OPPORTUNITIES FOR SUSTAINABLE AND INTELLIGENT MOBILITY IN THE RESPONSIVE CITY

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ABSTRACT

The growth of the world population indicates that about 70% of the inhabitants will live in cities by 2050. This implies the need for infrastructure, resources, basic services, and transportation available to serve this population and guarantee their quality of life.

To meet these requirements, some cities have adopted technology to obtain data and information that allow for the analysis of these new dynamics from the perspective of smart cities.

Other cities have also involved criteria focused on the well-being of the community-environmental system from the perspective of sustainable cities. There are other cities that transcend the sustainable and intelligent status to become responsive cities where the interpretation and analysis of data is provided by and for citizens. This allows them to become key in the planning and development of their city and the construction of these cities in the future.

Mobility in the development of cities is important and in a responsive city it is no different. It allows for the dynamic action of the population to satisfy their needs. Mobility worldwide is based on the private car and infrastructure grows as a function of this. The associated environmental, economic, and social impacts have wide ranging consequences.

Likewise, the COVID-19 pandemic has revealed an additional motivation to opt for public transport, cycling, or walking instead of the private car. This requires rethinking cities and adapting their physical, technological, and social infrastructure to facilitate this transition.

The evaluation of mobility in cities is based on indicators that allow the monitoring of important aspects from specific practices in each territory. However, the framework of responsive cities is not clearly or comprehensively identified resulting in the need for an investigative process aimed at forming a citizen-centered mobility evaluation model, integrating the holistic precepts of smart and sustainable cities.

1. PLANNING CITIES FOR THE FUTURE

The dynamics of the cities are accelerating their pace according to the urbanization process increase. The emerge of new settlers implies the supply of infrastructure, basic services, transport, employment, dwelling and additional resources that will allow them to improve their quality of life, thus, the conventional planning models are inadequate for the attention of new requests.

Currently, management instruments have been developed which provide a framework to the cities to modify their planning approach, on one hand, to achieve the sustainable urban development (United Nations, 2017), and on the other hand, supported by technology, to attain smart cities (ECLAC, 2020a).

The need to connect the community participation in the city development process has aroused the chance to address a more inclusive urban planning approach that allows to have responsive cities.

Below, the sort of stated cities are contextualized:

1.1 Smart and sustainable cities

The smart city is a concept that implies different meanings, although, it is generally connected with those cities in which information and communication technology – ICT are widely used. A first definition assumes the smart city as a construct to improve the quality of life, it is formulated bearing in mind three concepts: digital city, green city and city of knowledge, which are characterized by the use of data center technology in an ecological sight and a data value-based, information and knowledge production, respectively (Yin et al., 2015).

Another view relates to smart city with a prospective achievement in terms of economy, population, government, mobility, environment and livability (Aletà, Alonso, & Ruiz, 2017), (Albino, Berardi, & Dangelico, 2015), (Manville et al., 2014), therefore, the city is smarter if it is more competitive, preserves natural resources, the community is participatory, generates quality of life, integrates transport and ICT and promotes social and human capital.

The smart city is based on the creation and interaction of human capital, social capital and information and communication technology (ICT) infrastructure to generate greater economic and sustainable development and a better quality of life (Manville et al., 2014).

En este sentido, muchas ciudades están mejorando la calidad y el rendimiento de los servicios urbanos al ser digitalizadas e inteligentes (Kumar et al., 2020). However, “a city may also be smart when investment in social capital and infrastructure are made with a rational management of the natural resources and through a participatory governance” (Schaffers et al., 2011), which does not necessarily mean high investments in technology, bearing in mind resources availability according to the large city. (Manville et al., 2014).

Thus, it is clear that there is a variety of definitions about smart city and it is not possible to establish a universal meaning, nor there is a single way to measure it (Albino et al., 2015).

According to the International Telecommunication Union (ITU) and the Economic Commission for Europe (ECE), “a smart and sustainable city is an innovative city that uses ICT to improve the quality of life, the efficiency of operations, urban services and the competitiveness, at the same time that meets the needs of the current and future generations in economic, social, environmental and cultural features”. Smart and sustainable cities are provided with indicators to determine goals, gather data and evaluate their achievements, they are supported by a telecommunications infrastructure that is stable, secure, reliable and interoperable to provide support ICT-based applications and services (UIT-CEPE, 2016).

