Clearing the existing fog over the smart sustainable city concept: highlighting the importance of governance

Luiza Schuch de Azambuja
Tallinn University of Technology
Estonia
Luiza.Schuch@taltech.ee

Gabriela Viale Pereira
Danube University Krems
Austria
gabriela.viale-pereira@donau-uni.ac.at

Robert Krimmer
Tallinn University of Technology
Estonia
Robert.krimmer@taltech.ee

ABSTRACT

Population grow and rapid urbanization generate several consequences such as congestion, air, water and urban pollution, health issues, social inequality, natural resource shortage, among others. These challenges added to the technological development and digitalization of governments motivated new urbanization models relying on the use of technologies, which we can call digital city, intelligent city, eco city, sustainable city, and smart city. Besides, in 2015 the United Nations (UN) Member States published the UN Sustainable Development Goals (SDGs) to balance the economic, social and environmental dimensions of sustainable development, increasing the attention to sustainable ways of urban development. This context contributed to the emergence of the Smart Sustainable City (SSC) concept, which can be seen as a strategic response to overcome the urbanization challenges with the help of Information Communication Technologies (ICT). However, there is still uncertainty over the Smart Sustainable City concept and its main characteristics. In addition, limited attention has been given to smart governance aspects, which is recognized as crucial for sustainable development. Thus, this research aims to contextualize the emergence of the SSC concept, identify its characteristics, and to offer a Smart Sustainable City conceptual framework considering the main aspects of a SSC and highlighting the governance dimension. In order to do so, a literature review was performed. The contributions of this research are twofold: (i) strengthening the scientific discussion on smart sustainable city governance, providing its definition; and (ii) suggesting a conceptual model that illustrates a SSC including the three pillars of sustainability (social, economic and environmental), urban infrastructure connecting the SSC elements, and the governance dimension, aiming to guide and provide a balance between the other SSC dimensions.

CCS CONCEPTS

• **Applied computing → Computers in other domains →** Computing in government → *E-government*

KEYWORDS

Smart sustainable city, Smart governance, Smart and sustainable cities, Sustainable development, Urban sustainability.

1. INTRODUCTION

The percentage of the world's population residing in urban areas reached 55 in 2018, representing an increase of 25 percentage points in comparison to 1950 [1]. This rapid urbanization generates sustainability challenges [2, 3]. Among those are, for instance, poverty, waste production, urban pollution, congestion, deteriorating and aging infrastructures, human health issues, shortage of natural resources [4, 5]. This scenario, added to the declaration of the Sustainable Development Goals (SDGs), motivated new urbanization models relying on the use of technologies. In particular, "Sustainable City" and "Smart City" became trendy topics in urban development [6, 7]. Smart City is frequently related to the use of information and communication technologies (ICTs) to connect and integrate critical infrastructures and city services [8, 9, 10], aiming to improve urban spaces, increase democracy, enhance the provision of public services and 'make' cities a better place to live [11, 12, 13, 14].

Moreover, the words sustainable and sustainability started to be used in some Smart City definitions, which was followed by the adoption of the term Smart Sustainable City (SSC) by some authors [e.g. 6, 15, 16]. However, there is still a fog over the SSC concept. Although there are some studies addressing smart sustainable cities, there is no agreed definition of what a SSC is [8, 13], nor a conceptual framework to be easily used, resulting in confusion among practitioners.

One available conceptualization of Smart Sustainable City was suggested by the International Telecommunication Union (ITU) - Telecommunication Standardization Sector and the United Nations Economic Commission for Europe (UNECE) in 2015, being: "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects" [17]. This definition does not mention anything related to governance, which has been identified as a major execution challenge for smart initiatives [18, 19, 20].

Despite the recognized importance of governance for sustainable development [2], there is limited research on ICT for sustainable development focusing on the governance domain [21]. Smart governance can be described as "crafting new forms of human collaboration through the use of ICTs to obtain better outcomes and more open governance processes" [22, p. 392]. Considering the relevance of governance for Smart Sustainable Cities [23] and the lack of studies characterizing SSCs, this paper focus on the following research question: How Smart Sustainable Cities can be understood considering its governance perspective?

