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**DOCTORAL THESIS**

# Exploring the Journey towards Smarter Sustainable Cities: Capacity Development for Evolving Governance Practices

Luiza Schuch de Azambuja

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**Declaration:**
Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for doctoral or equivalent academic degree.

Luiza Schuch de Azambuja

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# Teel targemate jätkusuutlike linnade poole: arenevate valitsemisstruktuuride suutlikkuse kasvatamine

LUIZA SCHUCH DE AZAMBUJA

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# Contents

## List of publications

The thesis is based on the following original publications:

**I** Soe, R. M., **Schuch de Azambuja, L**., Toiskallio, K., Nieminen, M., & Batty, M. (2022). Institutionalising smart city research and innovation: from fuzzy definitions to real-life experiments. *Urban Research & Practice*, *15*(1), 112–154. https://doi.org/10.1080/17535069.2021.1998592. ETIS 1.1.

**II** **Azambuja, L. S**. (2021). Drivers and Barriers for the Development of Smart Sustainable Cities: A Systematic Literature Review. *Proceedings of the 14th International Conference on Theory and Practice of Electronic Governance (ICEGOV'21)*. ACM, New York, NY, USA, 422–428. https://doi.org/10.1145/3494193.3494250. ETIS 3.1.

**III** Pereira, G. V., & **Azambuja, L. S.** (2022). Smart Sustainable City Roadmap as a Tool for Addressing Sustainability Challenges and Building Governance Capacity. *Sustainability (Switzerland)*, 14(1), 1–22. https://doi.org/10.3390/su14010239. ETIS 1.1.

**IV** **Azambuja, L. S**., Pereira, G. V., & Krimmer, R. (2020). Clearing the Existing Fog over the Smart Sustainable City Concept: Highlighting the Importance of Governance. *Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance (ICEGOV'20)*. ACM, New York, NY, USA, 628–637. https://doi.org/10.1145/3428502.3428595. ETIS 3.1.

**V** **Azambuja, L. S.**, & Soe, R.-M. (2023). Devising an Urban Learning Centre for Municipalities in Eastern Partnership Countries. In: *Janssen, M., et al. New Sustainable Horizons in Artificial Intelligence and Digital Solutions. I3E 2023. Lecture Notes in Computer Science*, vol 14316. Springer, Cham. 403–417. https://doi.org/10.1007/978-3-031-50040-4_30. ETIS 3.1.

**VI** **Azambuja, L. S**., Lheureux-De-Freitas, J., Moreira, C. R., & Macadar, M. A. (2014). A Smart City Initiative: A Case Study of Porto Alegre 156. *Proceedings of the 15th Annual International Conference on Digital Government Research (dg.o '14)*. ACM, New York, NY, USA, 245-252. https://doi.org/10.1145/2612733.2612768. ETIS 3.1.

**VII** Macadar, M. A., Lheureux-de-Freitas, J., **Azambuja, L. S.,** Luciano, E. M. (2016). Contact Center in a Smart Cities View: a Comparative Case Study of Curitiba (Brazil), Porto Alegre (Brazil) and Philadelphia (USA). *Proceedings of the 9th International Conference on Theory and Practice of Electronic Governance (ICEGOV '15-16).* ACM, Montevideo, Uruguay, 2016. Ed. Bertot, J., Estevez, E., Mellouli, S. New York, 215−222. https://doi.org/10.1145/2910019.2910063. ETIS 3.1.

**VIII** Pereira, G. V., Testa, M. G., Macadar, M. A., Parycek, P., **Azambuja, L. S.** (2016). Building Understanding of Municipal Operations Centers as Smart City Initiatives. *Proceedings of the International Conference on Electronic Governance and Open Society: Challenges in Eurasia (EGOSE' 16).* ACM, 19−30. https://doi.org/10.1145/3014087.3014110. ETIS 3.1.

## Author's contribution to the publications

Contribution to the papers in this thesis are:

**I** Second author. The author of the doctoral thesis is not the lead author of this article yet was still involved in writing up the research design, preparing part of the literature review, data collection, and analysis of the results.

**II** The author of the doctoral thesis is the **sole contributor** to this paper. The author also presented the work at the conference and discussed its results and implications with the academic community.

**III** The author of the doctoral thesis contributed 50% to the publication. The starting point of this article was based on the prior work of the author; thus, the author was responsible for the original draft in addition to data validation and data curation. The conceptualisation, choice of methodology, reviews, and editing were done together with the second author.

**IV** First author. The starting point was based on the prior work of the author of the thesis. The author also presented the work at the conference and discussed the results and implications with the academic community.

**V** First author. The author of the doctoral thesis was the lead author of this paper, responsible for writing up most of the content of the paper, including the literature review, and creating the conceptual framework for the article. The author presented the work at the conference and was the corresponding author with the conference panel.

**VI** First author. The author of the doctoral thesis was the lead author of this paper, responsible for writing up most of the content of the paper, including the literature review, also doing research design, data collection (all interviews), and coding. This paper was based upon the authors Bachelor's thesis, which was supervised by the fourth author of the paper. The author also presented the work at the conference and discussed the results and implications with the academic community.

**VII** Third author. The author contributed to this paper by being responsible for one of the three cases included in the paper.

**VIII** The contribution of the author of the doctoral thesis to this paper was around 15%. This publication was developed based on the previous work of the first author who was responsible for most of the work.

# 1 Introduction

My smart city (SC) journey began in 2013, during my final year of undergraduate studies. Working at a multinational IT company at the time, my initial thoughts regarding smart cities were largely centred around the application of advanced technologies within urban environments. However, my perspective began to change when a professor recommended that I read the paper "Building Understanding of Smart City Initiatives" (Alawadhi et al., 2012). This paper triggered my interest in smart cities, prompting me to choose it as the topic for both of my bachelor's theses. Subsequently, my academic trajectory guided me towards a transition from smart cities to smart sustainable cities, culminating in the focus of my master's thesis. Now, in my doctoral thesis, I aim to explore the journey towards smarter sustainable cities with a focus on increasing local governance capacity for the transformation of cities.

This thesis delves into the development of smarter sustainable cities, which can be seen as providing an innovative approach to complex challenges ranging from population growth to climate change and aiming to improve the quality of life in cities in a sustainable way. Given that achieving the sustainable development of cities requires a fundamental shift in governance practices (da Cruz et al., 2019; Tomor et al., 2019; Wilkes-Allemann et al., 2023), smart cities demand novel municipal governance approaches (Przeybilovicz & Cunha, 2024). However, since local governments often lack the required capacities (José & Rodrigues, 2024; Mayne et al., 2020), the development of smarter sustainable cities presents a multifaceted challenge, which this thesis endeavours to explore.

## 1.1 Scope and aims of the thesis

The global population reached eight billion at the end of 2022 (United Nations, 2022). Additionally, in 2007 the urban population exceeded the rural population for the first time in history, with projections indicating that by 2050, nearly 70 percent of the world's population will reside in urban areas (United Nations, 2019). Urbanisation has been driven by several factors. Cities offer a greater number of economic opportunities, attracting people from rural or less developed regions in search of better employment prospects and improved access to services, such as education and healthcare. However, alongside these opportunities, rapid urbanisation raises complex challenges, including social inequality, violence, poverty, urban pollution, traffic congestion, health issues, and resource constraints (Estevez et al., 2016; Sodiq et al., 2019).

