This kind of processes become a priority for smart cities to present a methodology for developing a smart integrated strategy. To this end, it is necessary to consider a future vision or a city project that boosts social/economic/environmental sustainability, including local development, citizen's participation, nature resources conservation and 'urban metabolism', which is a key concept to develop.

It is clearly not possible to speak of urban metabolism without understanding that it represents a key tool for sustainable urban planning, design and infrastructure. As seen in [7, p. 3], "there is an extensive need to quantify the aspects of consumption and waste production of urbanizing

areas. Cities are presumed like ecosystems, an aggregation of various metabolism". And when someone is talking about ecosystems, the discussion focuses on the exchange of matter, energy and information, applied in cities and their inhabitants.

#### C. Improvement of Environmental Sustainability

It is a requirement for smart cities to generate harmony and concordance between environment and sustainable evolution. Residents of smart cities need to optimize energy consumption and be aware of the value of energy, and the losses generated by its misuse. In other words, a green smart city upgrades the quality of life of its citizens and guarantees its own sustainability. Then, the question that can most symbolize this section is how to measure the level of development of sustainability. This can be done in a simple way by observing its indicators: air quality, availability and quality of green spaces, carbon footprint, ecological footprint, water footprint, and emphasis on waste treatment and recycling.

Under the guidelines and recommendations of the United Nations and other national organizations, there are usually national and local organizations that are able to intervene in these measurements and also carry out comparisons between cities, giving rise here to the concept of how green a city is (or could be) like with respect to others. For example, only analyzing green spaces [Fig. 1, 5]:

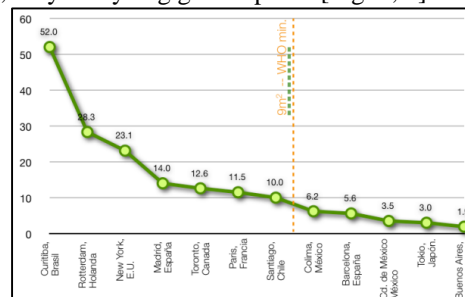


Fig. 1. Comparative representation of square meters of green space per person in cities of the world - Information collected from the 2005 population census.

The World Health Organization (WHO) states that, for public health, every city should have a minimum of 9 m<sup>2</sup> of green space per person (represented by a vertical orange line in the graph). An optimal amount would sit between 10 and 15 m<sup>2</sup> per person. Consequently, it is evident that there is a serious problem: the population tends to continue growing, but not enough new green spaces are created to generate a harmonious and fully dynamic rhythm. All this is about a rhythm that does not go hand in hand with population growth that is exceeded by it and, consequently, generates an impact, which is appropriate to measure.

#### D. Sustainable Urban Mobility and Transport

Transportation greatly influences sustainability and quality of life in cities, and for this reason good planning is required considering social, cultural, economic, political and technological perspectives. To achieve sustainable transportation, there are four main groups of strategies according to [8]:

- 1.Reducing the need for transportation; urban planning, reduction of emissions, reduction of motorized transport.
2. The potentialization of modal change; use of alternative modes of transportation to the private vehicle.
3. Development of clean transportation systems; vehicles with low emissions and use of alternative fuels.
4. Improvement of transport efficiency; reduction of environmental impacts through the control of vehicular flows, the organization and management of traffic. [8, p. 91].

Based on these strategies, different countries can carry out an adequate planning taking into account the mobility patterns and type of transport of their regions to improve and transform them into the required ones by a smart city.

#### *E. Open Data*

The Open Data (OD) concept is probably the least known, but one of the most fundamental when it comes to a smart city and its ideals. Data must be easily accessible, both for citizens of the same city or external entities in general, because it makes their processing possible by citizens and motivates the creation of plans or complementary services, generally by private entities based on the data obtained. This concept is typical of Open Governments (OG) that are transparent and do not hide their information, generating an appropriate environment to capture innovation or collaboration, in the forms of proposals or investments. Then, there is also the political role, whose relevance is undeniable.

In the following two sub-sections, a more concise study of the above-mentioned aspects will be developed.

#### *Free access – Feedback*

Information that should be available to everyone, requires feedback too. The main idea is to create an «OD ecosystem» in which there are mechanisms that can help users to obtain, use and interpret OG data and generate value from it, through the study of their contributions towards information, towards the government and also towards other users. In short, Alexopoulos, Loukis, and Charalabidis suggest that “one essential element of open data ecosystems concerns their development through user adaptation, feedback loops and dynamic supplier and user interactions and other interacting factors” [9, p. 63].

Definitely, feedback is fundamental because it involves citizens in OG administration and promoting their active participation.