The first motivation behind this research is to provide a better understanding of the Smart Sustainable City concept. The second is to stimulate the scientific discussion on SSC governance. Therefore, the aims of this study are to identify and explain the main characteristics of Smart Sustainable Cities, and to establish a conceptual framework for Smart Sustainable Cities that contemplate their governance. To achieve these aims, we performed a literature review to understand the emergence of the SSC concept, its definition, and to identify its main dimensions and characteristics based on the smart city literature that includes 'governance' and 'sustainable' or 'sustainability'.

The remainder of this paper is organized as follows: the next section contextualizes the emergence of the Smart Sustainable City term, which includes the urbanization phenomenon, ICT development and the publication of the sustainable development goals. In the sequence, the research methodology is described. Afterwards, we present the results of the literature review, explaining the main characteristics of SSCs. The subsequent section suggests the SSC conceptual framework, representing the dimensions and characteristics of smart sustainable cities in a simple and complete way. The last section summaries the research and suggests future studies.

2. BACKGROUND

2.1. Urbanization, Sustainable Development and its Goals

According to the United Nations World Urbanization Prospected [1], the number of people living in urban areas reached 4.2 billion in 2018, whereas in 1950 this number was 751 million. The promises of urbanization (e.g. cities promoting economic development and higher productivity) are not equal as its challenges. The list of urbanization issues includes social stress and poverty expansion (greater homelessness, higher crime rate); urban pollution (water, land, air); health effects; resource constraints (energy, water, land); spatial dynamics (obstacles to access resources, cities and megacities); among others [5]. Public and private organizations are looking for innovative ways to overcome these challenges, or, in other words to achieve sustainability. Kemp et al. [24] explained that sustainability can be understood as protecting facilities and cultural diversity to create a better and impartial world. In their words, "sustainability is best viewed as a socially instituted process of adaptive change in which innovation is a necessary element." [24, p. 13].

The starting point for the discussion on sustainable development (SD) started in 1987 when the World Commission on Environment and Development (WCED) published a report titled "Our Common Future" as a "global agenda for change". The report stated that "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [25, p. 41], and suggested directions mainly focused on three pillars of sustainability as following: social (e.g. population and human resources), economic (e.g. industry and jobs) and environmental (e.g. environmental degradation and ecosystems). Five years later, in 1992 at the United Nations Conference on Environmental and Development (UNCED) in Rio de Janeiro – Brazil, those recommended actions were debated by more than 178 governments who, in this occasion, created the Agenda 21, the Rio Declaration on Environment and Development, and the Statement of principles for the Sustainable Management of Forests [2, 24].

More recently, in 2015, the United Nations (UN) Member States adopted the UN Sustainable Development Goals (SDGs) comprised of 17 Global Goals and 169 targets proposed to balance the economic, social and environmental dimensions of sustainable development. Each goal contains from five to 19 targets, whereas each target can be monitored by one more indicator. One third of the SDGs' indicators have an urban element [26]. Consequently, cities are protagonists to achieve the goals that fall under local government responsibility [8, 13, 23, 27, 28]. The Sustainable Development Goal most related to the local level is the SDG11 "Sustainable Cities and Communities: Make cities and human settlement inclusive, safe, resilient and sustainable", which is comprised by ten different targets. To provide one example, the target 11.3 states that "By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries" [26].

2.2. Smart Cities' definitions and the Existing Criticism

The definition of smart city suggested in 2007 by Giffinger and others [11] is among the most used concepts for planning and measuring smart city actions [29, 30]. According to their model, a Smart City (SC) can be understood through six main characteristics consisted of many factors and indicators, as following: Smart Economy (competitiveness, innovative spirit, entrepreneurship, economic image and trademarks productivity, flexibility of labor market, international embeddedness, and ability to transform); Smart People (level of qualification, affinity to life-long learning, social and ethnic plurality, flexibility, creativity, cosmopolitanism/open-mindedness, participation in public life); Smart Governance (participation in decision-making, public and social services, transparent governance, political strategies and perspective); Smart Mobility (local accessibility, inter-national accessibility, availability of ICT infrastructure, sustainable, innovative and safe transport systems); Smart Environment (attractivity of natural conditions, pollution, environmental protection, sustainable resource management); and Smart Living (factors related to quality of life as cultural and education facilities, health conditions, individual safety, housing quality, touristic attractivity, and social cohesion) [11]. Another multidisciplinary approach for SC was suggested by Chourabi et al. [31], who proposed an integrative framework to analyze initiatives considering eight dimensions (Technology, Organization, Policy, People and Communities, Economy, Built Infrastructure, Natural Environment, Governance). In a recent study, Yigitcanlar et al. [7] indicated the most mentioned perspectives of Smart City, classifying them as (i) drivers: community, technology and policy; and (ii) desired outcomes: productivity, sustainability, accessibility, wellbeing, livability and governance.