In an era marked by rapid urbanisation and technological advancements, cities worldwide are looking for innovative ways to address local challenges with the help of information and communications technologies (ICTs), giving rise to the concept of the smart city (SC). However, the initial proliferation of SC projects has primarily been driven by the adoption of emerging technologies, highly influenced by technology companies, such as IBM and Cisco Systems (Batty et al., 2012; Mora et al., 2019). Despite this initial emphasis of SC developments on smart applications (i.e., corporate and technology-driven initiatives), recent years have shown a slow shift from a techno-centric approach towards a people-oriented one (Kubina et al., 2021).

Moreover, challenges associated with urbanisation and growing concerns regarding climate change and its impacts, have motivated a global pursuit of sustainable development (SD), as evidenced by agendas such as the Sustainable Development Goals

(SDGs)[1]. Even though these are global concerns, the successful achievement of the SDGs has directed attention also to cities and, consequently, to smart cities (Sharifi et al., 2024). This context contributed to the emergence of the concept of the smart sustainable city (SSC).

Smart sustainable cities can be understood as an evolution of smart cities, aiming to address urban challenges while fostering long-term sustainability by employing technological advancements and collaborative approaches. The author of this thesis was motivated to explore the development of smarter sustainable cities by building upon the perspective of smartness as a 'continuum in which local government officials, citizens and other stakeholders could think about and implement initiatives that attempt to make a city smarter' (Gil-Garcia et al., 2015, p. 79), which added to the growing recognition of the need to integrate sustainability principles into the concept of smart cities.

The pursuit of sustainability has shifted focus from governments as institutions to governance as the process of governing (Estevez & Janowski, 2013; Janowski et al., 2018). Despite the increasing interest in this topic, governance mechanisms remain one of the most undertheorized and relatively overlooked dimensions of smart cities (Mora et al., 2023). Scholars have recognised the necessity of investigating strategies (Höjer & Wangel, 2015) and tools to guide the planning and implementation of smart (sustainable) city initiatives (Angelidou, 2016; Ismagilova et al., 2019; Lara et al., 2016; Martin et al., 2019).

There remains a need to explore mechanisms that could strengthen governance capacity for the development of smarter sustainable cities. Therefore, this thesis sets out to investigate governance tools and strategies that can support it.

The aim of the doctoral thesis is to investigate and contribute to the development of smarter sustainable cities by addressing three research questions:

1. How can a systematic overview of smart city research and innovation contribute to the concept of smart sustainable cities?

2. What are the drivers and barriers, and main governance conditions influencing the development of smarter sustainable cities?

3. Which strategies can be used in the development of local governance capacity for smarter sustainable cities?

Through a comprehensive analysis of these research questions, this thesis aims to advance the understanding of the complexities involved in the development of smarter sustainable cities. Exploring this topic requires an overview of key concepts associated with smart(er) sustainable cities, including innovation in the public sector, smart governance, and capacity development. These concepts will be discussed in the next section (1.2) to establish a foundation for the subsequent analysis and discussion. Furthermore, the structure of the thesis and its main contributions will be outlined in the final section of this introductory chapter (1.3).

[1] Sustainable Development Goals: https://www.undp.org/sustainable-development-goals

## 1.2 Literature background

### 1.2.1 The evolution of the concept of the smart city

The roots of smart cities have been identified in the 'cybernetically planned cities' of the 1960s and in the proposals for networked or computable cities in the urban development plans for the 1980s (Gabrys, 2014). However, as an object of scientific interest, the term 'smart city' first appeared in 1992 and acquired prominence around the mid-2000s when technological advancements began to reshape the urban landscapes (Mora et al., 2017). In the late 2000s and early 2010s, governments, businesses, and tech enthusiasts increasingly embraced the idea of integrating various technologies, such as IoT (Internet of Things), data analytics, and other solutions, to transform urban environments, which resulted in a trend of tech-driven and supply-side driven urban development (Hollands, 2008; Lara et al., 2016; Mora et al., 2017).

The discourse surrounding smart cities has evolved significantly in recent years, challenging the once-dominant notion of technological determinism. Critics like Hollands argue that 'progressive smart cities must seriously start with people and the human capital side of the equation, rather than blindly believing that IT itself can automatically transform and improve cities' (Hollands, 2008, p. 315). His critique underscores the need to transition from a primary techno-centric focus to one that prioritises human-centric values (Ju et al., 2018; Kubina et al., 2021; Lara et al., 2016; Rozario et al., 2021; Yigitcanlar et al., 2018).

Despite the abundance of previous studies on smart cities, the term remains somewhat nebulous and lacks a clear definition. Over the last decades, scholars have attempted to conceptualise the 'smart city' (Albino et al., 2015; Dameri, 2013; Kummitha & Crutzen, 2017) and proposed different frameworks (Chourabi et al., 2012; Giffinger et al., 2007; Monzon, 2015; Nam & Pardo, 2011a). Some studies have approached the SC concept through 'building blocks' or aspects that collectively represent what a smart city entails (Dameri, 2013; Giffinger et al., 2007; Gil-Garcia et al., 2015; Neirotti et al., 2014).

Following this approach, a smart city is a city that performs well in terms of economy (competitiveness), mobility (transport and ICT), environment (natural resources), people (social and human capital), living (quality of life), and governance (participation), built on the 'smart' combination of endowments and activities of self-decisive, independent, and aware citizens (Giffinger et al., 2007). This conceptualisation of smart cities based on six dimensions (economy, mobility, environment, people, living, and governance) is useful for defining the areas of action for the SC initiative and its assessment indicators.

In terms of a framework for initiatives, a great contribution to the literature was the Smart City Initiatives Integrative Framework developed by a group of researchers (Chourabi et al., 2012). This integrative framework is useful for analysing smart city initiatives through eight dimensions: technology, organisation, policy, people and communities, economy, built infrastructure, natural environment, governance.

Gil-Garcia, Pardo, and Nam (2015) have extended the previously mentioned integrative framework, offering a comprehensive multidimensional conceptual framework of ten components that make a city smart(er). The authors explained that the suggested components should be analysed in terms of the degree of smartness and not on the spectrum of 'being smart' or 'not being smart'. Among the ten components suggested by Gil-Garcia, Pardo, and Nam (2015) are governance, engagement, and collaboration (as one building block), and data and information.

Besides frameworks, there are other city terms linked to the smart city concept. These include, for instance, the digital and intelligent city (Camero & Alba, 2019; Nam & Pardo, 2011a), the ubiquitous, wired, hybrid, and information city (related to the use of smart technologies in cities), or the creative, learning, humane, and knowledge city (related to human factors) (Nam & Pardo, 2011a).

Likewise, there are city terms related to sustainable cities as compact cities and eco-cities, which are perceived as 'central paradigms of sustainable urbanism and the most prevalent and advocated models of sustainable cities' (Bibri & Krogstie, 2021, p. 1). Sustainable cities can be understood as attempting to balance the aim of cities with the principles of sustainable development, being about people, environment, learning, social changes, and balanced conditions on a long-time horizon development (Bibri & Krogstie, 2017b; D'Auria et al., 2018). More recently, authors have also related the need of 'going green' as the foundation for the sustainable realisation of the growth potential that is linked to 'getting smart' (Stamopoulos et al., 2024).

