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Analysis of Guatemala city applying the european smart cities model

Análisis de la ciudad de Guatemala aplicando el modelo europeo de ciudades inteligentes

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ABSTRACT

This paper presents an analysis of five parameters that make up a smart city adapted to Guatemala City. These parameters were extracted from the European Model of Smart Cities found in the report "Smart Cities: Classification of large European cities". Due to the uncertainty surrounding the global meaning of a smart city, the parameters proposed to encompass the topic at all consist of: Economy, Population, Governance, Mobility and Environment. Each of these will be evaluated with three selected indicators based on the availability of the data required for the analysis, which are currently available for Guatemala City. Next, the state of each parameter is based on an analysis and development based on official qualitative and quantitative data extracted from the corresponding ministries, public entities and reports from non-profit organizations. Given that the collection of information has concluded and the final status of each of the five parameters in the body of work has been determined, the conclusions chapter summarizes the gaps and limitations for adapting the Model to this particular city. Finally, recommendations are included for the dissemination of this study and its possible adaptation for other cities with characteristics similar to those of Guatemala City.

Palabras clave:
ciudad de Guatemala, parámetros de una ciudad inteligente, adaptación al modelo de desempeño, desarrollo urbano.

RESUMEN

Este trabajo presenta un análisis de cinco parámetros que conforman a una ciudad inteligente adaptados a la Ciudad de Guatemala. Dichos parámetros fueron extraídos del Modelo Europeo de Ciudades Inteligentes encontrado en el reporte “Ciudades Inteligentes: Clasificación de las ciudades europeas de gran tamaño”. Debido a la incertidumbre que rodea al significado global de una ciudad inteligente, los parámetros propuestos para abarcar el tema en absoluto consisten en: Economía, Población, Gobernación, Movilidad y Ambiente. Cada uno de estos será evaluado con tres indicadores seleccionados con base en la disponibilidad de los datos requeridos para el análisis, con los que actualmente se cuentan para la Ciudad de Guatemala. Seguidamente, se

	fundamenta el estado de cada parámetro con un análisis y desarrollo con base a datos cualitativos y cuantitativos oficiales extraídos de los correspondientes ministerios, entidades públicas e informes de organizaciones sin lucro. Dada por concluida la recopilación de información y determinado el estado final de cada uno de los cinco parámetros en el cuerpo del trabajo, el capítulo de conclusiones sintetiza las brechas y limitaciones para la adaptación del Modelo a esta ciudad en particular. Por último, se incluyen recomendaciones para la difusión del presente estudio y la posible adaptación de éste para otras ciudades con características similares a las de la Ciudad de Guatemala.

Introduction

Cities, generally speaking have a vital role in the social and economic spheres worldwide, as well as a great impact on the environment (Mori & Christodoulou, 2012). Therefore, the proper and controlled management of all the elements that make them up plays an important role in their development. Globally, cities have begun to look for solutions that enable transportation linkages, varied land uses, and high-quality urban services with positive long-term effects on the economy (Albino et. al., 2015).

According to data identified by the United Nations, by 2050 there will be approximately 9.7 billion inhabitants worldwide. Of these, more than 50% live in cities (UN, 2011-2019) which means that city governments continuously face an extensive range of challenges: they have the need to produce wealth and innovation, but also health and sustainability (Meijer & Bolivar, 2016). The socio-spatial segregation of the population and voluminous sprawl has produced several pressures on the quality of life and environment of all citizens (Morataya, 2011). Due to the intemperance caused by former governments, the problem continues to persist and increase, and these events complicate the implementation of new methodologies for improvement in all areas of development.

At the beginning of 2013, there were approximately 143 smart city projects underway or completed. Among these initiatives, North America had 35 projects; Europe, 47; Asia 50; South America 10; and the Middle East and Africa 10 (Lee at al., 2014). Based on the fact that the analysis in this article focuses on adapting a project of this type to Guatemala City, which is developing; it is worth mentioning that 20 of the total number of these projects conducted in 2013 were located in countries that are also developing countries today. However, it is not possible to make use of existing information on these projects or their methodology, given that they were planned from the outset around the concept of sustainable development. On the contrary, Guatemala City was by no means designed for sustainable technological purposes.

