Implementing a smart city in a developing country: The case of Guatemala City

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Abstract. *Technologies have become indispensable tools nowadays and their adoption in urban environments is essential for sustainable welfare. This holds particular importance in developing countries, which often face high demographic pressure and significant challenges in improving the quality of life of their citizens. Collaborative efforts in implementing smart-city initiatives have proven to be effective in enhancing the efficiency of urban services and driving economic development. Given Guatemala City's status as the most populous urban centre in Central America, and with the region experiencing rapid urbanization, its transformation into a smart city has become significant. This strategy will not only improve the well-being of its citizens but also offer valuable insights for similar urban settings, providing a relevant framework to evaluate its efficacy in uplifting welfare and competitiveness.*

Keywords. *smart cities, competitiveness, developing countries, Latin America and the Caribbean, Guatemala*

1 Introduction

Technological advancements have been the driving force behind great economic and social transformations throughout history; discoveries like gunpowder, the invention of the steam engine, and the use of electricity for industrial and domestic purposes are examples of breakthroughs that have marked turning points in human history, forever altering how humans interact with each other and their environment. Since the second half of the 20th century, a new technological revolution has emerged with the advent of digital computers and process automation, leading to what is known as the Third Industrial Revolution (Rifkin, 2018). This period has seen the systematization of daily activities and the widespread use of computers for households and individuals. The interconnection of different computing devices via the Internet has ushered in the era of information and communication, often described as the gateway to a new Industrial Revolution, characterised by significant advancements such as the rise of social networks, the Internet of Things (IoT), Big Data analysis, Artificial Intelligence (AI), or even Quantum computing, leading to increased dependency of human activities on technology and even blurring the boundaries between physical, virtual, and biological realities (Schwab, 2016).

The potential use of emerging technologies, with millions of people interconnected and having instant and unlimited access to all kinds of information, is simply immeasurable. The advancement of these technologies leads to the creation of new industries and types of jobs while others become obsolete and disappear. Technological advancements also lead to improvements in efficiency and productivity, providing a unique competitive advantage in a globalized world that can suddenly shift balances in markets, forcing companies and governments to adopt these tools and adapt swiftly to changes to keep their competitiveness. This is particularly crucial in developing economies, as technological adoption, while capable of generating wealth and new opportunities, can also exacerbate economic inequalities, especially in its disruptive potential in labour markets (Brynjolfsson & McAfee, 2014). Lack of access to technological tools at the speed they appear, as well as the educational gap in their adoption, can leave a population behind economically, directly affecting the quality of life of its inhabitants.

Major economic transformations often occur when technological advances converge with transcendent historical events. Currently, we live in the convergence of the digital revolution and the urbanization of the population worldwide. For the first time in history, the population living in urban areas surpasses the

population of rural areas, with Latin America being the second region with the highest level of urbanized population, only behind North America. However, almost all Latin American countries are considered developing economies (United Nations, 2014). The continuous growth of the world population, especially in urban areas, presents a significant challenge in developing efficient and sustainable cities, which generates the need and the opportunity to take advantage effectively of technological resources in urban planning, administration, and governance, especially in developing countries.

Being Central America the region with the greatest population growth rate in Latin America, the implementation of smart city initiatives in Guatemala City presents an interesting case to evaluate the effectiveness and applicability of this proposal in other developing countries that exhibit similar conditions and face similar challenges. Therefore, the following paragraphs will define the concept of a smart city and its scope, as well as the importance of its application in emerging economies. Subsequently, the smart city initiatives implemented in Guatemala City will be presented, and their effectiveness will be evaluated, as well as the areas of opportunity that still need to be addressed, to determine their applicability in other developing countries.

2 Smart cities in developing economies

The idea of a smart city has acquired increasing prominence in recent years, primarily in governmental circles and particularly at the municipal level; however, as it is an emerging concept, its definition is broad and admits various interpretations. In general terms, a smart city is one that effectively uses Information and Communication Technologies (ICTs) in urban management. Nevertheless, the scope of smart cities extends beyond merely providing urban services and encompasses strategic decision-making and governance of cities, efficiency in the operation of local governments and other public institutions, and initiatives that increase the level of competitiveness in cities (Bouskela et al., 2016). In addition to governmental use, the term smart city is also used commercially by companies that provide technological tools to public and private organizations that deliver urban services to the population.

Sustainability has recently been incorporated into the conception, meaning that smart cities are those that aim to satisfy the current and future needs of their citizens in economic, social, and environmental aspects (International Telecommunication Union, 2014). Smart cities focus on the economic and social well-being of their residents while ensuring the sustainable use of available resources for their preservation over time, positioning themselves as attractive hubs for external entrepreneurs and workers who seek security, quality of services, and employment opportunities. Technology in smart cities is employed to collect and analyse vast amounts of data generated constantly and in real-time to predict and mitigate urban problems, as well as to offer proactive solutions for their citizens. Even though, the implementation of these solutions must be conducted through orderly and systematic planning and management to ensure effective and quantifiable results, without losing sight of the primary goal of urban development, which is to improve the quality of life of people.