Notwithstanding the importance of technology for smart cities, there are some criticism regarding the technocentric focus taken by some researchers [10, 29, 32, 33]. A smart city "is not system-driven but service-oriented" and should have a comprehensive commitment to innovation in management and policy, being not only a technological concept but related to socioeconomic development [10, p. 190]. Smart City was also referred as a type of e-government willing to create new channels of communication and interactions with citizens and to provide better and proactive urban services [34, 35]. Another criticism found in the SC literature is the lack of environmental approaches. Although some smart city definitions include key words like 'sustainability' or 'natural environment', a weak connection between smart city and environmental sustainability was proven by previous studies [15] and there is no convincing commitment to the sustainable development goals [36].

2.3. Sustainable Cities and Smart Cities towards Smart Sustainable Cities

As well explained by the work of Höjer and Wangel [37], the rise of the Smart Sustainable City concept can be related to five developments: (i) Globalization of environmental problems and sustainable development: challenges considered as global concerns; (ii) Urbanization: cities as the core of the sustainability discussion; (iii) Sustainable urban development and sustainable cities: more interest on sustainable actions and plans, from different perspectives like academia, public and private sector; (iv) Information and Communication Technology development: new solutions, more technological capacity, cost reduction; and (v) smart cities approaches. Endorsing the above-mentioned developments (iii) and (v), a literature review showed a growing interested on the analysis of differences and similarities of *Smart* cities and *Sustainable* cities [e.g. 13, 16, 30, 38]. Likewise, other studies were interested in the possible contribution of smart city's initiatives and tools for sustainable urban development [e.g. 6, 15].

Sustainable city can be considered as a new attitude or philosophy which balance its goals in line with the principles of sustainable development [30], or as a "set of diverse approaches to applying the knowledge of urban sustainability and related technology to the planning and design of the built environment, i.e., existing and new cities" [39, p. 224].

Comparing sustainable cities and smart cities, Bibri and Krogstie [38] listed some discrepancies, including: sustainable cities are focused on infrastructure and urban metabolism, being design-oriented, whereas smart cities are focused on the use of advanced technology to provide better services, but lack design considerations for sustainability (also mentioned by Ahvenniemi et al. [16]); sustainable cities attempt for sustainability goals, and smart cities for smart targets; smart cities should enhance their physical landscape for sustainability, whereas sustainable cities need to enrich their informational landscape; finally, smart cities need to absorb the goals of SD, while sustainable cities should smarten up as to their contribution to these goals [38]. Although there are many variances between the terms, both concepts cannot be thought of as contrasting [30]; they can, in turn, complement each other. Considering the 'pros and cons' of Smart Cities and Sustainable Cities, and the existing criticism pertaining SC (technocentric focus, and the lack of sustainability approaches and environmental concerns), it can be affirmed that the amalgamation of the terms looks promising. In this sense, this study considers a Smart Sustainable City as a combination of Smart City and Sustainable City.

3. METHODOLOGY

The research approach used in this study includes a review of the interdisciplinary Smart City literature giving special attention to sustainability, sustainable development and governance, with the aim of characterize Smart Sustainable City. According to Paré et al. [40], review articles have the aim to synthetize the existing literature without the analysis of primary data. The aforementioned authors suggested a typology consisting of nine types of review papers. Following their classification, the present paper can be considered a theoretical review as it draws on existing conceptual studies with the goal of developing a new conceptual framework [40].

The idea was to perform a conceptual analysis to determine keywords, general elements and possible characteristics of Smart Sustainable Cities according to the existing Smart City literature. The conceptual analysis method was used in the studies of Jabareen [41] and Yigitcanlar et al. [7], who followed the tactics suggested by Miles and Huberman [42] to generate meanings from different data sources aiming to build a theoretical or conceptual framework. As this research has a similar aim of developing a conceptual framework, the methodology adopted was adapted from the previous mentioned studies. The steps performed in this study were: (i) selecting an initial conceptualization of smart sustainable city; (ii) identifying SSC themes; (iii) reviewing the literature to identify available SSC concepts and smart city concepts that could be applied to SSC; (iv) identifying SSC characteristics, classifying them according to the predefined themes and recognizing similarities or patterns among themes; (v) synthetizing the themes (dimensions) and their main aspects; and (vi) developing a framework to represent the dimensions and characteristics of SSCs.