When it comes to smart sustainable cities, which constitutes the primary focus of this thesis, the literature has attributed the emergence of this concept to five key developments: (i) globalisation of environmental problems and sustainable development: challenges seen as global concerns; (ii) urbanisation: cities as the core of the sustainability discussion; (iii) sustainable urban development and sustainable cities: more interest on sustainable actions and plans, different perspectives from the academia, the public and private sectors; (iv) development of information and communication technologies: new solutions, more technological capacity, cost reduction; and (v) smart city approaches: ICTs and the interconnection of systems, synergies between private and public sectors (Höjer & Wangel, 2015). SSCs can be seen as the intersection of smart, city, and sustainable, as illustrated in Figure 1.

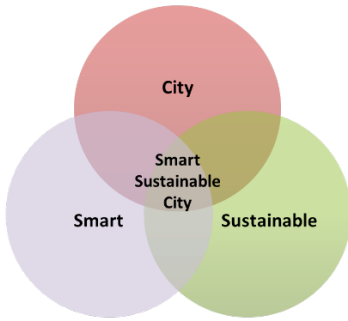


*Figure 1. Smart, Sustainable, City (Source: own elaboration based on Höjer & Wangel* 2015)

Höjer & Wangel (2015) explain that cities can be neither sustainable nor smart, or cities can be sustainable without being smart, or smart without sustainability concerns, or technologies can be used for sustainable development in other environments that are not cities. Therefore, the authors believe that it is only when smart technologies are used for making cities more sustainable that a city can be considered a smart sustainable city.

However, the investigation of Yigitcanlar et al. (2019) has indicated that cities cannot become smart without being sustainable. The authors have found three major weaknesses or challenges of smart cities in delivering sustainable outcomes as 'heavy techno centricity, practice complexity and ad-hoc conceptualisation of smart cities' (Yigitcanlar et al., 2019, p. 362). Their investigation was based on a systematic literature review of publications on smart and sustainable cities.

Regarding academic interest, Figure 2 illustrates the number of articles on smart cities and smart sustainable cities published by year (searching by article title, abstract, or keywords)[2]. The first document published in Scopus mentioning SC was in 1997, whereas the first mentioning SSC was in 2008.

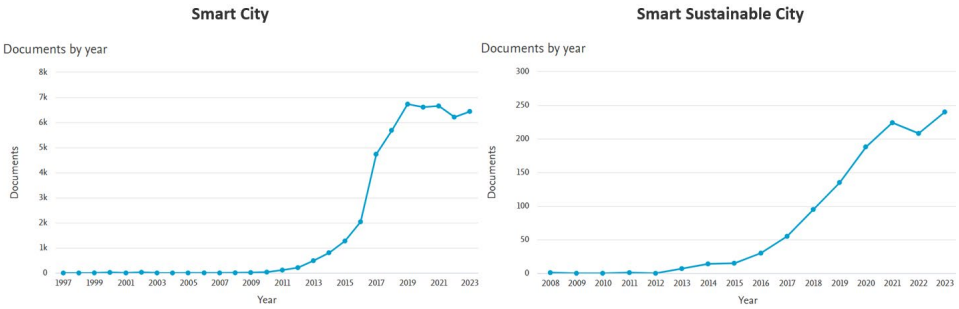


*Figure 2. Articles on smart cities and smart sustainable cities by year (Source: Scopus)*

Following the results of this search, the number of SC publications started to grow year by year in 2012, reaching its peak in 2019 when 6732 records were published. Since then, it has been relatively stable. On the other hand, the academic interest in SSC has been growing considerably since 2015. In 2023, when smart sustainable cities reached their peak of interest, 240 articles were published in Scopus. Nonetheless, the number of SSC publications by year is still much lower than SC publications.

In terms of subject area (Figure 3), the topic appears to be a multidisciplinary one, as academic publications are from different fields. SC research has been dominated by computer sciences and engineering, whereas SSC research is almost balanced between computer science, engineering, and social sciences, followed by energy and environmental sciences.

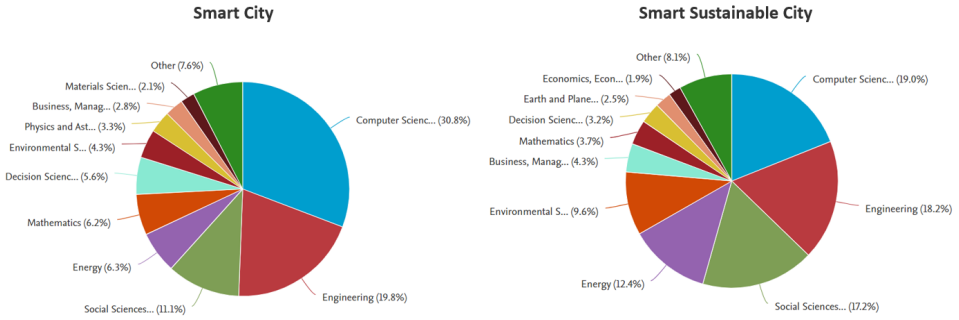


*Figure 3. Articles on smart cities and smart sustainable cities by subject area (Source: Scopus)*

[2] Search performed in Scopus in March 2024.
For smart cities: TITLE-ABS-KEY ("smart cit*"), year range: 1997 to 2023, resulted in 47,174 records. For smart sustainable cities: TITLE-ABS-KEY ("smart sustainable cit*" OR "sustainable smart cit*" OR "smart and sustainable cit*" OR "sustainable and smart cit*" OR "smart sustainability"), year range: 2008 to 2023, resulted 1213 records.

This Figure illustrates that both SC and SSC are attracting the interest of scholars from different disciplines. However, it is not possible to know based on this simple keyword search whether the publications are engaging researchers from different disciplines in one single research.

In terms of topics, scholars have been focused on assessment indicators (Al-Nasrawi et al., 2015; Coutinho et al., 2019; Hara et al., 2016; Kitchin et al., 2015; Sharifi, 2020; Shen et al., 2018), comparing indicators used in smart city and in sustainable city assessments (Ahvenniemi et al., 2017; Al-Nasrawi et al., 2017; Huovila et al., 2019; Marsal-Llacuna et al., 2015; Sharifi, 2020). Another topic that has been attracting recent widespread interest is the potential benefit of smart (sustainable) cities for achieving the Sustainable Development Goals (SDGs) (Blasi et al., 2022; Grossi & Trunova, 2021; Sharifi et al., 2024).

### 1.2.2 Governance, innovation, and smart sustainable cities

This section presents a short overview of public administration reforms related to innovation in the public sector and discusses governance in the context of smart sustainable cities.

The adoption of ICTs by governments has reshaped public administration processes and is changing how governments interact with citizens and deliver services (Estevez & Janowski, 2013; Pollitt, 2011). The discussions around a potential necessity for evolving governance paradigms in the digital era, where traditional government-centred frameworks appear increasingly outdated, is a recurring discourse supported by many scholars (Dunleavy et al., 2006; Estevez & Janowski, 2013; Janowski, 2015; Janowski et al., 2018; Kitchin et al., 2015; Meijer et al., 2019; Osborne, 2006).

For example, Dunleavy et al. (2006) have claimed that the New Public Management (NPM) 'is dead' and is being replaced by Digital Era Governance (DEG), whereas ICTs will reintegrate various functions and expertise clusters that were fragmented into single-function organisational units by the NPM. New Public Management has been explained by Hood (1995) as an alternative to the traditional Progressive Public Administration (PPA) which introduced a different concept of public accountability built around electronic data and networking, challenging the fundamental principles of PPA by approximating public and private sectors.