In addition, the role of communication technologies and social platforms is important: information and political participation are never missing. They open a new meeting space, which is totally in the hands of the younger population, for example.

#### *Political role*

OG cannot be discussed without understanding the concept that leads the political role in this framework. An OG needs to concentrate a series of functions/roles that make it characteristic, with the aim of being efficient and active in its actions (and consequences). As Geiger and von Lucke note:

One can observe seven different Open Government Trends that describe the characteristics and some features of the concept of Open Government:

- 1) Building of new communities
- 2) Information and Open Data
- 3) Common Editing and Design
- 4) Common Consulting and Discussion
- 5) Common Decision Making and Ordering
- 6) Common Action and Programming
- 7) Common Commenting. [10, pp. 266-267].

There are seven pieces that an OG must put together, in a correctly and orderly way, to generate the processes and also get the necessary feedback. Then, those pieces build concepts. In simple words, this can be translated into a sequence of concepts that the political role must cover, in order to be an OG: transparency in action and execution, accessibility of all data, active listening towards citizens and involvement, and coordination in decision-making, including all participants.

Thinking about OG’s peculiarities and characteristics, in terms of way of acting and the consequent response, it is possible to state: no OD = no OG. There must be transparent and massive collaboration inside a structure in which everything is properly integrated and connected to each other, to prevent it from shaking or falling.

### III. THE CONSTRUCTION AND OPERATION OF A SMART CITY

The above elements alone, even though they are the foundations and important resources, will not work for the purposes that a smart city sets out to do. It is an indispensable and indisputable requirement that they work in a coordinated manner, to achieve efficiency. For this reason, they should be understood through global management and work.

#### *Management and Global Working of the Key Elements*

The key elements previously mentioned in section II are part of the definition of the cities that are defined as smart. This group of key elements compose six “*dimensions*” that give a great notion of what this concept encompasses, in terms of management and working:

- 1) Smart Economy
- 2) Smart Mobility
- 3) Smart Environment
- 4) Smart People
- 5) Smart Living
- 6) Smart Governance [4, pp. 140-141].

For everything expressed in this sub-section and in the previous one, the chain and the links that represent and characterize a smart city are very clear. This lead, as well, to a clear perspective: there is no smart city without smart people.

Beyond presenting these key elements, it is important to analyze the dimension that they allow to create in a smart city. Many current cities own them, and yet it does not mean that they are smart, but it means that they are in a process of adaptation-achievement of objectives. In fact, the concept of smart city is usually associated with an overcrowded city, where there are many small cities

(populationally speaking) that are smart or are in the process of being smart. Often, overpopulation is negative or counterproductive in terms of the work to be carried out and the available economic resources that are destined to them.

On the other hand, it must be understood that the conversion and/or adaptation into a smart city is a continuous process, which requires a certain constancy and logical organization. It is not a question of partial work, for example, in some sections of a locality, but must be present throughout the locality to consider it intelligent. In this way, it can be said that the process can be partial or under development, but it must conclude being global.

#### IV. THE ROUTE TO SMART LATIN AMERICAN CITIES

Now, that the foundations are known, and the construction and operation have already been explained, it is time to discuss the built work: the route, which, although it is already finished, must be traveled.

It is a fact that a smart city represents a process that can be variable from city to city (or, in some cases, from nation to nation), but it shares the objective of being global within the dimension or the true scope that a place has or aims to have. And it requires not only a physical-urban but also an organizational-economic infrastructure. This is also a variable aspect in the different continents of the world, given the same context in which every country is immersed and the impact of globalization on a smart city (or in a smart-to-be city). Therefore, it is convenient and interesting to divide the study of the phenomenon of existence or construction of this type of cities in a continent, and this time it is going to be done in relation to Latin America.

The significant growth of the Latin American population in recent years is well-known fact. In this sense, the Department of Economic and Social Affairs (DESA, UN) has shown:

Globally, more people live in urban areas than in rural areas, with 54 per cent of the world's population residing in urban areas in 2014. In 1950, 30 per cent of the world's population was urban, and by 2050, 66 per cent of the world's population is projected to be urban. [11, p. 1].

This revision, made by the UN, accurately indicates the extensive phenomenon of urbanization, and this generates a starting point to analyze their interrelationship with smart cities: if the population grows, infrastructure is forced to grow too.