As a starting point (steps i and ii), the general categories of SSC were taken from the work of ITU [17, 43], which defined the main SSC domains as Economy, Environment, Society and Governance. After (step iii), a literature review was performed using a keyword search-based approach [44]. The set of key words selected was: ("smart") AND ("city" OR "cities") AND ("governance") AND ("sustainability" OR "sustainable") which resulted in 275 records in Scopus and 299 records in Web of Science. This search was realized on March 08, 2019. The title and abstract of all papers were checked to select the articles that could be relevant for this study. The selection criteria applied (steps iii and iv) resulted in 80 records for analysis. It was included studies containing information of the roots of the smart sustainable city concept, papers bringing smart city definitions which included sustainable or sustainable development, or articles that mentioned SSC characteristics, applications, or differences between smart cities and smart sustainable cities. The word "governance" was included in the search aiming to give attention to governance aspects, as governance is of great importance for sustainable growth. Worthy to mention that some additional literature was also included in the review through a forward and backward method [45, 46].

The final stage of the literature review process (steps v and vi) was to present the findings and to suggest a conceptual framework for smart sustainable cities. As the objective of this research was not to explore the whole state of art of the smart and sustainable city literature, the data analysis (literature review) was performed until reaching the data saturation model, which is related to the "degree to which new data repeat what was expressed in previous data" [47, p. 1897]. Including the additional literature, 45 records were used to build the conceptual framework.

4. LITERATURE REVIEW

This section brings the results of the literature review. First, some SSC definitions are discussed. After, the main aspects and characteristics of a smart sustainable city are presented, classified according to the themes (dimensions) identified in the analysis of the literature. Lastly, the SSC dimensions are summarized based on the respective characteristics.

4.1. Definitions

The main definition of SSC identified is the one by ITU [17], which connects aspects of a smart city (being innovative and using ICT to improve quality of life and to provide services) with the sustainability pillars (economic, social, and environmental). Likewise, Höjer and Wangel also mentioned the importance of thinking about the future in their definition of SSC as "a city that (i) meets the needs of its present inhabitants, (ii) without compromising the ability for other people or future generations to meet their needs, and thus, does not exceed local or planetary environmental limitations, and (iii) where this is supported by ICT" [37, p. 10]. Their definition was based on the sustainable development concept, however the authors added "ability for other people" as a way to highlight the global responsibility towards a sustainable development. Overall, a Smart Sustainable City is a continuous transformative process, based on the collaboration and engagement of different actors, building different capacities (human, technical and institutional) in a way to improve the quality of life, protect natural resources, and pursuing socio-economic development [48].

Guedes et al. [20] investigated the most important drivers for the development of more intelligent and sustainable cities, classifying them into two groups: governance-related and technology-related. They concluded that the highest priority aspects are related to governance, being "urban planning, cities infrastructure, sustainability, mobility, public safety, health, and public policies" [20, p. 14]. Other examples of driving forces found in the literature are regarding government policies, innovation [66], urban infrastructure [49, 71], environmental standards [31], social responsibility, citizen participation and engagement [8, 18, 10, 66]. The "innovative" characteristic of a SSC was highly mentioned by academics. Bibri and Krogstie [39] mentioned the use of different innovation systems as, for instance, the Triple Helix of university–industry–government. Their definition of SSC is: "an interplay between scientific innovation, technological innovation, environmental innovation, urban design and planning innovation, institutional innovation, and policy innovation, smart sustainable cities represent and involve inherently complex socio–technical systems of all sorts of innovation systems" [39, p. 226].

4.2. Smart Sustainable City characteristics

As explained in the methodology, the four themes (Society, Economy, Environment, and Governance) suggested by ITU [43] were used as a starting point to classify the characteristics of a Smart Sustainable City. Nevertheless, the definitions of smart (sustainable) city frequently include aspects related to the city infrastructure and the use of ICT. In this way, during the analysis of the literature, the authors found the necessity of adding an additional category to classify the characteristics of SSC, namely "Urban Infrastructure". The Table 1 summarizes the findings of the literature review bringing the five main SSC dimensions found

in the literature and the aspects of each dimension together with the respective references.