The NPM encapsulates several principles such as drawing lessons from private-sector management, encouraging entrepreneurial leadership, emphasising performance management, breaking down public services into basic units, and increasing the use of markets, competition, and contracts for resource allocation and service delivery in certain regions (Hood, 1995; Osborne, 2010; Osborne, 2006). For some authors, the NPM was a transition from traditional public administration to New Public Governance (NPG) which combines the strengths of public administration and the principles of new public management (Osborne, 2006).

The global debate around sustainable development is shifting attention away from traditional governing to new paradigms of governance (Estevez & Janowski, 2013). Kemp et al. (2005) explain that the concepts of governance and sustainable development share common origins, emerging in the late 1980s to address the evolving discourse surrounding societal change and complex challenges.

Governance is another term without a universally agreed definition (Glass & Newig, 2019), but it can be understood as the process of governing organised in structures and procedures (Kramers et al., 2016). Governance is fundamental for decision-making

(Janssen & van der Voort, 2016) and includes programmatic directions, budgetary and resource allocations, interactions with external actors as well as with internal organisations, agencies, and departments (Alawadhi et al., 2012), which are usually described in formal institutions like policies, laws, and regulations.

Governance is evolving, resulting in a range of (new) governance paradigms that can be used in the context of smart sustainable cities, such as collaborative, adaptive, open, problem-oriented, platform, smart governance for sustainable cities, smart urban governance, among others (Janowski et al., 2018; Janssen & van der Voort, 2016; Meijer et al., 2019; Przeybilovicz & Cunha, 2024).

Meijer and Bolivar (2016) explained that some scholars refer to smart governance as the government of a smart city, while others see smart governance as smart decision-making, or smart administration, or smart urban collaboration, related to innovative ways of decision-making, administration, and new forms of collaboration. Similarly, Noori et al. (2021) clarified that governing a city to become a smart city means policy creation and mechanisms to facilitate the development of a smart city, whereas smart governance is the result of the application of ICT to transform traditional government and increase transparency, efficiency, effectiveness, and accountability of governance structures and operations.

Smart governance is related to innovative ways of decision-making, administration, and new forms of collaboration (Meijer & Bolívar, 2016), based on stakeholder engagement, ICT-based provision of services, and network-based relationships as collaborations or partnerships (Gil-Garcia et al., 2015). The study of Tomor et al. (2019) investigated smart governance for sustainable cities and defined smart governance as a 'technology-enabled collaboration between citizens and local governments to advance sustainable development' (Tomor et al., 2019, p. 3). Their framework encompasses governmental organisation, citizen participation (government-citizen collaboration), and the use of technology.

As can be noticed, collaboration is strongly associated with governance. Collaborative governance has been explained as a sharing of responsibility and authority between urban governments and/or governmental departments, citizens, the private sector, and stakeholders working together in problem-solving and decision-making (Viale Pereira et al., 2017, p. 533). When comparing the components of collaborative governance and smart governance, smart governance literature focuses on structures and organisation, whereas collaborative governance frameworks are more concerned with the elements that influence the collaborative process, such as trust, leadership, shared understanding (Van Twist et al., 2022). In sum, the adoption of ICT by governments and governance practices drives the emergence of concepts related to smart governance (e.g., collaborative smart governance, smart urban governance).

Another approach that has been adopted in various sectors and regions over the past years is transition management (Loorbach, 2010; Mora et al., 2023). Transition management can be understood as a governance approach based on complex systems theory and governance, which according to Loorbach (2010) is an innovative approach for two reasons: 'it offers a prescriptive approach toward governance as a basis for operational policy models, and it is explicitly a normative model by taking sustainable development as long-term goal' (2010, p. 163). The review performed by Mora et al. (2023) investigated how innovation management theory could help expand smart city transitions and their governance dimension. Even though there are many previous

studies on public sector innovation and smart cities, and a growing academic interest in smart city governance, little work has been done addressing smart (sustainable) cities, innovation, and governance capacity.

### 1.2.3 Capacity and related terms

The lack of public sector capacity has been acknowledged by previous studies as a huge challenge (Ferraris et al., 2020; Janowski, 2016; Mayne et al., 2020). There are multiple terms related to capacity, such as competence, competency, and capability, and that might cause some confusion. The following paragraphs outline their meaning.

Competence and competency are concepts from the management strategy literature of the 1990s (Le Deist & Winterton, 2005). Competence is related to what is necessary for an occupation or a job position, for instance, domain competences are 'the willingness and ability, on the basis of subject-specific knowledge and skills, to carry out tasks and solve problems' (Le Deist & Winterton, 2005, p. 38). Competences can be divided into conceptual (cognitive, knowledge and understanding) and operational (functional and applied skills). Whereas competencies (plural of competency) encompass knowledge (cognizance of facts and principles gained from formal training and/or experience), skills (a developed proficiency) and attitudes (execution of skills) that allow someone to execute the responsibilities associated with their assigned roles (Blanchard & Thacker, 2004).

Le Deist and Winterton explain that the terms competence/competences and competency/competencies are used in different ways around the globe. For instance, functional competences are often being added to behavioural competencies in the USA, while France, Germany and Austria are adopting a more holistic framework including knowledge, skills, and behaviours as competences (Le Deist & Winterton, 2005)

Capability is often associated with innovation and refers to a feature or process that can be developed or improved (Lanny Vincent, 2008). From a structural perspective, capabilities include skills and knowledge as well as work practices and behaviours within organisations (Mayne et al., 2020).

Regarding the differences between capabilities and capacities, Kattel and Mazzucato explain it as two parallel cultures: 'Schumpeterian business literature and practice around dynamic capabilities of the firm, and Weberian public policy discussion focusing on capacities of the state' (Kattel & Mazzucato, 2018, p. 788). Dynamic capabilities support dynamic actions, or the capabilities to anticipate, adapt and learn within and across organisations (World Health Organization, 2022). In sum, public sector capacities revolve around the organisational structures within public institutions and dynamic capabilities focus on skills that enable change (Karo & Kattel, 2018)

In this thesis, capacity is a wide-ranging term related to the power to hold, receive, and accommodate resources (human and others). Therefore, the capacity development process can be used for guiding the development of competencies and capabilities as well. Capacity development can be operationalized on three levels: the individual (i.e., improving individual skills, knowledge, and performance through training, experiences, motivation, and incentives); the organisational (i.e., improving organisational performance through strategies, plans, rules and regulations, partnerships, leadership); and the enabling environment (i.e., improving policy framework to address economic, political, environmental, and social factors, including economic growth, financing, etc.) (UNDG, 2017) (**V**).

## 1.3 Thesis structure and main contributions of the publications

This doctoral thesis consists of eight original publications that collectively explore the development of smarter sustainable cities, guided by three research questions.

The first research question (RQ1) focuses on understanding how a systematic overview of smart city research and innovation can contribute to the concept of smart sustainable cities. The findings of articles **I**, **IV**, and **III** are used to answer this question.

The second research question (RQ2) investigates drivers, barriers, and governance conditions influencing the development of smarter sustainable cities. This question is addressed across publications **II**, **III**, **VI**, **VII**, and **VIII**.