Smart Cities

From the constant need to create solutions to the variety of existing problems arises the term "smart city". There is no single template to frame or define it, nor is there a "one-size-fits-all" template that fits all the issues it can encompass (O'Grady and O'Hare, 2012). However, there are two perspectives to define this term. First, those such as Glaeser & Berry (2006) who expose how smart cities are categorized by numbers and literal intelligence, such as the percentage of the population who have a bachelor's degree, college degree, PhD or those who know 2 or more languages. On the other hand, as a second perspective, Whashburn & Sindhu (2010) focus more on problem solving by adapting new methodologies. These types of authors demonstrate how a smart city should be oriented towards reducing challenges that may include resource scarcity such as energy, health, housing, deteriorating or inadequate infrastructure (such as potable water, renewable energy, roads, education and transportation), price instability, climate change, and most of all the demand for better economic opportunities and social benefits.

In terms of academic literature, the meaning of "smart" covers a range of technological features, such as self-configuration, self-protection and self-optimization. Then, in industrial literature with a tendency in business and industrial instruments, "smart" refers to the astute performance of products and services, artificial intelligence and independent machines (Nam & Pardo, 2011).

In this way, we can proceed to define a smart city as one that focuses or dedicates its resources towards the constant implementation (through research and development studies) of improvements in all areas that have an impact on the economic and social development of the city. This, with the sole purpose of offering an improvement in the quality of life to its

inhabitants that is evidenced by a favorable increase in the economy, education, access to services, mobility such as logistics and infrastructure, efficiency and sustainability in the environment and most importantly, safety and high quality of life.

Figure 1

Indicators of a smart city

Parameters

The first "Economy" parameter is used to describe a city with "smart" industry. This especially involves industries in the areas of information and communication technologies (ICTs) as well as the application of ICTs in the production process. Therefore, the first parameter to be studied is public spending on research and development as well as on education.

The second "Population" parameter. It investigates the educational level of the total percentage of citizens, their skills and opportunities for growth. The foundation of a smart city is formed by the individuals who inhabit it, placing in a high position their capacities of understanding because they are the ones responsible under the command of their superiors to engineer and implement the improvements.

Next, the third "Governance" parameter refers to the relationship between government representatives and the population. Good governance as a fundamental aspect of intelligent administration also refers to the use of new methods of communication for its citizens. Likewise, smart cities are used to discuss the use of modern technology in everyday urban life (Giffinger, et al., 2007).

In the penultimate parameter of "Mobility" we focus on modern transportation technologies. New "intelligent" transportation systems are therefore emerging in order to improve urban traffic and population mobility. To know how to conduct the "Mobility" study, it is necessary to analyze the current structure in order to know how the implementation of these new technologies can solve them.

The last parameter is "Environment". It is intended to analyze natural conditions, pollution, resource management and also efforts towards environmental protection (Giffinger, et al., 2007).

Guatemala City

Proceeding to the present day Guatemala City extends over 228 km2, making it the largest city in Central America. According to the National Institute of Statistics and the Judicial Organism of Guatemala, in the last census carried out this year, the approximate population has

a total of 995,393 inhabitants. It is home to 20% of the country's population, as well as the main political, economic, social and social headquarters and most economic activities (Morataya, 2011). However, it is important to consider the metropolitan area that extends outside the city; as it reaches an estimated 3.5 million inhabitants (INE, 2018). They have an impact on all the activities in the area of this study because they circulate, consume and are part of the movements that take place on a daily basis.

Method

Following the classification proposed by Hernández et al. (2014) the present work has a mixed descriptive approach and employs content analysis. The inclusion of quantitative data complements the content analysis, giving an idea of the magnitude of impact on the five parameters. These data are taken from various studies with the same purpose, although focused on cities with varied backgrounds and needs.

An analysis of five of the parameters proposed by the European Model of Smart Cities to Guatemala City is developed. Within each one, three indicators are included, selected for the reason that they have the most information available as well as their ease of adaptation to a city of this type. Finally, it is necessary to mention that the following analysis develops five of the six parameters, excluding the last one "Life". This is due to the fact that this parameter is continuously mentioned in the development of all the previous ones, making a section dedicated only to this one unnecessary.

Results

Economy

Presented as the first indicator, public spending on R&D and education are characterized as the "innovative spirit" factor of a smart city according to Dr. Giffinger (2007). In Guatemala City, this indicator is monitored by two different public entities: the National Science and Technology System and the Ministry of Education.