The adoption of technological tools must also be accompanied by the transformation of processes in public and private institutions responsible for the management and governance of the cities. The lack of inter-institutional coordination and integration represents one of the greatest challenges in implementing initiatives for the evolution of traditional cities into smart cities; hence the need for the commitment of the different stakeholders is required to integrate into the development of strategic projects since cities become smart only when the complex challenges that digital transformation entails are addressed comprehensively. The implementation of ICTs must be coordinated with a joint development strategy that considers the social, economic, and environmental spheres and the necessary transformations therein, incorporating projects that attempt to improve urban planning, infrastructure, and governance, and to foster sustainable and integrated development through collaborative planning processes and citizen participation.

The execution of transformation projects towards smart cities has been driven as a solution to the demographic pressure faced by many cities around the world and is an especially useful strategy in developing countries, which currently show the highest rates of population growth. Although smart city initiatives have been mostly implemented and studied in developed countries, it is in developing countries where innovative technologies have shown a greater impact on the operation of urban services, increasing productivity, competitiveness, and improving liveability in the cities (Antwi-Afari et

al., 2021). Working collaboratively, the modernization of cities has shown positive results in various fields, such as mobility and traffic, water and energy provision, waste collection, security and surveillance, and risk management, among others.

There is no doubt that creating smart cities is significant in addressing urbanization challenges, but at the same time, it is also necessary to consider the implications of implementing these initiatives, especially in developing countries. The main challenge often lies in financial limitations for technology investment, making it crucial to find sustainable financing models involving private sector participation and international cooperation. As well, many cities in developing countries lack adequate basic infrastructure and have significant digital gaps that need to be addressed. The absence of regulatory frameworks and clear policies for managing the volumes of collected information, especially regarding the privacy and security of personal data, raises concerns for users, pointing out the need for concrete regulations and measures for data protection and cybersecurity to ensure confidentiality and integrity of information. As discussed above, overcoming these challenges requires a comprehensive approach and long-term commitment from institutions as well as citizens.

3 The case of Guatemala City

Guatemala City is the capital of the homonymous country, which is located in a volcanic valley at 1500 meters above sea level. It has an approximate population of three million within its urban core, although its metropolitan area reaches an estimated five million people, making it the most populous and extensive urban agglomeration in Central America and the Caribbean (National Institute of Statistics, 2020). The city was founded 500 years ago and has been in its current location for almost half of that time, being its fourth settlement. The city was established in the middle of the volcanic mountain range that crosses the Central American isthmus, very close to the geological fault that marks the division of two continental tectonic plates, which added to the country's locations in the Caribbean Hurricane Corridor, makes the city highly susceptible to natural disasters, being these the cause of its successive relocations. However, these conditions have also favoured human settlement, since the valley where it is located has very fertile lands, abundant water sources, and a pleasant and temperate climate with stable temperatures throughout the year, considering its privileged location in the centre of the Americas and its proximity to the two largest oceans.

Central America is currently the second most rapidly urbanising region in the world. According to current urbanization rates, the urban population in Central America will double by 2050, accommodating over twenty-five million inhabitants (Maria et al., 2018). Being the most populous and extensive city, Guatemala City is the one that faces the greatest demographic pressure and, consequently, the one that ought to prepare and adapt the most to host this population growth and provide better urban services to its future inhabitants, ensuring the proper and sustainable use of resources. The strategic plans that are implemented in the coming years will settle the level of human development and economic growth the city will achieve, as well as its competitiveness as a global city. Therefore, the implementation of strategies to transform Guatemala City into a smart city results more than evident, while it also provides an excellent opportunity to study its application in other cities with similar conditions and challenges, primarily in the Latin American region.

Due to the demographic explosion since the second half of the 20th century, several plans and policies have been launched to promote the economic and social development of Guatemala City and its metropolitan area. Since the end of the century, efforts have been made to integrate the surrounding municipalities into a common metropolitan area, developing joint strategies to carry out programs that improve the public transportation system and urban mobility, water management, waste collection, and civil security, among others. Likewise, efforts have been made to involve the private sector in these plans to develop public-private alliances that aid in the financing and execution of these programs. However, most of those proposals have been carried out as separate initiatives without a concrete plan.