The third research question (RQ3) examines strategies for developing local governance capacity for smarter sustainable cities. Articles **III** and **V** serve as the basis for answering this question. The following paragraphs summarise the publications and their contributions to achieve the aim of this doctoral thesis.

Article **I** explores the characteristics of smart city research and innovation, emphasising the importance of cross-disciplinary collaboration in addressing real-life challenges. This article is motivated by the fact that academic literature has predominantly focused on defining smart cities as a phenomenon, resulting in a lack of robust consensus on the concept. The article aims to review the concept of the smart city as an evolving subject and map it with related research groups. Moreover, it contributes to understanding the importance of multidisciplinary research and innovation for smart city development, outlining a list of research groups dealing with smart cities worldwide, including the identification of their respective focuses and approaches. By providing an overview of global research centres dedicated to the subject of smart (sustainable) cities, this article advances the ongoing discourse on innovation and knowledge-sharing in urban development. Additionally, the article introduces the case study of the FinEst Centre for Smart Cities, recently established in Estonia.

Paper **IV** aims to clear the existing fog over the concept of the smart sustainable city and highlights the importance of governance for SSCs. This publication discusses the challenges of urbanisation, sustainable development, and the intersection of smart and sustainable cities. The contributions of this research are twofold: strengthening the scientific discussion on smart sustainable city governance and suggesting a conceptual model for SSCs that describes the SSC through the three pillars of sustainability (social, economic, and environmental), urban infrastructure, and governance.

Paper **II** investigates the factors influencing the development of smart sustainable cities. The main contribution of this publication is an extensive list of 57 drivers and 63 barriers classified according to the dimensions of the SSC conceptual framework developed in **IV**. The findings revealed 'governance' as the most significant domain for SSC development, and multistakeholder engagement as one of the main challenges. Moreover, these findings emphasise the interdisciplinary nature of SSC and highlight the complex relationships of the elements that shape the trajectory towards SSC development.

Article **III** suggests a Smart Sustainable City Roadmap as a tool for addressing sustainability challenges and building governance capacity, which includes three phases and 11 key governance conditions. This study was motivated by the limited availability of research-based practical recommendations to support the planning and implementation of SSC initiatives. This article advances the knowledge gap between smart sustainable city development and governance capacity.

Paper **VI** is centred around the initiative 156 Speaks Porto Alegre (156 POA), which serves as a municipal channel for non-emergency services and information requests. The empirical findings underscore the significance of coordination, technology, and interdepartmental collaboration in achieving the objectives of the initiative.

Paper **VII** also focuses on municipal channels for non-emergency services and information requests, offering a comparative case study. First, it presets the case of the Call and Information Centre 156 of Curitiba (156 Curitiba). The second part of the paper compares the results of the 156 Curitiba with similar cases in other cities. This research sheds light on the alignment of these initiatives with the overarching goals of smart city development. The findings indicate governance as the main challenge of the initiatives.

Paper **VIII** builds an understanding of municipal operations centres as an effort on the city to become smarter. Municipal operations centres have played an important role in responses to social events and natural disasters to address the urgency and dynamism of urban problems. This paper studies three cases in Brazil: the Centre of Operations Rio (COR) in Rio de Janeiro, the Integrated Centre of Command (CEIC) in Porto Alegre, and the Centre of Operations at Belo Horizonte (COP-BH) in Belo Horizonte. Furthermore, it explores the main dimensions and factors for establishing those centres as smart city initiatives and proposes a multidimensional understanding of municipal operations centres framed from empirical evidence.

Paper **V** investigates how to foster capacity development in municipalities and identifies the learning needs of local authorities. It presents the case of the Urban Learning Centre (ULC) for municipalities of the Eastern Partnership launched in 2023 as an ecosystem for positive transformations in municipal capacity. This study emphasises the role of continuous learning in adapting to the dynamic challenges faced by urban communities.

This thesis is structured as follows: Chapter two provides an overview of the methodology applied in the articles comprising the body of the thesis. Chapter three presents the findings corresponding to RQ1, offering a comprehensive analysis of how a systematic overview of smart city research and innovation contributes to the concept of smart sustainable cities. Chapter four outlines the findings related to RQ2, which explores factors influencing the development of smarter sustainable cities. Similarly, chapter five describes the findings corresponding to RQ3, suggesting strategies for developing local governance capacity to support smarter sustainable city development. Chapter six discusses the findings, drawing connections between the research questions and providing strategies for smarter sustainable cities. Finally, the concluding section outlines final considerations, presents the implications of this thesis, and suggests avenues for further investigation.

# 2 Methodology

This chapter outlines the research strategies and methods employed in this study. First it presents an overview of the methodology. Second, it elaborates on the methods of data collection and analysis of each publication.

This doctoral thesis is a consolidation of eight original pieces: two articles in peer-reviewed journals (**I, III**), and six papers included in the proceedings of international conferences, which are indexed by Scopus and/or Web of Science (**II, IV, V, VI, VII, VIII**). The conferences are well-known and established in the field of digital government and electronic governance.

Table 1 offers an overview of the methodology of this doctoral thesis. For each publication, it presents the main research problem, aim or purpose, research questions, research strategy and data collection methods, and the level of analysis. The subsequent paragraphs provide additional details on how these methods have been applied in each publication.

*Table 1. Overview of methodology*

| | **Research Problem** | **Aim / Purpose** | **Research Strategy and Data Collection Methods** | **Level of Analysis** | **Main Research Question(s)** |
|---|---|---|---|---|---|
| **I** | Lack of systematic overview of who the actual SC research actors are | Review SC as an evolving subject and map it with smart city-related research groups globally | Case study - Literature review and desk research | Concept (research and innovation, SC research centres) | • Which are the actual research groups globally dealing with the smart city concept? • What are their disciplinary focus areas? |
| **II** | Lack of holistic understanding of factors influencing the development of SSCs | Identify aspects that influence the progress of smart sustainable cities | Systematic literature review | Concept (SSC drivers and barriers) | • What are the main enablers and challenges for the development of smart sustainable cities? |
| **III** | Lack of tools to support the planning and implementation of SSC initiatives | Suggest guidelines for the development of SSC initiatives in the format of a generic roadmap | Design science - Literature review, desk research, project documents, survey, and workshop | Concept (SSC challenges, and governance practices from Latin American and European SSC initiatives) | • What are the conditions for building smart sustainable city initiatives to address sustainability challenges? • How to build local governance capacity for the development of smart sustainable cities? |

| | | | | | |
|---|---|---|---|---|---|
| **IV** | Uncertainty over the SSC concept and its main characteristics | Contextualise the emergence of the SSC concept, identify its characteristics, and suggest a conceptual framework for the SSC | Literature review | Concept (SSC) | • How can smart sustainable cities be understood from the governance perspective? |
| **V** | "Wicked problems" faced by the public sector require innovative approaches and the development of dynamic capabilities | Investigate how to foster capacity development in municipalities, and identify the learning needs of local authorities | Case study - Survey, project reports | Concept (learning needs and the ULC initiative) | • How to foster capacity development and continuous education in municipalities? • What are the learning needs of local authorities' members of the M4EG? |
| **VI** | Need of understanding the implementation of SC initiatives | Analyse a city initiative based on the SC integrative framework | Case study - Interviews | Smart city initiative (channel for non-emergency services) | • How to implement initiatives to attend to citizen's needs aiming for a better quality of life? |
| **VII** | Need of understanding the implementation of SC initiatives | Analyse a city initiative and compare it with similar SC initiatives | Comparative case study - Interviews | Smart city initiative (channel for non-emergency services) | • How to implement initiatives to attend to citizen's needs aiming for a better quality of life? |
| **VIII** | Need of understanding the main dimensions for implementing municipal operations centres in the SC domain | Analyse the main dimensions and factors for implementing municipal operations centres as smart city initiatives | Multiple case study - Interviews | Smart city initiative (municipal operations centres) | • What are the main dimensions and factors for the implementation of municipal operations centres as smart city initiatives? |