Starting with R&D, in Guatemala City all activities related to scientific and technological research are coordinated by the National Secretariat of Science and Technology (SENACYT) and directed by the National Council of Science and Technology (CONCYT) (SENACYT, 2018).

The funds and budget are allocated by need or by activity development, causing the figures to vary from year to year. In order to provide an overview of the resources available to these entities, Table 1 is presented below.

Table 1

Relevant figures of Guatemala's R&D budget

Budget	Amount (€)
Total R&D budget of the country	3.368.790
Total budget executed	2.986.752
Approximate budget to Guatemala City	153.127
Percentage	%
Percentage of total executed	88,66
Total percentage of GDP	0,0048

Note: Source: SENACYT, 2018

Education is an indispensable instrument for human development, since it enables the acquisition of new knowledge, skills and competencies that allow the population to have access

to a greater number of opportunities. This is why it is called a key factor towards the implementation of a smart city. The figures for the Education budget are shown in Table 2.

Table 2

Relevant figures of Guatemala City's education budget

Students	Figures
Total school-age population (4 to 21 years)	264.725
Total students withdrawn	19.897 (7.5%)
Budgets	**Figures**
Approximate total education budget	€89.008.486
Total GDP spent on education	0.13%
Approximate annual amount per student	€336.2

Note: Source: Own elaboration based on MFP, 2019 and MINEDUC, 2001.19

Regarding the state of employment, it should be noted that by the beginning of 2010, they generated approximately 53% of national jobs, 79% of industry, 61% of the services branch offered and finally 86% of jobs in commerce (Morataya, 2011). Table 3 shows the data collected:

Table 3

Relevant figures of the labor force and unemployment in Guatemala City

Population	Figures
Population 15 years and older	706.702 (71%)
Economically active population	437.313 (44%)
Population working outside the city	6.036 (1.38%)
Unemployment rate	**Figures (%)**
Unemployment rate in the city for 2010	69.678 (7%)
Unemployment rate in the city for 2015	28.867(2.9%)

Note: Own elaboration based on INE, 2018; América Economía, 2016; MGI, 2016 and Morataya, 2011.

After analyzing the economic indicators, an overview of the general state of the economic parameter can be made.

As for the indicator dedicated to R&D, it is evident that the insufficient funds dedicated to these areas bring a variety of chain problems, thus impeding the main goal of human development. Based on the data presented in the indicator, according to the funds dedicated to education, each student in Guatemala City is allocated approximately €34 per month for the ten months of the course. Clearly, this is a figure that is not evenly distributed, with the majority going to official or municipal education. The aforementioned then argues that the educational quality offered to them is not sufficient or effective, starting from pre-primary and primary to basic and diversified (INE, 2018). Creating a mentality in which education is not seen as necessary.

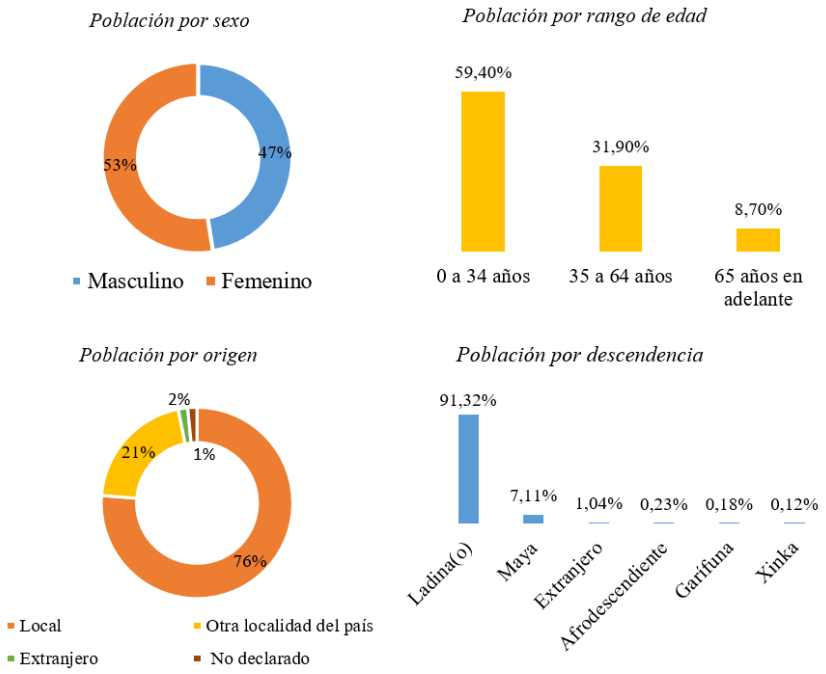
Finally, with respect to the GDP per capita and unemployment rate indicators, there is no doubt that their figures are largely the result of the first indicator. Guatemala as a country has one of the lowest levels of investment in the world. The total investment rate stands at around 14 percent of GDP, which is well below the average of 21 percent for Latin America. The limited investment in the economic sector has a knock-on effect on the positive growth of the indicators analyzed. Thus, it can be said that continuous improvement methods dedicated to the life of the population are not promoted; only enough to keep it stable.