Table 1: Smart Sustainable City aspects

	Aspects	References
Governance	Context	[20, 49, 50, 60, 66, 68]
	Policies and Regulations	[7, 10, 18, 20, 43, 50, 51, 52]
	Organization and Structures	[35, 43, 50, 51]
	Processes	[35, 43, 50]
	Roles and Responsibilities	[21, 50, 66]
	Decision Making	[9, 11, 28, 35]
	Stakeholders	[3, 39, 48, 50, 53]
	Collaboration / Participation	[10, 48, 53, 54, 55, 56, 57]
	Engagement	[8, 18, 48, 58]
	Data Sharing / Exchange	[9, 10, 28, 31]
	Transparency and Accountability	[11, 18, 31, 43, 59]
	Communication	[18, 34, 35, 43, 52]
	Compliance	[13, 15, 20, 43]
	Measurements	[13, 50, 58, 59]
Social	Social Inclusion	[58, 60, 61, 62, 63]
	Aware Citizens	[8, 11, 18, 30, 58, 64]
	Culture and Recreation	[28, 43]
	Social Networks	[11, 43, 65]
	Demographic (incl. education)	[11, 43]
	User Experiences	[8, 43]
	Equal Access, Accessibility	[7, 11, 43]
	End Consumers (services)	[10, 20, 29, 34, 35, 43, 65]
	Social Needs	[20, 37, 43, 65]
	Quality of Life	[7, 8, 11, 37, 48, 65]
	Social Collaboration	[18, 48, 64, 65]
Economic	Innovation and R&D	[10, 11, 39, 43]
	Entrepreneurship	[11, 18, 52]
	Opportunity and Competitiveness	[11, 66]
	Employment	[18, 31, 43, 49, 52]
	Gross Domestic Product	[43, 48, 52]
	Market	[18, 35, 43]
	Viability and Flexibility	[11, 31, 43]
	Investment	[21, 43, 59]
	Public Private Partnership	[18, 20, 21, 39, 43, 53, 66]
	Productivity and Value Chain	[7, 11, 18, 43, 59]
Environment	Sustainable and Renewable	[7, 8, 11, 20, 43, 48, 58]
	Land Use	[43, 64, 65]
	Biodiversity	[28, 43, 52]
	Resource Management (energy, water)	[11, 43, 48, 59, 64, 67]
	Air Quality	[43, 48, 58]
	Waste Management	[21, 43, 58]
	Sanitation	[20, 68]
	Conservation and Preservation	[11, 48, 49, 67]
	Mobility	[11, 20, 64]
	Liveable and Green Areas	[59, 64, 65]
Urban Infrastructure	Transport Systems	[11, 20, 21, 30, 69]
	Water and Energy Systems	[21, 52, 67, 69]
	Smart Buildings	[59, 67, 70]
	Smart Grids	[20, 21, 69, 70]
	Sensors	[21, 30, 67, 71]
	Networks and Interoperability	[8, 20, 21, 28, 55, 71]
	Broadband and Connectivity	[31, 39, 49, 71]
	Databases / Data Analytics	[28, 39, 58, 71]
	Cloud	[8, 28, 38, 39,71]
	Emerging Tech: Big Data, IoT, AI	[28, 30, 39, 71]
	GIS	[49, 69]

4.3. Smart Sustainable City dimensions

The social theme includes everything that is related to people as social responsibility, informed citizens, community development, participative and engaged citizens, accessibility, etc. Smart sustainable cities need informed citizens, as they are important actors in order to reach sustainability [18]. In addition, social sustainability refers to guaranteeing quality of life, providing city services for the population (health care, welfare, physical safety and education), and ensuring social inclusion and citizens participation. SSCs should balance the need of various communities aspiring to foster educated and informed citizens, who are key players in city initiatives and have an important role on ensuring sustainability [18, 72]. The social theme of SSC can be related to the "People and Communities" dimension of Chourabi et al. [31]'s framework and to the "Smart People" and "Smart Living" characteristic of Giffinger et al. [11].

The economic theme is characterized by innovation, research and development (R&D), entrepreneurship, labor, investments, partnerships, among others. SSCs should provide economic stability, should innovate, attract business and capital, increase regional attractiveness and competitiveness [18, 35], improving productivity, and developing, attracting and retaining workforce [31]. In sum, the economic domain aims to ensure economic growth, creating opportunities for a diverse and dynamic economy, establishing economic sustainability. The capability to innovate and capitalize economically is what makes a city smart [18]. Comparing to other frameworks, it is related to the "Smart Economy" of Giffinger et al. [11] and to the "Economy" of Chourabi et al. [31].