Article **I** examined and described the concept of the smart city from different standpoints, such as geography (east–west, culturally grounded approaches), time (how it has evolved and future research), the science of cities (multidisciplinary, wicked problems), and multistakeholder research collaborations (cities, industries, and academia). After reviewing the SC concept as an evolving subject, it was mapped with international groups and institutes affiliated with this domain. Two qualitative methods were applied. This first part of the study was based on the authors' internal evaluation

with involvement of a global key expert in this field (Michael Batty, co-author in the article) and a detailed analysis of secondary data such as web pages. The second part of the article is an in-depth case study of the FinEst Centre for Smart Cities.

Paper **II** conducted an extensive systematic literature review, encompassing a total of 169 articles. The study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses – PRISMA 2020 Statement, recognised for its ability to accurately summarise evidence (Page et al., 2021). This approach is recommended particularly in fields where the integration of diverse academic disciplines is necessary. Systematic literature reviews are considered more reliable than traditional reviews because they employ a transparent and reproducible process for selecting literature (Tranfield et al., 2003). The findings were categorised according to the SSC conceptual framework developed in Paper **IV**. Subsequently, the results of paper **II** were utilised in article **III**.

Article **III** applied the design science research (DRS) method, following a four-step approach, including: (1) defining the main concepts and dimensions within the SSC context (**IV**), (2) identifying sustainability challenges for the development of SSC initiatives (**II**), (3) analysing key governance aspects from 12 SSC initiatives from Europe and Latin America, and 4) designing an actionable research-based roadmap and practical recommendations as an SSC Governance Roadmap. The SSC Governance Roadmap and the general guidelines for strengthening SSC governance capacity constitute the final contribution of this article to the knowledge base, being part of the DRS rigour cycle. This step included a survey and a workshop to collect feedback from experts to improve the quality of the suggested roadmap. One limitation of this article is that the roadmap has not been applied to any case in practice. Nevertheless, this limitation was reduced through the collection of expert feedback and validation rounds.

In publication **IV**, a literature review was conducted to understand the emergence of the SSC concept and to identify its main dimensions and characteristics. The steps performed in this study were: (i) selecting an initial conceptualisation of the smart sustainable city; (ii) identifying SSC themes; (iii) reviewing the literature to identify existing SSC concepts and smart city concepts that could be applied to SSC; (iv) identifying SSC characteristics, classifying them according to the predefined themes and determining similarities or patterns among the themes; (v) synthetising the themes (dimensions) and their main aspects; and (vi) developing a framework to represent the dimensions and characteristics of SSCs.

Paper **V** studied the case of the Urban Learning Centre (ULC) for municipalities of the Eastern Partnership. The data of this study was collected from primary and secondary sources, including research and project deliverables, project reports, a learning needs survey, and organisational websites. A survey was used to map the learning needs of the local authorities, the data collection instrument chosen was a written questionnaire, as this method is indicated when it is necessary to collect data from many persons (Van Thiel, 2014). The survey was translated into five languages (Armenian, Azerbaijani, Georgian, Romanian, Russian, and Ukrainian), and the study sample size included 350 local authorities. The results of the survey were used to define and prioritise the content to be included in the ULC and its delivery method. The learning programmes were defined in a collaborative process online and offline.

**VI** studied the initiative 156 POA, exploring its integration with the Smart City Initiatives Framework proposed by Chourabi et al. (2012). The data collection was done via face-to-face individual interviews following a semi-structured interview protocol. The analysis followed the dimension of the framework as follows: (1) management and

organisation, (2) technology, (3) governance, (4) policy, (5) people and communities, (6) the economy, (7) built infrastructure, and (8) the natural environment.

**VII** studied the Call and Information Centre 156 Curitiba (156 Curitiba) and compared it with two other similar initiatives. The data collection to study the 156 Curitiba was carried out by semi-structured interviews following an interview protocol (the same as in article **VI**). Secondary data (including the results of paper **VI**) were used to compare the results of the 156 Curitiba with the 156 POA in Porto Alegre, Brazil, and with the Philly 311 in the city of Philadelphia in the USA.

**VIII** aimed at identifying the dimensions and factors for implementing municipal operations centres as smart city initiatives. To achieve the main objective of the research, multiple cases were analysed. Semi-structured interviews were conducted for all cases, supported by an interview protocol. The sample selection was done following the snowball technique. Among the limitations of this research is that the number of participants in the interviews differed between the three cases.

As described, this thesis includes cases from different regions, mainly from Latin America and Europe. The in-depth exploratory case studies of smart city initiatives (**VI, VII, VIII**) are all from cities in Brazil. Additionally, article **I** provides an in-depth case study of the FinEst Centre for Smart Cities in Estonia, and paper **V** discusses the Urban Learning Centre in Eastern Europe.

In sum, to develop the necessary knowledge to achieve the aim of this thesis, the author examined the multidisciplinary nature of smart city research and innovation (**I**), suggested a conceptual framework for SSCs (**IV**), investigated drivers and barriers for SSC development (**II**), proposed an SSC governance roadmap (**III**), studied one case of a channel for non-emergency services as a smart city initiative (**VI**), performed a comparative case study of a channel for non-emergency services (**VII**), analysed multiple case studies of municipal operation centres as smart city initiatives (**VIII**), and studied one initiative for capacity development in municipalities (**V**). Additionally, the knowledge gained from participation in smart sustainable city related projects (i.e., CAP4CITY, FinEst Twins, UNDP Urban Learning Centre), which can be considered as learning from experience, provided insights and helped the development of the analysis and overall conclusions of the thesis.

The preliminary results of the thesis have been discussed at international events, including in two PhD schools, one in Gdansk, Poland, and one in Pühajärve, Estonia, and in one workshop in Guimarães, Portugal. Other preliminary results of future studies related to this thesis have been presented in the form of posters in Linköping, Sweden (Azambuja, 2022; Temple et al., 2022).

Finally, the publications comprising the body of the thesis have been presented by the author and discussed at international conferences, workshops, and project dissemination events in Aguascalientes – Mexico (**VI**); Athens – Greece (**II, IV**); Tallinn – Estonia (**I**); La Plata and Bahía Blanca – Argentina, Porto Alegre and Passo Fundo – Brazil, Santiago – Chile, and Bogota – Colombia (**III**); Istanbul – Turkey, Singapore – Singapore, and Curitiba – Brazil (**V**).

# 3 Understanding smart sustainable cities

This chapter builds a better understanding of the smart sustainable city concept, aiming to address the first research question of the thesis. The first part of this chapter summarises the main findings of article **I**. The second section introduces the SSC conceptual framework developed in paper **IV.** The third section combines the SSC framework and the main findings of article **I**.