Population

Guatemala City, having moved on four different occasions and also being the capital of the country, hosts a great diversity of population. This may come from different parts of the country or from abroad and may be manifested as cultural, ethnic and linguistic diversity. Therefore, the following data extracted from the Census are presented to support this argument:

Figure 2

Demographics of the population of Guatemala



Note: Source: INE, 2018

Initially, the following population indicators are directly related to the concept of human development. It describes the achievements of a city in relation to different dimensions, one of them being access to knowledge and a decent standard of living. Without further ado, the most relevant approximate data for the following indicator are presented in Table 4 below:

Table 4

Relevant figures for the population with higher education in Guatemala City

Population	Figure
Population over 25 years old	530.132 (53.26%)
Total population with advanced education	36.049 (3.62%)
Graduates	**Figure**
Graduates over 25 years of age	34.459 (6.5%)
Master's degree graduates over 25 years of age	1.590 (0.3%)

Note: Source: Lemarchand, 2017; MINEDUC, 2018

For the next indicator, different digital skills were taken into account within a high percentage of the population. These include not only economically active individuals with advanced knowledge of basic coding or Microsoft Office-type software. The main reason for the inclusion of all stakeholders is due to the impact they have or will have on all areas of the city. The following data include individuals aged 7 years and older as well as executives and workers from different companies in Guatemala City.

Table 5

Figures relevant to the digital literacy of the population of Guatemala City

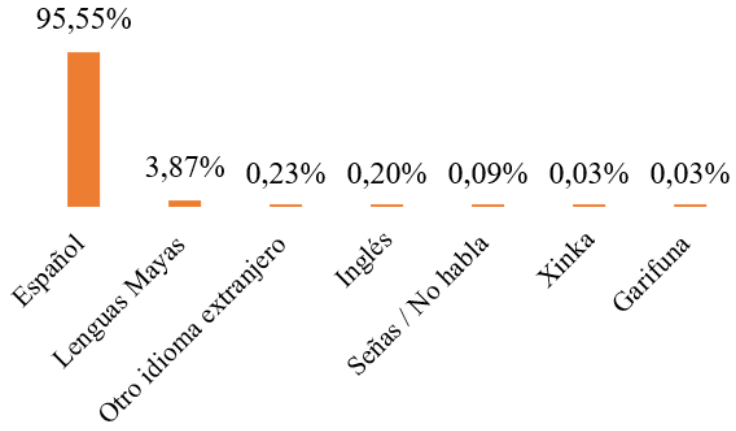
Population	Figure
Population 7 years and older	823.541 (82.73%)
Population using cell phones	686.460 (83.35%)
Population using computers	437.433 (53.11%)
Population using the Internet	512.366 (62.21%)
Population using the 3	413.195 (50.17%)
Population using cell phones and computers	418.986 (50.87%)
Population using cell phones and internet	498.236 (60.49%)
Population using computers and internet	427.192 (51.87%)

Note: Source: MINEDUC, 2018

Finally, in this last population indicator, the level of knowledge of foreign languages in the population of Guatemala City is developed. In general, the knowledge of languages by maternity or apprenticeship within the city is divided as follows:

Figure 3

Percentage of languages by mother tongue



Note: Source: INE, 2018

Table 6

Knowledge of foreign languages as a second language by population at the country level and its approximation to the city

Language	Country	City
English (52.8%)	8.236.800	525.568
Other foreign language (3.2%)	499.200	31.853
English proficiency level	52.50% (moderate)	53.51% (moderate)

Note: Source: INE, 2014; EF, 2019

From the data presented, it can be determined that, of the total population evaluated in Guatemala City, only 0.43% have English or another foreign language as their mother tongue. On the other hand, although the main intention of this indicator focuses only on foreign languages, it is of utmost importance to mention the variety of native communities in the country with unique dialects that make it multilingual.