If the population grows, the urban infrastructure will grow, and this will make all the locality or city grow. Although this indicates that the world is much more urbanized (because of globalization and the most recent estimates of the UN indicating 8500 million inhabitants in the world by the year 2025, and 9.8 billion by 2050 [11]), and that multiple cities in Latin America have been able to follow the urbanization trend, this does not mean that Latin American cities, even if they have grown, are smart. As has been previously stated, being or becoming smart is a huge process: cities must interconnect the key elements that they have available and determine those they want to have, and all this is a fact that is different from one country to another, as is also the sociopolitical context of each country and its present or possible dimensions.

Within all the LA context, promoting and planning smart cities requires the intervention of three groups of actors: large technology companies with their teams of expert consultants, multilateral organizations and urban governments [12]. Firstly, a smart urbanization needs technological solutions to address urban problems, solving them and seeking to improve quality of life and reduce costs, where companies present themselves through campaigns and justifiably necessary investments. Secondly, the role of organizations comes into play: UN through their well-known interventions and studies already mentioned (Sustainable Development Goals 2030 Agenda, Annual International Forums, Reports, Revisions), and others such as the World Bank and the Inter-American-Development Bank (IDB) that provide financing as well as technical assistance in pursuit of development that is, of course, in agreement with the government in question. Finally, governments themselves represent the real decision-makers, because they are the ones who define the strategies and who must be able to project themselves internationally if they seek to attract investments, technology, tourism, or earnings in any of its forms.

Latin America, in all its extension, covers twenty countries. And each of them presents particular realities and situations. Anyway, what smart (or smart-to-be) cities share is the sequence of designing the planning, emphasizing mobility; providing safety and environmental solutions, including programs relevant to the development of that planning; and, finally, undertaking the plan or initiative, that is, the project executed and operating.

LA cities face a big challenge in comparison to cities on other continents when it comes to be a smart city or make projects around it. As Cacace has stated,

With problems of poverty, crime and lack of access, Latin American cities face a much greater challenge than their counterparts from other regions of the world when designing smart city projects. Large cities such as Buenos Aires, Medellín or Rio de Janeiro are making budgetary efforts to modernize both their urban infrastructure and the services they provide to citizens, from smart traffic lights to improve mobility, and the installation of surveillance cameras to improve public safety [13].

This indicates and reaffirms that the context of LA is a bit complicated, but variable from city to city. Thinking about the Internet-access parameter, although Internet use has increased sharply in Latin America and the Caribbean in recent years, statistically one in two people does not have access of any kind. This shows the shortcomings of the context. However, within LA, there are great differences between countries: while in Argentina almost 60% of the population has access, in Cuba it does not reach 10% and even politicians are practically prohibiting its use day by day. As well as this, with the fundamental role of technology around the operation of a smart city, and with the IoT, in countries like Cuba the route becomes impossible and non-existent, because there is not even one of the most important "foundations" that have been introduced.

However, within the process that smart cities require, great examples of development are observed, in terms of cities that are becoming cleaner, efficient, innovative and

smarter: Santiago (Chile), México (México), Bogotá (Colombia), Buenos Aires (Argentina), Rio de Janeiro (Brazil), Curitiba (Brazil), Medellín (Colombia), and Montevideo (Uruguay) [14].

As an example, Rio de Janeiro (RJ) can be analyzed as a smart city from its beginnings, to observe the starting point and the current point, also considering the passage of time. This study-case could be synthesized in an important strategy which contains the information in form of metrics, events and processes; and all that must be known and shared across organizations in a real-time manner. Although the level of infrastructural development of this city is well-known, as well as its resources and constant growth, the foundations that help RJ in the conversion to a smart city appear strongly in 2010, with the intervention of two famous technology companies. An operations center, called Rio Operations Center (COR), was built by them to achieve the objectives of coordination and control in terms of public safety. Also, a system of general monitoring and of prevention of climatic phenomena was developed in pursuit of health and weather forecasting. The center has offices that include traffic surveillance, security, weather forecasting, electricity and gas providers, data exchange amongst themselves to increase the efficiency of their services [15]. Also, it achieves a total physical and virtual union of the city and what happens to the city. The center is, thus, a large OD system that also provides an app through which citizens can access and observe what happens in real time as well as proposing/discussing public policies and initiatives for the development of projects.

After having constituted the COR (a few years ago), RJ won an international recognition as one of the seven most important and relevant smart cities in the world. Furthermore, the role of the IDB in RJ has been crucial:

The basis for the development of the Smart City Plan for Rio de Janeiro was the expansion of the local government's telecommunications network, which has intensified the presence of the government throughout the city. The Smart City Plan consists of initiatives and projects that integrate the strategic planning of the local government and further strengthen the citizens' relationship with the city and the government. [16, pp 13-15].