The environmental domain is usually related to natural environment protection and restoration, green building practices and energy saving, which is often included in city's strategic goals

[35]. Cities should create environment-friendly initiatives aiming to create better spaces to live [7, 31]. Briefly, it is about stablishing an environmentally responsible and sustainable approach which "meets the needs of today without sacrificing the needs of future generations", reinforcing prevention and resilience for natural and man-made disasters and addressing the impacts of climate change [43]. The environment theme is directly related to the "Smart Environment" of Giffinger et al. [11] and to the "Natural Environment" of Chourabi et al. [31].

The governance theme comprises programmatic directions, the allocation of resources and budget, the interactions with external actors and internal partnerships with different departments and agencies [35]. It includes regulations and mechanisms with reasonable and proper policies and processes in a standardized manner [43]. Governance factors includes collaboration, leadership, participation and partnership, communication, data-exchange, service and application integration, accountability and transparency [18, 31]. In short, the governance pillar refers to the ability of administrating policies and engaging different stakeholders. The governance theme is directly related to the "Smart Governance" of Giffinger et al. [11] and can be a combination of "Governance", "Organization and Policy" of Chourabi et al. [31].

Urban Infrastructure refers to the physical and built infrastructure (roads, transportation, factories, buildings, subways, bridges, tunnels, etc.) and to the digital infrastructure (Information Communication Technology) [31]. Regarding built infrastructure, first cities should ensure affordable housing facilities as water and energy supply systems. Likewise, the usage of emerging technologies is crucial for the development of smart sustainable cities [7, 13, 16, 18], being considered an enabler for achieving sustainability [8]. As explained by Guedes et al. [20], smart grid energy, smart buildings, logistics applications, and technological applications for cities are technology-related drivers for SSC development.

The use of digital infrastructure in the context of urban planning and development refers to *urban ICT*, which at the technical level embraces hardware and software, as follows [71]:

- **Hardware** refers to wireless communication networks, telecommunication systems, internet infrastructure, cloud and fog computing, middleware architecture, database systems, computers and terminals, sensors, smartphones;
- **Software components** include communication and network protocols, decision support systems, database integration and management applications, modeling, simulation and visualization methods, real–time operation processes, enterprise integration methods, big data analytics – e.g. statistical analysis, data mining, machine learning, among others.

Bibri explained that those digital infrastructure components are used for "sensing, collecting, storing, coordinating, integrating, processing, analyzing, synthesizing, modeling, simulating, managing, exchanging, and sharing urban data for the purpose of monitoring, understanding, probing, and planning modern cities to achieve particular goals." [71, p. 766]. For a smart sustainable city, these goals mean improving quality of life, urban operations and services while guaranteeing competitiveness and sustainability. Hence, the aim of using urban ICT is to comprehend how the city works, willing to improve a wide range of city functions/domains.

Aina [49] in his work presented many smart sustainable cities best practices, from real cases, which were classified by the author as 'smart infrastructure' or 'sustainability factors'. His study confirmed that infrastructure is necessary but not enough for smart sustainable city development. According to him, there is a need of: "taking the debate beyond the development of physical infrastructure and looking at how citizens can be fully involved and not just counting social media and internet penetration" [49, p. 56].

Finally, the literature review and the analysis of Smart City definitions that include "sustainable" or "sustainability" showed similarities with the conceptualization of SSC. According to Caragliu and others, a city is considered smart "when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance." [56, p. 70]. Likewise, some conceptualizations found in the literature connects more than one SSC themes. To illustrate: "intelligent use of ICT within an interactive infrastructure to provide advanced and innovative services to its citizens, impacting quality of life and sustainable management of natural resources." [8, p. 90]; another is "a technologically advanced and modernized territory with a certain intellectual ability that deals with various social, technical, economic aspects of growth based on smart computing techniques to develop superior infrastructure constituents and services" [19, p. 1].