After completing the development of the main population indicators, it is possible to infer both the reason for their status and the variables that affect them. First, with respect to the percentage of the population with advanced education, there is no doubt that the number

of graduates has increased over the years. However, its improvement is directly linked to public investment in education, which significantly limits its development. The scope of advanced education in Guatemala City remains limited due to the scarcity of regulations and investment in student, teaching and academic offerings.

Continuing, the status of the digital literacy and foreign language indicators is similar. The skills are not fully developed. Regarding digital literacy, there is no doubt that a high percentage of the population has the necessary knowledge for the average use of devices. Regarding the last indicator, it can be said that the knowledge of foreign languages is not diverse in a high percentage. In any case, the figures of the three indicators present a clear potential in social and human capital; which currently at the country level has a value of 52.2 out of 100 (Schwab, 2019). For this reason, it can be inferred that, when correctly oriented, it can have a high impact on the development of the population and the different associated parameters.

Government

This third parameter focuses on the type of relationship that exists between the actors of the main governmental entities and the population. This relationship includes all institutions of higher education and research centers as well as every individual in the population who is active in the development of the city. Essentially, in order to obtain effective results; fields of action have to be identified according to their strengths and weaknesses as well as to advise which governance approach is more effective to achieve the cooperation of all stakeholders (Lombardi, et al., 2012).

The three indicators chosen to be developed have as their main focus to express the potential for participation in decision making, the availability of public and social services and government transparency in all areas.

Through Table 7, it can be noted that the only public center is the University of San Carlos and therefore this evidences that approximately 68% of all higher studies and advanced education centers are run by the private sector (Lemarchand, 2017). On the other hand, based on more subjective indexes, Table 8 shows the general results obtained based on the offer of these academic studies.

Table 7

Universities and research centers in Guatemala City by type and academic offerings in 2011

University	Faculties	Degrees	Masters	Doctorates	Research Centers
Universidad de San Carlos	10	109	113	8	33
Universidad del Occidente	4	14	-	-	-
Universidad del Istmo	6	15	6	-	1
Universidad del Valle	4	29	9	-	11
Universidad Francisco Marroquín	5	19	12	1	5
Universidad Galileo	9	49	44	-	6
Universidad InterNaciones	3	9	1	-	-
Universidad Mariano Gálvez	12	34	51	12	3
Universidad Mesoamericana	2	9	3	3	1
Universidad Panamericana	7	12	14	-	-
Universidad Rafael Landívar	9	110	34	-	11
Universidad Rural	7	9	7	1	-

Universidad Pablo	San	7	5	7	-	-
Total		**85**	**423**	**301**	**25**	**71**

Note: Source: CONADUR/SEGEPLAN, 2014; Rosado, 2011

Table 8

Quality indexes based on the supply of academic studies and research centers

Index	Rating (1-7)
Quality of research institutions	3.5
University-industry collaboration in R&D	3.5
Availability of scientists and engineers	4

Note: Source: Schwab, 2016.

As for the second indicator, an online e-government refers to Internet technologies that act as a platform for the exchange of information, provision of services and conducting transactions with citizens, businesses and other branches of government.

In more specific terms, the most recent national action plan includes 5 axes with different commitments to reach the goal. These are divided into the following:

- Access to public information and institutional archives.
- Technological innovation (Creation of an open data portal, a technical roundtable to address issues of technological innovation, online public services, municipal services and public information requests).
- Citizen Participation (Creation of programs and mechanisms for opinion, collaboration and participation).
- Accountability (Transparency of actions in integrated management for disaster risk reduction).
- Fiscal Transparency (Creation of an open and participatory budget process in public finance, tax administration, public health and social assistance, and education).

In order to analyze them, it was necessary to access the official platform of the Municipality of Guatemala City. In it, there are three tabs containing external links depending on the topic to be covered. As can be seen in Figure 4, the required information from the 5 axes was accessed without any problem. However, according to the existing reports of the three action plans carried out to date, the monthly monitoring and review of these plans was not carried out correctly. This is evidenced by the fact that the rating of timeliness and level of compliance with each commitment only exists for the first two plans, with 14% for the first and 63% respectively. Regarding the third plan, being this the most recent of the years 2016-2018; there is no information about the follow-up that has been carried out. On the other hand, there is also no action plan formulated for the years 2019-2021.