Presenting the already-called "key elements", and then since the creation of the COR, the city has become smarter and smarter. And IDB promoted the action of the two technology companies, by financing the COR through economic resources, which was only possible because of the support of the executive power and the politicians, who understood that an environment like this one would contribute to the development of the city and the improvement of quality of life of the population. This shows that the context that the city presented before the COR was totally suitable to promote all the "smart aspect", but it needed an investment that also came with a base strategy, in order to achieve the operational-functioning rhythm it currently has. And this task was carried out correctly by the bank and the companies in charge. COR is the backbone of this developing smart city [16, p. 57].

Despite all the positive aspects, RJ has some new challenges to be overcome, such as analyzing cybersecurity; "planning for the future" by studying the ways population

grows and then developing strategic plans in a correct, timely manner; handling of systematic errors and ways of eliminating them; and, perhaps the most important of all challenges, increasing the use of virtual reality as a tool for simulation, operation and analysis of future probable impacts on reality.

All in all, it becomes really clear that the political and business factor is quite important. Nevertheless, the economic one is not less important, because in some countries of LA the priorities are different: if, unlike RJ, a city wants to be smart but does not have elements, resources or investments, its transformation will be quite disadvantaged. This is the case of Honduras, with more than half of its population in extreme poverty, and high levels of inequality. As well as this, as previously stated, infrastructure is forced to grow when the population demands it for their quality of life and, consequently, a smart growth of the city is fostered.

It can be stated that where cities have the priority, possibility, need and desire to become smart, it will be possible. This is the case of Buenos Aires, which at a steady rhythm in the last years has developed growth strategies in pursuit of the transformation to smart. Unlike RJ, BA has a growth objective more focused on optimizing and developing urban infrastructure than on a digital transformation as is a priority in RJ. This is precisely due to the priorities and rhythms given within the strategies to be applied: Buenos Aires takes positive steps in terms of construction for urban growth, promotion of green transport, and measurement of traffic for its intelligent improvement but all of these are just starting strategies in what becoming smart means. BA would clearly need a significant investment in ICT, like RJ, to see a broader, faster and smarter transformative growth.

Basically, Buenos Aires is a city that has all the skills and elements to become smart, and already acts in search of it (public and free Wi-Fi, apps with real-time city information, interactive underground transport terminals, promotion of the use of bicycles and electric skateboards instead of conventional transport...), but many times the economic and political factor modifies or stops the strategies to be projected. While this is reflected in the rhythm of growth, it does not mean that BA is not moving forward as a smart city. In fact, multiple projects are evaluated month by month, and they involve companies and entities that propose ideas and analyze their viability, both economic and functional.

All this means that the international context of globalization inspires the growth and what a smart community requires is not something unknown. The only need is to have a set of key elements, which correctly are prioritized by those who have to orchestrate work at a certain rhythm of development.

For all the reasons that have been developed, especially in this last section, a city can be smart only starting with a project, resources and well-executed strategies. It is interesting to establish the difference between countries and its economies, because this has an impact on their different possibilities and actions (and even within a country, realities can vary from city to city).

As a matter of fact, the key will always be the smart people within the city that is being analyzed: politicians, citizens and investors. In the order that has been established, decisions, actions and executions will depend on them; this is because politicians will decide, in the first instance, the regulations or guidelines to follow in order to be smart, then the inhabitants must contribute with their ideas and proposals to work with correct feedback rhythm, and, finally, the harmonious link between the first two mentioned aspects will consequently include the intervention of companies and resources in general (mainly, ICT).

## V. CONCLUSION

The importance of the process of conformation, operation and transformation of smart cities is understood. It is a process that encompasses different key elements and gives rise to “dimensions”, which can change according to social, economic, cultural and political contexts (and, clearly, according to the dynamics that exist in the development, progress and growth given in each city).

Analyzing this complex process in LA denotes certain deficits of the continent, but that do not apply to all countries equally because there are marked differences in terms of progress and pre-existence of smart cities, as well as smart city projects. The route to smart Latin American cities has great potential and a very long way to go. Although there are challenges to overcome in most countries that make up LA, with adequate strategies, resources and projects, it is quite certain that the journey is progressive but efficient and with firm steps.

Technological advances and infrastructure development are evident in multiple LA cities. However, one of the biggest challenges is in the hands of politicians, since their fundamental role defines the implementation of investments and the forms of execution and action of the tasks that are part of the process, as well as the need for transparency that is expected from a OG that works with OD. Corruption, unfortunately quite present in LA, is not an option that can occur in cities that intend to be or become smart. Finally, in this sense, citizenship is, the one that must act smartly in the form of feedback, for the purposes of growth and transformation.

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