In the context of smart and sustainable cities, it is possible to identify the contribution of ICT in the urban setting, which is focused on: i) The advantages of the effectiveness in the operations and urban services, ii) the means to improve the quality of life and iii) encouragement of environmental sustainability (UIT, 2020). It is highlighted the need of smart cities to face challenges such as inequality, insecurity, unemployment and ageing population to contribute to the achievement of the sustainable development goals. (Sharifi, 2019), (Ahvenniemi et al.,2017).

The conceptual evolution of the smart city allows to evidence a different approach, from the use of ICT to maximize the effectiveness of hard urban infrastructure to a style focused on the human being and soft infrastructure (Sharifi, 2019). This is the basis of the responsive city.

1.2 Responsive cities

Taking into account the technological perspective, smart cities are supplied with data to promote information units that support decision-making and the governance (McKenna, 2019a), (von Richthofen et al., 2019), (McKenna, 2019b), such a way to promote knowledge generation in the different actors of the city itself.

At this point, the technological genesis of smart cities has been hatched. However, recent trends based on concepts such as Society 5.0 or people-centered smart society (Hitachi-UTokyo, 2020) urge to advance to citizen-centered cities, thus, "smart" becomes a infrastructure layer in which technological contributions are enclosed by the empowerment of citizens to contribute with their welfare, health, mobility, and other essential criteria of their condition as members of society and inhabitants of the territory; this is the base of responsive cities.

Goldsmith y Crawford (Goldsmith, 2014) established the concept of responsive city based on the citizens commitment and governance during the digital age to encourage cities characterized by their agility, competitiveness and economic resilient, based on the contributions brought by information technologies. The responsive city gives citizens the chance to use smart technology to contribute to the planning, design and management of the city (Yigitcanlar et al., 2019).

The perspective of responsive city is focused on the citizen, so, the processes of the city are supported by technological resources to improve their performance and be more involved with the citizen, decision makers guide their decisions toward problem analysis and opportunities to promote the quality of life in the communities; and finally, local managers use the predictive value of data to make accurate decision. The responsive concept frames a synergy among decision makers, thoughtful citizens and 21st century technologies (Goldsmith, 2014).

While common cities are based on classical planning models where data is emerged, smart cities lay the foundation on technology, proving information; responsive cities are centered on the citizen, building knowledge themselves (Schmitt, 2017).

The responsive city tends to "return the city to its citizens, so, they get involved directly in the planning and management of their habitat. Thus, the citizen responsibility becomes the basis of a responsive city" (Schmitt, 2017).

Bearing in mind the characterization of modern cities, challenges and opportunities that arise regarding mobility will be addressed.

2. MOBILITY IN THE 21ST CENTURY

An increasing trend of population in cities has grown distance journeys (Guasch, 2002) due the expansion of the urban border because of the peripheries settlement and the low coverage of public transport service (Cervero, 2000).

The implementation of encouragement policies to use private vehicles and their reduction prices have caused the increase of motor vehicles (Lizárraga, 2006), (Despacio y ITDP,

2013) and for that reason, problems such as traffic jam, pollution and accident rate have been accentuated (Vasconcellos et al., 2016).

Besides, there are failures in affordability, so, people with lower incomes must assign a high percent of their economic sources to get around (Vasconcellos, 2001), it has a directly impact on social inequity.

Other problems related to transport are connected to security, equity and inclusion, in the same way, the air pollution causes illnesses that can cost around 15% of a person's income (Hidalgo & Huizenga, 2013).

In response to this scenario, the conventional planning mobility approach has been changing toward sustainable smart mobility, where preferences of investments on private vehicle infrastructure are discouraged and active transport modes such as walk or pedal take place articulated with a service quality in the public transport system to guarantee the participation of all social groups and reduce the effects associated with transport such as energy consumption, CO2 release, air quality or wasted space in the streets. (Gillis et al., 2015).

2.1 Sustainable Smart mobility

Mobility makes part of the smart city agenda which is supported by the adoption of sustainable transport practices (Yigitcanlar & Kamruzzaman, 2019).

The context of sustainable mobility includes the objectives of smart mobility: i) reduce pollution, ii) decrease traffic jam, iii) increase people safety, iv) lessen noise and v) improve speeds and cost of movement, which is doable if they are joined to this sort of city (Benevolo et al.,2016). Sustainable mobility also includes four smart perspective which deal with the design, system, infrastructure and usage (Lyons, 2018).