Figure 4. Online platform of the Municipality of Guatemala.

For the last population parameter, the number of households within Guatemala City that have access to internet at home is developed. To present the data in greater detail, the typology of each household is also included.

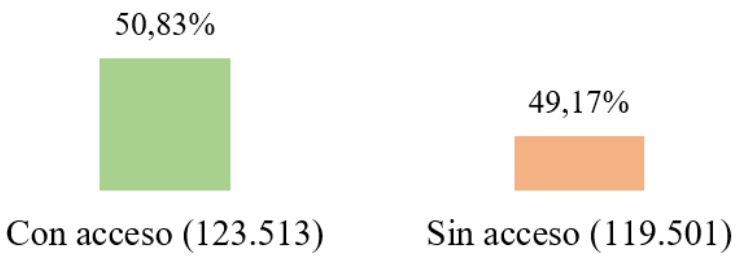
Table 9

Households by typology in Guatemala City

Typology	Figure
Unipersonal	23.894 (9.8%)
Nuclear	137.478 (56.6%)
Extensive	68.536 (28.2%)
Composed	10.525 (4.3%)
Co-chairs	2.581 (1.1%)
Total	243.014 (100%)

Note: Source: INE, 2018.

Figure 5
Percentage of households with Internet access at home



Note: Source: INE, 2018

After obtaining accurate data on the three main governance indicators, the task of determining their overall status is expedited. Proceeding with the case of universities and research centers in the city; it can be noted that 12 out of 13 institutions are private. The fact that they are means limitations for a large percentage of citizens due to the inability to cover the costs of assistance. In addition, the absence of post-graduate programs such as master's and doctoral programs imposes another important barrier to development on the city, directly related to the preparation of teachers to transmit knowledge.

Next, for the second indicator of online e-government, it should be noted how complete the official platform of Guatemala City is based on the 5 axes of the Open Government Partnership. Therefore, it is evident that existing governance norms and standards support and guide the city's population towards a high quality of life (Lombardi, et al., 2012). However, it is worth mentioning that there is a failure to update the data, which was proposed for every two years. Unfortunately, this affects the accuracy and transparency of information such as the timeliness rating of commitments. Finally, with respect to the indicator of households with Internet access at home, it can be noted that there is only 50.83% coverage of the population in the city. This indicates that connectivity among all stakeholders and leveraging of public platforms is limited.

Mobility

As the penultimate parameter of analysis, the issue of mobility is introduced. The first indicator is "local and international accessibility". This means the coverage of the same within the city, the satisfaction of the inhabitants for such access and its quality.

First, with respect to local accessibility, the three existing public media are included: Traditional, Transurban and Transmetro. Table 10 shows the use of different modes of transportation in the city.

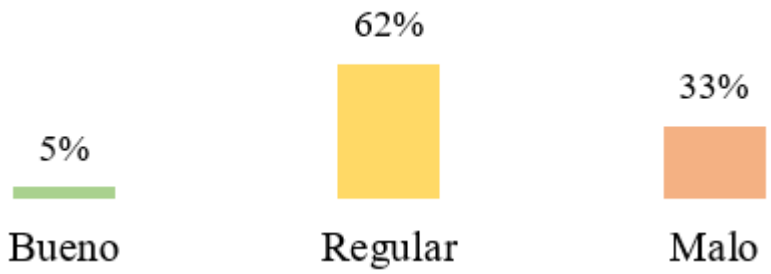
Table 10
Households in Guatemala City by means of transport

Means of transportation	Number of households
Automobile	115.763 (47.64%)
Motorcycle	52.588 (21.64%)
Public transportation or on foot	74.663 (30.72%)
Total	243.014 (100%)

Note: Source: INE, 2018

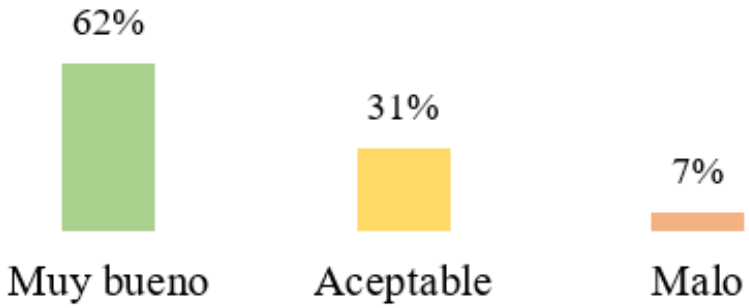
It is worth mentioning that, due to the percentage of coverage, reliability of use and safety, a high percentage of households opt for other means of transportation such as motorcycles or automobiles. In relation to this, Figures 6 and 7 illustrate the quality perceived by users of public transport in the city.