## 3.1 Smart cities through the lens of research and innovation

For a better understanding of the concept of the smart city, article **I** investigated it from different standpoints. Based on this analysis, two smart city models were identified.

The first model – 'planned pop-up techno-cities' – concerns the creation of technology-driven cities, primarily observed in Asia. This SC model combines futuristic technocratic solutions with Western urban planning ideologies and modernism.

The second SC model – 'improving the smartness and governance of existing cities' – is often seen in European and North American cities. In this model, local authorities, sometimes supported by national resources, are enabling, encouraging, or even procuring, new services or functions to be created by the private sector. Public resources in Europe are used to (re)formulate regulations, technical platforms, data hubs, Research & Innovation (R&I) programmes, or a combination of those. Thus, existing cities are only improved by the new, say, ICT services and governance practices (**I**).

Sustainability in energy and carbon savings, innovation in public transport, car-sharing and cycling are among the aspects gaining momentum in the European smart city discussions and rankings. This interest in rankings is an important aspect of European and North American smart city discussions. It promotes the cities, that is, shows that these cities are worth investments, in other words willing to have new jobs, new taxpayers, and new tourists. As stated in article **I**, the 'label' smart city, despite some academic criticism, still attracts investments. Consequently, some regions and cities are concerned with their performance in smart city-related rankings.

Considering the challenge of capturing the volume and the vagueness of academic research on smart cities, and its actual implications in cities, one way to understand the SC movement is to look at the most important sources of smart city research – the research groups and centres around the world (**I**). One interesting finding of this investigation is that among the list of over 50 centres in the fields of urban informatics, smart cities, big data, and related urban science, only two centres are focused on smart cities by their name (i.e., FinEst Centre and Harvard Data-Smart City Solutions). The overview of the centres dealing with smart city related research and innovation can be found in the Appendix of article **I**, including the name, location details, a brief description, and the year of establishment of each centre.

In this analytic overview of existing SC studies, a mismatch between conceptualisation of SC and actual SC research and innovation is pointed out. The literature review shows that there is no rigid research domain for the 'smart city', there is only a broad discussion of how a smart city could be defined without any clear consensus on that. The definitions of the smart city range from seeing the smart city as software-driven, to people-and-community needs driven, to very broad integrative frameworks combining a variety of domains like economy, people, governance, mobility, environment, and living (**I**).

Besides the overview of the centres, article **I** analysed the research performed by the FinEst Centre for Smart Cities as a case study. This case illustrates how a university-driven

research unit can initiate and drive smart city projects, involving cities, companies, and people in collaboration, illustrating the so-called triple-helix model. The aim of the FinEst Centre is to initiate long-term smart city research and innovation activities in collaboration with technology universities in Estonia and Finland, Estonian Ministry of Economic Affairs and Communications, and Forum Virium Helsinki. The FinEst Centre is organised around five streams (Soe, 2017), as illustrated in Table 2.

*Table 2. FinEst Centre: Main tasks and aims of the research streams (Source: **I**)*

| **Stream** | **Smart City Governance** | | |
|---|---|---|---|
| **Expected to do** | Study and develop holistic theories and models of urban governance, new data frames for the substance streams (Smart Mobility, Smart Energy, Built Environment) | | |
| **Paradigmatic orientation** | From narrow techno-orientation to broader holism | | |
| **Potential sources and subjects of data** | Theories/models of city-led innovations, sustainable transitions, citizen-government co-production, cross-border frameworks | | |
| **Stream** | **Smart Mobility** | **Smart Energy** | **Built Environment** |
| **Expected to do** | Domain-specific data production, based on substantial understanding of public policies, value networks, and business models etc. that would enable actual data-streams | | |
| **Paradigmatic orientation** | From modes of transport to urban mobility system(s) | From centralised energy supply to smart grids and local demand management | From human-oriented to life-oriented urban planning |
| **Potential sources and subjects of data** | *Humans in cars, transit, last mile, cross-border<br>*Cargo in different vehicles<br>*Self-driving vehicles in interactions with infrastructure, other vehicles, etc. | *District heating/cooling<br>*Energy flows in nearly zero-energy buildings<br>*Local energy production<br>*Market prices | *Lightning and outdoor conditions<br>*Experienced quality of the built environment<br>*Co-created scenarios<br>*Biodiversity and green infrastructure<br>*Collaborative urban planning processes |
| **Stream** | **Urban Analytics & Data** | | |
| **Expected to do** | System of Systems (different stakeholders' systems can interchange data through standardized APIs so that both ends understand data similarly) | | |
| **Paradigmatic orientation** | Enabling working Internet of Things systems through standardisation, harmonisation, and realistic business models | | |
| **Potential sources and subjects of data** | Data harmonisation (semantic and syntactic interoperability, visualisations of data flows, APIs, widgets, security, authentication and billing function, new revelations of IoT functions and processes, and a cross-border urban data platform (shared between Helsinki and Tallinn)) | | |

Another important aspect explored in article **I** concerns challenge-based pilots. The FinEst Centre conducts a significant part of its research via large-scale experimental pilots. A pilot is defined as the process of developing a new knowledge-based solution to an urban challenge. Pilots are focused on finding solutions in one of the streams or in a combination of different streams. This approach goes beyond academic specialisations as pilots are exclusively triggered by urban challenges and based on the input received

from local governments in Estonia. The aim of these large-scale pilots is to prototype research-based solutions especially for small and medium-sized cities around the world.

Overall, according to the study performed in article **I**, it is possible to affirm that smart city studies are not institutionalised, and there is no shift towards a theory of a smart city. This article concludes by stating that SC is a movement that connects several urban technology researchers and practitioners. From the academic perspective, the smart city is more like a glue that can combine different ideas from different disciplines under one very broad umbrella (**I**, p. 18).

## 3.2 Conceptual framework of the smart sustainable city

In an attempt to clear the fog over the smart sustainable city concept, paper **IV** suggests an SSC conceptual framework as illustrated in Figure 4.

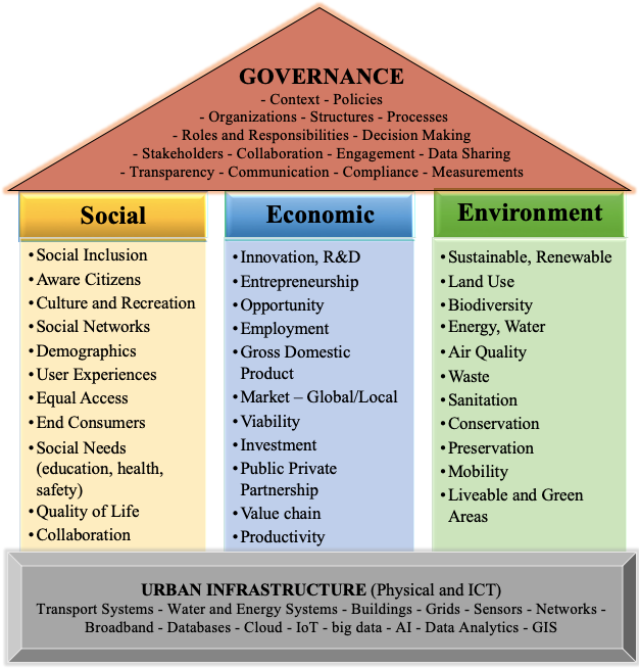


*Figure 4. Conceptual framework of the smart sustainable city (Source: **IV**)*

According to this framework, the SSC is represented by of a combination of five main dimensions. In the centre are three sustainability pillars (social, economic, and environmental), in the base is the urban infrastructure (physical and ICT), whereas governance is set as the 'roof' of the framework. Smart sustainable city governance is responsible for the coordination, managing of capacities, and definition of the strategy on how to ensure that all domains are being considered to reach sustainability.