The appropriate proposal about mobility framed within smart cities allows the implementation of projects that aim to answer community needs and tend towards sustainable (Battarra et al., 2018). Thus, sustainability has left to consider specific problems such as resource depletion and pollution to involve economic, social and environmental relations and their impact on solving problems (Litman, 2021).

The sustainability approach is given in mobility addressing the increase of urban congestion and pollution based on substantial changes in terms of logistic and transport affairs, private and public vehicles, as well as behavior and habits changes in order to keep in mind the quality of life, short and long-term impacts, affected population and the city planning (Mozos-Blanco et al.,2018).

According to Banister, sustainable mobility “supplies an alternative paradigm within with the complexity of cities is investigated and links between land use and transport are strengthened”. This requires actions to reduce the number and duration of journeys, promote modal change and encourage greater efficiency transport system. (Banister, 2008).

The main characteristics of the sustainable mobility approach are: i) it focuses on people, ii) it prioritizes accessibility, iii) it is proposed on a local scale, it recognizes the street as a useful space and not only as a vehicular road, v) it finds relevant the inverted mobility pyramid where pedestrians and cyclists are privileged in the upper part and the automobile drivers are placed in the lower part, vi) it is supplied with multi-criteria analysis to contemplate environmental and social concerns, it is focused on management, viii) it has a tendency to integrate people and traffic and, ix) it allows healthy benefits (Holden et al., 2019).

Currently, cities must assume smart and sustainable mobility, not only as a challenge but also as a necessity, taking into account the new requirements imposed by the Covid-19 pandemic.

2.2 COVID 19 and mobility

Coronavirus (COVID 19) has changed the environment sense and new vulnerabilities have emerged, for this reason, territory, distance, time, space and social relationships concepts must be rethought. The actual pandemic has exposed the need to modify people lifestyles as to the risks to health and life of the population, especially in urban areas (Moreno, 2020), this entails changes in city planning and, especially, in the mobility topic.

In this pandemic time, the communities have changed the people displacement modes, caused by virtuality that replaces many journey needs. Thus, technology and connectivity have been increasing to correspond with social distancing. According to this, ECLAC indicates that the Latin American and Caribbean region has the conditions to strengthen its technological capacity to face the consequent challenges through resilience, especially, in the transport, mobility, logistics and energy sectors. (ECLAC, 2020b).

The territory will be the character in these projected changes, then basic transport modes such as bicycles will be promoted, that will require the necessary infrastructure to be developed properly, in this case, bikeways and parking spaces are needed (Universidad de Los Andes, 2020). Likewise, walked displacements will have relevance in the new vision of post-pandemic mobility, it implies the adaptation of areas for the citizens circulation, the public space for its enjoyment and a pleasant environment that motivates them (ECLAC, 2021).

In conclusion, the pandemic has not necessarily had negative effects, as it has undeniably led organizations, families and people to redefine the mobility concept, for example, their transport modes, needs and time value used to fulfill their daily lives; that constitutes in a forced and disruptive process of adaptation for existing models that describe, model and implement sustainable mobility systems.

2.3 Sustainable mobility goals

Mobility in the current context is based on the pillars of sustainability: the social, economic and environmental features; in addition, with the scenario of responsive cities, it is necessary to articulate additional components: planning and governance, that allow to achieve the goals of sustainable and intelligent mobility.

In general terms, the mobility goals of the 21st century are presented as follows. The economic component focuses on the productivity and economic local development, energy efficiency, affordability, and operational efficiency.

The social component includes the equity, safety and human health, as well as, the community cohesion with the preservation of cultural heritage. The environmental component considers the reduction of emissions that contribute to climate change, the prevention of air, water and sound pollution, the reduction of hydric resource damage, the conservation of natural resources, the protection of the biodiversity and open spaces.

The good governance and planning component addresses inclusive, comprehensive and integrated planning (Litman, 2021).

3. MOBILITY EVALUATION

Mobility evaluation for urban context is commonly carried out from indices -or indicators- that consider different aspects of economic, social, environmental and operational issues. Currently, the evaluation models emphasize on sustainability requirements and integrate evaluations of technological types to involve the intelligent aspect in the assessment, to determine a sustainable and smart mobility.