Figure 6
Quality of the traditional transport service



Note: Source: Morán et al., 2001

Figure 7
Quality of Transmetro transportation service



Note: Source: Lossau, 2012

With the main methods of public mobility in mind, we then evaluate the sustainability and safety offered by these systems at present and their consequent effect on Guatemala City.

When U.S. cars, motorcycles or buses fail emissions tests, they are auctioned and bought by dealers in Central American countries such as Guatemala and Honduras. Therefore, due to lack of law enforcement, they continue to operate in Guatemala City. Table 11 shows the pollution data for the city.

Table 11
Comparison of the WHO standard level of particulate matter pollution (PM2, %) and the current level in Guatemala City.

Note: Source: USCG & Ecoquimsa, 2017

Recommended annual average level	Actual annual average level
10 milligrams per m^3	65 milligrams per m^3

Thus, the highest annual average exceeded the proposed recommendations by 5.5 times. This data makes it the sixth most polluted city in the Americas, with approximately 70% of the total coming from emissions from these vehicles. (Pskowski, 2019).

Finally, international accessibility within Guatemala City is made up of two distinct means of mobility; La Aurora International Airport and private long distance bus companies. The airport is the country's main air embarkation and disembarkation port. For 2019, it

reported an inbound and outbound movement of 2,983,042 passengers among 18 airlines; placing it among the four most trafficked airports in Central America (DGAC, 2019).

In terms of initiatives towards an advanced ICT infrastructure, the aerometer and the metrometer stand out. The Aerometro is a cable car type public transportation project designed to connect the neighboring city of Mixco to Guatemala City in a 100% electric way. It is designed to connect the existing Transmetro and bicycle systems to mobilize citizens in a more fluid manner. On the other hand, the Metrorail is introduced as a type of light rail also 100% electric.

In concluding the development of mobility in Guatemala City, it can be deduced that its current state is not adequate for its inhabitants and is far from optimal. Despite the partial effectiveness achieved by some existing systems, this is not sufficient in terms of coverage, safety and sustainability to meet the required demand. The continuous expansion of the city forces the increase of accessibility methods to its inhabitants. Therefore, the expansion of an effective mobility system is necessary to achieve urban planning (Morán et al., 2001).

Environment

This parameter briefly covers natural conditions, pollution, resource use and resource protection (Giffinger, et al., 2007).

Guatemala as a country is particularly vulnerable to the effects of climate change and this creates the need to carry out all responsibilities in relation to the environment. Therefore, and in response to the urgent need for action, Guatemala accepts the decisions taken at the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) by submitting its Intended Nationally Determined Contribution (INDC).

With regard to CO_2 emissions reduction, the following priorities are covered (CONADUR/SEGEPLAN, 2014):

- Conservation and sustainable use of forests and biodiversity.
- Sustainable management of water resources to achieve social, economic and environmental objectives.
- Agricultural technification and family farming for food security.

Guatemala is not a country with relevant emissions of this type. Therefore, despite being linked to the efforts of the United Nations and applying several regulations, it is excluded from the commitments to reduce these gases by the Kyoto Protocol (Kosch, 2013).

Due to the geographical position and topography of the country, the potential of the electricity sector is favored with respect to the diversification of the electricity matrix. Currently, this includes hydropower productions, geothermal, solar, wind, biomass and more (Lemarchand, 2017). In more specific terms regarding potential and origin, Table 12 shows power generation.

Table 12

Different power generation components for 2015.