5. SMART SUSTAINABLE CITY CONCEPTUAL FRAMEWORK

After contextualizing the emergence of the smart sustainable city concept, presenting some existing definitions and showing the aspects of each SSC dimension, this section places all elements together in order to develop a conceptual framework for smart sustainable cities that contemplate their governance. The Figure 1 illustrates the main characteristics of SSCs based on the results of the literature review of smart cities and sustainable cities highlighting governance aspects.
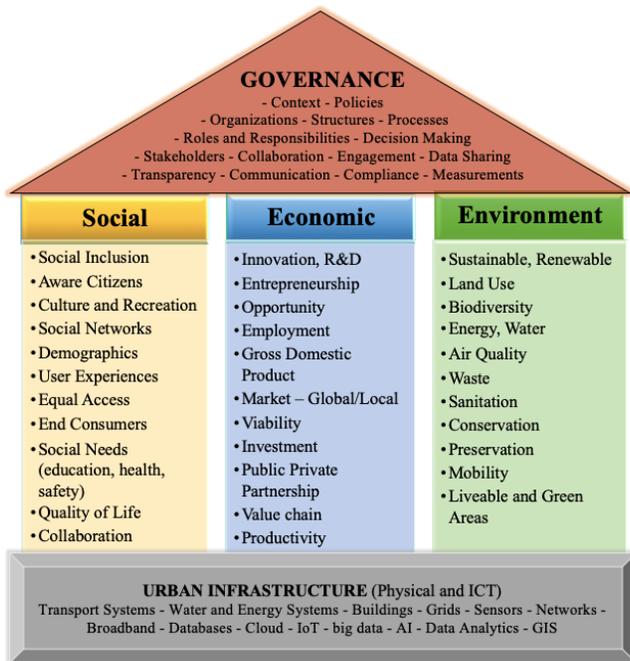
GOVERNANCE
- Context - Policies
- Organizations - Structures - Processes
- Roles and Responsibilities - Decision Making
- Stakeholders - Collaboration - Engagement - Data Sharing
- Transparency - Communication - Compliance - Measurements

Social	**Economic**	**Environment**
• Social Inclusion	• Innovation, R&D	• Sustainable, Renewable
• Aware Citizens	• Entrepreneurship	• Land Use
• Culture and Recreation	• Opportunity	• Biodiversity
• Social Networks	• Employment	• Energy, Water
• Demographics	• Gross Domestic Product	• Air Quality
• User Experiences	• Market – Global/Local	• Waste
• Equal Access	• Viability	• Sanitation
• End Consumers	• Investment	• Conservation
• Social Needs (education, health, safety)	• Public Private Partnership	• Preservation
• Quality of Life	• Value chain	• Mobility
• Collaboration	• Productivity	• Liveable and Green Areas

URBAN INFRASTRUCTURE (Physical and ICT)
Transport Systems - Water and Energy Systems - Buildings - Grids - Sensors - Networks - Broadband - Databases - Cloud - IoT - big data - AI - Data Analytics - GIS

Figure 1: Smart Sustainable City Conceptual Framework

Following the framework, this study considers that a SSC is made of five main dimensions: the three pillars of sustainability, social, economic, and environment; the governance on the top; and urban infrastructure (including urban ICT and physical infrastructure) as the base. All dimensions are connected and are essential in order to characterize a city as a SSC. To emphasize the importance of governance for smart sustainable cities development, this dimension was set as the 'roof' of the framework. In the other hand, the Urban Infrastructure dimension is seen in this study as the 'base' of a smart sustainable city, in order to connect all elements. The idea is that urban infrastructure can be considered as the ground 'layer' to deliver services and improve quality of life, whereas the smart sustainable city governance is responsible for the coordination, capability and strategy of how to ensure that all domains are being considered to reach sustainability.

Smart governance can be defined as the application of emerging technologies for improving decision-making processes [73]. At the local level, smart sustainable city governance strongly focuses on the decisions made by government for improving the quality of life in cities, being the intersection of the main smart city dimensions, including the social, economic and environmental domains. Smart city governance is a "form of smart governance, allocating decision-making rights to stakeholders (in particular citizens) and enabling them to participate in effective and efficient decision-making processes to improve the quality of life in cities" [73, p. 156]. Smart governance includes aspects such as collaboration, leadership, participation and partnership, communication [10, 11, 12, 56]; data-exchange, service and application integration, accountability and transparency [31]; and

data-base evidence to improve the quality of life in cities, which requires information sharing [73].