Next, the main characteristics of conventional mobility evaluation models are presented and the most relevant characteristics of a participatory evaluation proposal model are planned in the context of responsive cities, they are obtained from methods focused on documentary research (Geerts, 2011) and bibliometric analysis techniques (Cobo, 2011).

3.1 Conventional evaluation models

Some authors have studied the feasibility to analyze urban mobility based on indicators to: i) transport planning and infrastructure provision (Mihyeon & Parsons, 2016), ii) quality measurement of the public transport network (Zegras, 2006), iii) determination of the

relationships between urban planning and transport (Zhang & Guindon, 2006), iv) sustainability measurement of urban transport in different continents (Litman, 2008), (Litman, 2011), (Litman, 2021), (Tanguay et al., 2010), v) measurement of the three dimensions of sustainability (Haghshenas & Vaziri, 2012).

The mobility assessment is carried out by the significant contribution of the transport area through reduced environmental quality of a city. Thus, the transition towards sustainable mobility will contribute to the mitigation of negative impacts, optimization of the transport system and integration with urban planning policies (Battarra et al., 2018).

Since of the 20th century ending, initiatives aimed at achieving sustainable urban mobility were already identified (Commission of the European Communities, 1998). In order to measure and compare the state of urban transport systems in terms of sustainability, the indicators were created, so that different initiatives emerged for reducing the urban mobility effects on human health, environment and economic productivity, in terms of a sustainable development (Alonso & Monzón, 2011).

Sdoukopoulos et al. (2019), proposed a categorization of evaluation indicators for transport sustainability and formulated an index evaluation; however, this research highlights the difficulty in the use of this indicators due to a great variety of indicators that are available, as well as, their structure, the constant monitoring needs and the use context (countries of the First World) (Sdoukopoulos et al., 2019).

Based on the Sdoukopoulos' findings, other related researches about use of indices or indicators to assess sustainable mobility was documented. The number of indicators used by each identified author is presented in Figure 1.