Type	GWh	Percentage with respect to annual total
Hydroelectric	3,851.8	37.4%
Geothermal	251.5	2.4%
Wind	107.3	1.0%
Cogeneration	2,685.1	26.1%
Solar	149.3	1.4%
Biomass	1.1	0.01%
Biogas	4.0	0.04%
Thermal	3,251.8	31.6%
Total	10,301.9	100%

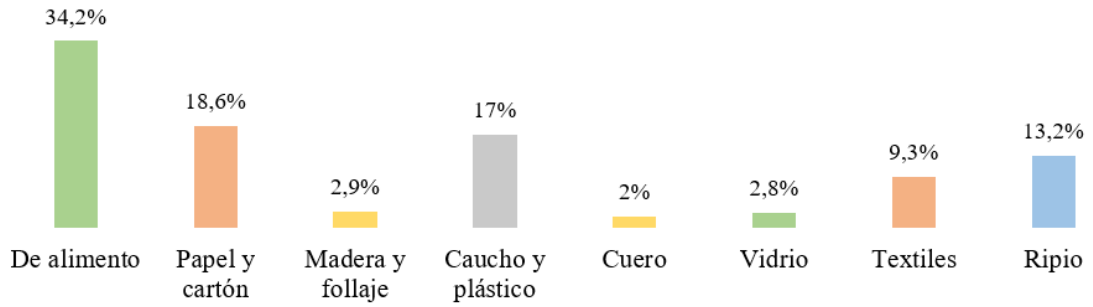
Note: Source: Lemarchand, 2017

With respect to efficient water use, Guatemala has three hydrographic basins: the Gulf of Mexico, the Atlantic and the Pacific, 38 watersheds and 194 bodies of water. Despite this, it is one of the countries with the lowest water supply per person in Central America.

The last indicator is waste control, focusing on the proportion and management of recyclable and non-recyclable solid waste from any source. First, with respect to waste produced in households in Guatemala City.

Figure 8

Composition of household solid waste



Note: Source: INE, 2015

When 93.5% of household waste is collected, whether by private or municipal service, it is taken to one of the 17 open dumps around the city. Of all of them, none has an environmental impact study from MARN.

With the environment parameter completed and with the essential data presented in each of them, the general state of the environment is quite clear. Since MARN is the entity responsible for all environmental and natural resource issues in Guatemala City and the entire country, it is appropriate to indicate that the poor control and the social, economic, environmental and sanitary impact falls on them. However, they are funded by the government, which means that their actions are directly linked to the budget allocated to them.

Regarding the first indicator, there is no doubt that there is a variety of regulations in force that cover a high percentage of the problems facing the city today. However, these are not adequately exercised or monitored. The lack of coordination between entities, complete allocation of resources and compliance with already stipulated rules are some of the factors that most affect the achievement of the proposed goals against CO2 emissions.

Next, the second indicator regarding the efficient use of water and electricity is favored by Guatemala's geographic location. The wide variety of natural resources available around the country and the high coverage of them within the city mean that the issue of scarcity is not often mentioned. However, the best quality can also become the least favorable if not properly controlled.

Finally, the information presented with respect to the waste control indicator clearly shows the almost nonexistent infrastructure for waste collection services, as well as in most of the city's landfills, which are only places for final disposal, where there is no adequate management or logistics for the waste that arrives daily.

Discussion and conclusions

With the states of each parameter in mind, both the results obtained and the gaps and limitations of the study are analyzed.

The insufficient funds dedicated to the development of each parameter, the incorrect administration and management carried out by the responsible actors in their areas, as well as the scarce interconnection among them, prevent the transmission of key information among them. Consequently, the ability to use such information to create behavioral patterns and establish improvement actions towards a smart city becomes impossible to carry out in a seamless manner.

Despite the extensive availability of laws, regulations and articles to promote the functioning of the parameters and quality of life of citizens, as well as to avoid risks; these are affected by the failure to exercise or enforce the respect and authority of the same causing the problems presented to continue to occur and increase in fatality.

The variety of more severe problems throughout the country that the Government of Guatemala has to address, as well as the fact that Guatemala City is in the best state compared to the other cities within its territory, limit the scope of a smart city initiative. For this reason, the work of implementation falls to non-governmental organizations, which, although they manage to implement such initiatives, have limited scope due to the lack of support from the main entities.

As a last point, it is vitally important to mention that the lack of updated data or lack of precise information on the parameters in general or indicators specific to Guatemala City, limits the scope of the study with respect to its current status and consequently the equity of information included in all parameters. Therefore, in cases where it was not possible to obtain what was required at the city level, it was necessary to use the country level, thus affecting the accuracy of the results. However, it is evident that the nature of the model applied to analyze Guatemala City is dedicated to European cities only. It is structured by means of indicators for each parameter, which emerge from areas in which researchers in these European cities take for granted that they exist. On the contrary, in the case of Guatemala City, it was necessary to make a selection of indicators based on the information that was possibly available, which meant the exclusion of possibly significant indicators.

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