Nam and Pardo highlighted the importance of policies for smart governance. They defined city innovation in terms of technology, organization and policy. Policy means "mechanisms to address institutional and non-technical urban problems and create conditions enabling for a smart city" [10, p. 187]; including redesigning relationships between government and actors. In terms of actors, there is an electronic linkage of "multi-level, multi-jurisdictional governments and all non-governmental stakeholders such as firms, nonprofits and citizens" [10, p. 190]; thus, it is necessary a cross-organizational management and appropriate leadership for cross-boundary settings and networks in order to establish interoperability and collaboration [10]. The cross-sector approach was highlighted as a key aspect: "the model of governance in such multi-agency initiatives is key to achieving desired outcomes and sustainability." [9, p. 2953]. In terms of smart initiatives, there is no perfect or uniform governance model. The governance can be participatory, hierarchical, and/or hybrid [35]. It can be classified into top-down (mainly government-led) or bottom-up (citizen-driven) [74].

Likewise, the governance of a smart sustainable city embodies a collection of technologies, people, policies, practices, resources, social norms and information sharing to support the city's functioning [31]. A city is made of citizens; thus, they should be able to participate, to monitor government activities, and to provide feedback. An individual citizen and civic groups are key players in smart sustainable city initiatives. In this way, citizen engagement is strongly mentioned by academics [18, 75] as a characteristic of SSCs. According to Martin et al. [75, p. 1]: "the potential to empower and include citizens represents the key to unlocking forms of smart-sustainable urban development that emphasize environmental protection and social equity, rather than merely reinforcing neoliberal forms of urban development". Therefore, governments should create mechanisms for citizen participation and engagement in decision making, design of city services and so on [35]. Furthermore, governance is needed to balance the multiple, and maybe contrasting, interests among city inhabitants [30].

6. CONCLUSIONS AND FURTHER RESEARCH

The results of the literature review and the conceptual framework proposed in this study helped to clarify the smart sustainable city concept and to identify its characteristics. Answering the main research question "How Smart Sustainable Cities can be understood considering its governance perspective?", the conceptual framework suggested in this research defines a smart sustainable city as a combination of many factors, which can be classified according to the three sustainability pillars (social, economic and environment), together with governance factors, and making use of urban infrastructure (physical and digital). The definitions of SSC address the importance of balancing socio-economic development in a way that does not harm future generations. This is a fundamental difference between smart cities and smart sustainable cities, in which the later has a global focus.

In sum, smarter cities refer to more responsive governments, allowing citizen engagement, ensuring transparency and more effective collaboration with different partners, using smart technologies. To be called 'smart <u>sustainable</u> city' a city should govern the relations with various stakeholders, ensuring the balance of the three sustainability dimensions (social, economic and environment), supporting green initiatives, using ICT to connect the city systems with the coordination of a smart sustainable city governance. Smart sustainable city governance can be explained as governing with a focus on citizen's needs (citizen-driven), making use of ICT (in particular to collect, integrate and analyze important data to be used in decision making), engaging multi-stakeholders and using collaborative approaches (intra-departmental and external collaboration). Furthermore, smart sustainable cities should ensure good communication and information sharing, strengthening the relationship between various stakeholders. The governance of a smart sustainable city is the 'roof' of a smart sustainable city in the sense that this domain through its components should be able to ensure socio-economic development and environmental aspects of the city.

In terms of contributions, this research suggests a conceptual framework to describe the characteristics of smart sustainable cities that highlights the importance of governance and proposes a conceptualization for smart sustainable city governance. This conceptual framework can be used to study smart sustainable cities initiatives, helping to classify the SSC aspects (drivers, outcomes) into the five dimensions. Another important aspect is that in order to be considered a smart sustainable city, initiatives should contemplate all dimensions at the same time.

Although its results provides a solid reflection on the SSC concept and stimulate the scientific discussion on the topic, this research is not exhaustive in its suggestions and proposals. We also do not have the pretension that this is a definite framework, but a guiding framework to identify the SSC characteristics and to support cities in their path to become smart and sustainable.

Among the limitations of this research is the selected sample for the literature review, which could be expanded bringing different perspectives. There is also a non-intentional bias towards existing concepts and definitions in the analyzed literature. Future research could include the study of concrete smart sustainable cities' initiatives to identify how they balance the three sustainability pillars, as well as governance and urban infrastructures elements. Finally, further studies can also identify enablers and challenges for smart sustainable cities development according to the five dimensions proposed by the SSC Framework here suggested.

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