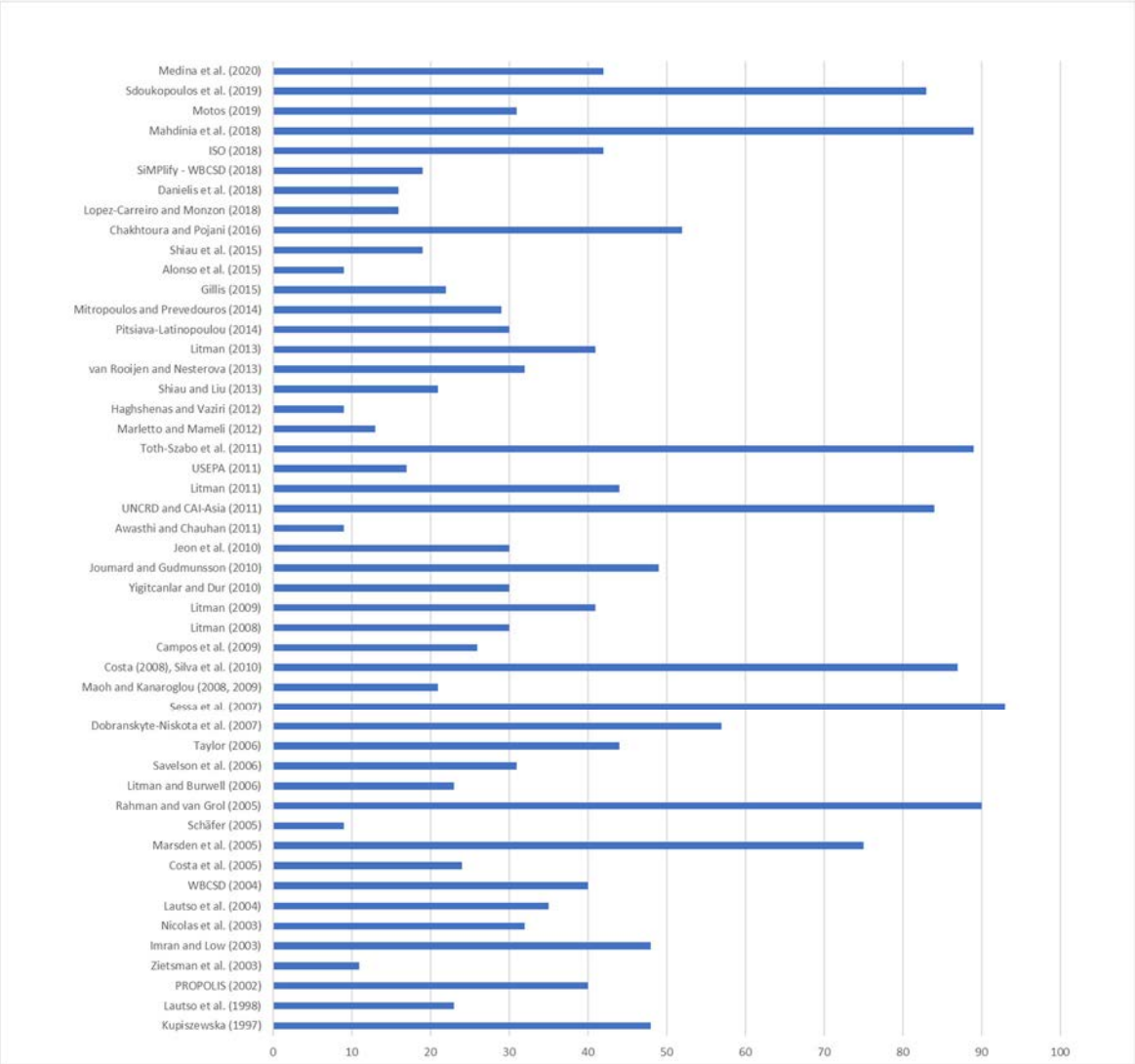

Figure 1: Roadmap regarding the indicator's quantification in sustainable mobility assessment initiatives

In conclusion, there is a considerable number of alternatives for evaluating the different constitutive aspects of cities, including mobility. These tools allow the evaluation of the main functions of conventional and smart cities. It is expected to obtain a strategy that involves a transition from this type of cities to responsive cities, where the citizen becomes the direct identifier of their needs, besides an information and knowledge contributor through the research solutions, using digital tools or smart technologies that he/she may have at his/her willingness (Levenda et al., 2020).

In order to contribute in the transition towards a smart and sustainable city, the sustainable mobility evaluation is an important factor, because the existing models to achieve this type of city still do not fully include all the aspects that must be taken in this high-level process, this constitutes a knowledge gap (Ibrahim et al., 2018).

3.2 Participatory evaluation model

According to sustainability indicators that can be applied in transport and planning assessment (Litman, 2021), actually, their use is been expanded. However, despite involving economic, social and environment issues like the pillars of sustainability in the environmental mobility evaluation, it is evident that urban dynamics have changed, and both, the active participation of citizens and a greater concern for environmental issues are indispensable in the planning of the future cities.

As evidenced in different worldwide experiences, citizens have the opportunity to change mobility patterns in their cities, promoting an active mobility and demanding changes in that sense (van Laake & Pardo, 2018). Thus, the citizen empowerment allows them to achieve a proactive participation in sustainable and equitable projects, facilitating political changes in their favor to improve their quality of life (Moscoso et al.,2020).

The 2030 agenda also emphasizes two challenges to improve the quality of life in cities: i) not repeating public policies patterns that have not generated a desired impact and ii) include citizens in order to guarantee their rights access. (Naser et al., 2021).

One of the fundamental citizen rights is the right to participation, as part of decision-making in their interest areas. Therefore, the citizenry transition that acts as an observer of their reality is necessary, towards an active and committed citizenry that participates in their city changes processes (Salazar, 2019).

To achieve a participatory evaluation proposal for sustainable and smart mobility, it is necessary to look upon the fundamental principles of citizen participation: Transparency and access information, Voluntariness, Non-exclusion, Equity, Responsiveness, Recognition and respect for the diversity, (Naser et al., 2021).

Likewise, it is necessary to determine a desired level of participation, since it is expected in responsive cities that have an important commitment from citizens, so, they can contribute with their knowledge and live experiences to achieve more effective, efficient, relevant and sustainable to the future.