The first integral proposal to formulate a centralized policy that sought urban development emerged in the first decade of 2000, which focused on efficient attention to urban demands through a multi-sectorial process to apply rules and regulations effectively and direct territorial planning actions for sustainable development. In this framework, the first action was the development of a Territorial Development Plan and subsequently the implementation of other projects, just as a new bus rapid transit (BTR) system

called “Transmetro”, a municipal ecological belt, digitalization of paper archives and a one-stop shop for citizen services. In 2010, a major transformation process began with the integration of all IT systems into a single local-based (currently cloud-based) management platform, which laid the foundations for the development of new digital projects.

In 2014, the Municipality of Guatemala organized the contest “Creating a Smart City” for the design of digital applications that facilitate access to public services, and two years later formulated the plan "Guatemala, Smart City", which encompasses several development projects that were already underway, such as the expansion of the public transportation system and the placement of video surveillance cameras, along with other digital transformation and e-governance programs, to steer their implementation towards the development of a smart city (Román, 2024). Within this framework, three projects are currently being implemented: the expansion of Transmetro lines and the creation of the TuBus system, for which a zero-emission electric line is being incorporated, the development of smart traffic lights and smart parking meters to improve urban mobility, and, finally, the implementation of a citizen card to simplify the payment of urban services in a unified electronic system.

The technological initiatives to transform Guatemala City into a smart city have benefited an estimated three million people in the metropolitan area and have trained more than a thousand municipal workers and citizens in the use of electronic systems. The digitalization of procedures has standardized more than 300 processes and automated 480 activities in total, which, together with the expansion of online services and the implementation of an electronic payment platform, has allowed public income to increase by 30% (Román, 2024). These changes have also speeded up the provision of services, reducing processes that previously took days to just minutes. For the coming years, the projects planned are the rehabilitation of the railway line for the construction of a tram system on the North-South axis, the creation of an aerial metro system on the East-West axis, the expansion of bicycle lanes around the city and the creation of a garbage sorting line in the municipal dump, which are being promoted through joint work between the public and private sectors.

The path that Guatemala City must traverse to become a smart city is still long since there are still areas where insufficient progress has been made, such as water treatment and waste management, requiring actions from the responsible institutions to address them promptly. Possibly the greatest challenge that the city currently faces is its inter-municipal integration, as effective adoption of new technologies and processes requires cooperation from all municipalities within the metropolitan area to expand the scope of these initiatives. Political will in policymaking is key for the coordination and implementation of development programs, as well as for conducting further studies to measure results and provide strategic guidelines for continuous improvement and sustainability. However, some recent projects have been promoted through inter-municipal alliances as an attempt to unify the programs to benefit the entire metropolitan area. The journey thus far has helped raise levels of welfare and competitiveness, and the prospects for Guatemala City as a smart city in Latin America are promising.

4 Conclusion

We are at a critical moment in history, at which ICTs have become essential tools for carrying out all human activities, and their adoption in cities is decisive for the sustainable well-being of their inhabitants. This is particularly important in developing countries since they usually face greater demographic pressure and greater challenges in improving the quality of life of their populations. By working collaboratively, the implementation of smart city initiatives has proven to be an effective strategy for improving efficiency in the delivery of urban services and managing projects that promote greater economic development and competitiveness. As Guatemala City is the most populous and extensive urban agglomeration in Central America and the Caribbean, and it is the second most rapidly urbanising region in the world, the implementation of strategic proposals for its transformation into a smart city is a significant necessity to ensure the economic and social well-being of its citizens.

Since the beginning of this century, the Municipality of Guatemala has led most of the initiatives of integral urban development, consolidating them in 2016 with the plan "Guatemala, Smart City", which provides a unifying framework for several multidisciplinary projects conducted with the vision of creating a functional and sustainable smart city. The results of these projects have been positive, and millions of citizens have benefited from them; however, most of these projects have focused on urban security and

mobility, which were the most urgent problems, but still few results have been achieved on the management of resources and sustainability. Likewise, it is still necessary to promote these projects in the entire metropolitan area of the city, for which the integration of all municipalities must be a priority, and to involve the private sector in developing public-private alliances that aid in the financing and execution of the initiatives.

The research conducted on the actions taken by Guatemala City for its transformation into a smart city provides an interesting framework for its implementation in developing economies since the adoption of electronic tools through a unified plan with a single vision has provided positive results in increasing the level of citizen well-being and the competitiveness of the city, ranking it as an attractive emergent city in Latin America to live and invest in, despite having some structural problems that have not yet been addressed. However, it is necessary to expand research on the results of programs and projects since more measurements are needed to evaluate their effectiveness, especially in municipalities within the metropolitan area that lack many of them. Likewise, it is recommended to compare the results obtained by the city of Guatemala with other emerging cities outside Latin America, to better identify the initiatives that generate the greatest impact. The results obtained will provide a proper reference framework to demonstrate the effectiveness of smart cities and complement it with other programs aimed at raising the welfare and competitiveness levels of the population.

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