The first participation level is the informative one, where there is no dialogue with people and a purely information is delivery by the authority. A second level is consultative, where opinions, proposals and interests of citizens are obtained in relation to a public interest subject. The third level is decision-making, where citizens directly influence decision-making on an interest subject. Finally, the fourth level corresponds to co-management, where an articulation between the citizenry and the authority is expected, with the purpose to involve in the design, implementation, control and evaluation of a public interest activity and to influence in an associated decision-making. (Naser et al., 2021).

Currently, research is in progress and it proposes an evaluation model for urban mobility with a participatory approach, it emphasizes in social and environmental mobility aspects, that tries to achieve sustainable and smart mobility. Mobility is being analyzing in the context of sustainable and smart cities that is also responsive, therefore, the importance of the citizens quality of life is highlighted from the new planning of urban mobility.

To achieve this, the need to invest in mobility priorities is accentuated: the first priority is the pedestrian, followed by non-motorized modes, other transport modes, an optimized public transport system and, finally, the private vehicle.

The global context and environmental quality mean a determining aspect in the mobility evaluation, with the criterion that they directly affect the population health and their quality of life. The importance of ecological restoration to achieve green spaces throughout cities to promote active mobility is highlighted.

The built environment constitutes a relevant aspect for evaluation, as the quality public space is required to offer the enough infrastructure for all transport modes and the enjoyment for all social groups.

Connectivity is another important aspect to link-up, because it enables access to the city and its services, regardless of the transport mode used. The purpose is to achieve proximity, balance between time and space, affordability and accessibility.

Urban design becomes relevant, because it allows recovering the social meaning of the city; where safety aims to have streets and safe transport modes, further, urban corridors restored from an ecological point of view, structures and heritage recovered and integrated with the city mobility, where forgotten cultural and historical places are recovered and can be enjoyed on travel routes.

Transport centered on sustainable communities implies the permanent participation of the community in decision-making related to urban mobility and the possibility of discouraging the dependence on private vehicle, searching that infrastructures investments associated with it are reduced.

Financial management is another aspect to consider when evaluating mobility, especially regarding to public transport, that should consider all social groups, including people with physical disabilities, women, people of all ages and low-income people, with the purpose to facilitate their accessibility to the system.

The use of technology to measure some environmental, operational and social parameters is another aspect to consider in the urban mobility evaluation model, where, in participatory processes, the community will be permanently articulated with the local

authority to contribute in the decision-making that are necessary, this can be facilitated with this type of technological instruments.

The finished model is expected to be disseminated in 2022 to contribute to the knowledge basis regarding sustainable and smart mobility and to contribute to the transition towards achieving responsive cities based on citizen participation.

4. CONCLUSIONS

Increasing population in cities and its consequent increase in infrastructure, basic services, transportation, employment, housing and those additional resources that allow them to improve their quality of life, make a necessary change in conventional urban planning models, that are insufficient to attend the new requirements.

The need to link-up the community participation in city development processes has given rise to the opportunity to determine an even more inclusive approach to urban planning, which, together with the previous ones, allows achieving responsive cities, that is, centered on the citizen.

For the mobility case, a transition has been taking place in the conventional mobility planning models towards sustainable and intelligent mobility, to guarantee the participation of all social groups and reduce the effects associated with transport, such as the consumption of electricity. energy, CO2 emissions, air quality, street loss spaces or the impact on public health.

In the current context, Covid-19 pandemic has made it possible to redefine mobility, from transport modes, their needs and the time value used to comply with daily life, that constitutes a forced and disruptive adaptation process of existing models that describe, modeling and implement sustainable mobility systems.

Nowadays, the mobility evaluation in the context is based on the pillars of sustainability: social, economic and environmental issues; furthermore, in the responsive cities' scenario, it is necessary to articulate an additional component: planning and governance, where the technology integration, knowledge and people participation will make it possible to achieve the goals of sustainable and smart mobility.

To achieve a participatory evaluation proposal for sustainable and smart mobility, it is relevant to bear in mind the fundamental principles of citizen participation and determine the desired level of participation, that in responsive cities the greatest citizen commitment is expected, they can contribute with their knowledge and life experiences to achieve more effective, efficient, relevant and sustainable results over time.

Finally, some of the aspects registered in this proposal for the urban mobility evaluation are related to the invert mobility priorities, the global context and environmental quality, the built environment, connectivity, urban design, and transport-oriented sustainable communities, financial management, the use of technology in the city, among others, to contribute to the proposed objective.

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