Following the SSC framework (**IV**), the social, economic, and environmental dimensions of an SSC are the ones driving or motivating the development of SSC initiatives, while the governance and the urban infrastructure dimensions correspond to the 'smartness' of the initiatives, which means that these aspects are the ones influencing the development and implementation of initiatives.

## 3.3 Innovation towards smarter sustainable cities

Considering the SSC framework (**IV**) and the findings of article **I**, the following representation is suggested:

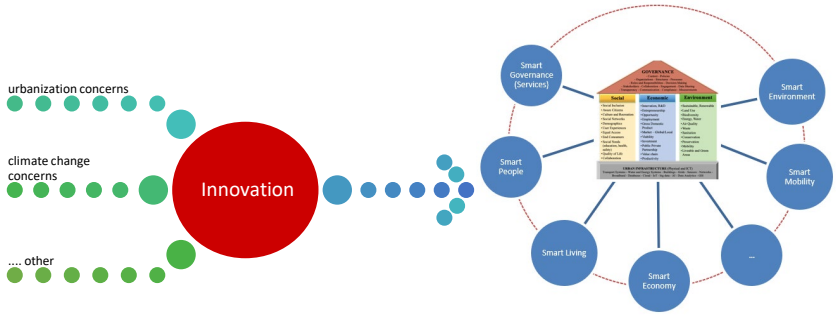


*Figure 5. Smarter sustainable cities through innovation*

Figure 5 illustrates that research and innovation can foster the development of solutions and initiatives that have the potential to address one or more domains of the city (mobility, education, health, economy, among others), contributing to the development of smart(er) (sustainable) cities. For instance, the research agenda of the FinEst Centre for Smart Cities (**I**) is organised into research streams (governance, mobility, energy, built environment, and urban analytics and data). These streams cover, to a certain extent, four out of five of the SSC dimensions proposed in paper **IV**.

# 4 Factors influencing the development of smarter sustainable cities

This chapter presents the main factors influencing the development and implementation of smart (sustainable) city initiatives, aiming to answer the second research question of the thesis. The first section outlines the drivers and barriers identified through an extensive systematic literature review performed in paper **II**. The second section presents the main findings of the empirical cases included in articles **III, VI, VII** and **VIII**. The final section of this chapter summarises the findings.

## 4.1 Drivers and barriers for smarter sustainable city development

Through a systematic literature review, which included 169 papers, 57 drivers and 63 barriers for the development of SSCs have been identified in paper **II**. Table 3 presents the findings, which were grouped by the SSC dimensions of the SSC conceptual framework developed in paper **IV**.

*Table 3. Drivers and barriers for the development of smart sustainable cities (Source: **II**)*

| SSC dimension | Drivers | Barriers |
|---|---|---|
| **Social** | • Living aspects as community needs and public provision of urban services<br>• Innovative healthcare and sanitation facilities<br>• Education facilities to elevate the literacy rate<br>• Accessibility and social inclusion<br>• Social responsibility, informed citizens, knowledge sharing<br>• Community development, collectivism, volunteering networks<br>• Participative and engaged citizens | • Lack of citizen participation<br>• Lack of trust<br>• Lack of social awareness<br>• Cultural diversification<br>• Citizen's inequality<br>• Digital divide<br>• Resistance to change<br>• Social exclusion and gentrification<br>• Unavailability of services for different communities<br>• Lack of connection between technological and social infrastructure |
| **Economic** | • Innovation, urban labs, Research and Development<br>• Crowdsourcing<br>• Knowledge and sharing-based economy, portfolio-thinking<br>• Sustainable management of resources, circular economy<br>• Partnerships, multisector synergies<br>• Promotion of social and human capital<br>• Workforce availability (skilled and non-skilled)<br>• Attract and retain workforce, flexibility of the labour market | • High cost of urban infrastructure, imbalance of investments<br>• Lack of funding and investors; short time horizon of investments<br>• Volatility of global economy<br>• Mono-sectoral economy<br>• Competitiveness (local against regional and international markets)<br>• Imbalance between competitiveness and quality of life<br>• Unemployment, lack of equal access to labour market<br>• Lack of qualified human capital<br>• Weak public-private partnership |

| SSC dimension | Drivers | Barriers |
|---|---|---|
| | • Urban attractiveness<br>• Tourist attractive projects | • Inefficiency of resource management |
| **Environmental** | • Energy related: renewable resources, saving initiatives, smart systems<br>• Water related: monitoring quality, efficiency of water usage<br>• Pollution prevention and reduction<br>• Air pollution monitoring, emission control systems<br>• Smart waste management<br>• Recycling<br>• Availability of environmental standards<br>• Environmental projects and green initiatives<br>• Quality of urban space, land use planning<br>• Mobility related: efficient transport systems, cycle paths<br>• Smart building, responsive building envelopes (RBE) | • Climate change<br>• Growing population, imbalance between liveability and environment<br>• Increasing resource consumption<br>• Scarcity of resources, loss of biodiversity and natural habitat<br>• Lack of resource sharing<br>• Lack of a holistic approach to environmental sustainability<br>• Lack of knowledge on how ICT can decrease energy consumption<br>• High level of air pollution<br>• Inefficient waste management<br>• Traffic density and inefficient public transport system |
| **Governance** | • Transparency and openness<br>• Citizen empowerment, interactive and participatory services, co-production, co-creation, bottom-up approaches<br>• Information and knowledge sharing, communication channels<br>• Supportive government policies<br>• Urban planning: strategy and vision definition<br>• Context adaptation, analysis of current situation, flexibility<br>• Capacity planning (i.e., infrastructure, cost, and human resources)<br>• Clear definition of roles and responsibilities<br>• Leader / champion: dedicated organisation / person for SSC initiatives<br>• Definition of Key Performance Indicators (KPIs); monitoring / assessment | • Lack of planning; lack of vision and strategy<br>• Lack of project management<br>• Lack of capacity (HR)<br>• Lack of IT knowledge among city planners<br>• Lack of operational capability<br>• Lack of capacity building (training)<br>• Structural issues: isolated silos; lack of internal cooperation<br>• Structural issues: complexity of organisational structures<br>• Lack of alignment, conflicts of interests<br>• Lack of knowledge and information sharing<br>• Lack of engagement opportunities<br>• Poor public-private partnership<br>• Centralized decision-making process, top-down approach<br>• Political instability and complexity<br>• Lack of political will and support<br>• Lack of transparency and trust<br>• Lack of regulation and legislation<br>• Inability of policies<br>• Multiplicity of policies and programmes |

| SSC dimension | Drivers | Barriers |
|---|---|---|
| | • Collaborative decision-making; participatory governance models<br>• Stakeholders' engagement: internal (cross-sector) and external<br>• Managing conflicts of interests<br>• Data-driven decision-making and availability of real-time data<br>• Urban proactiveness for service provision<br>• Data governance: data quality, data sharing and data privacy policies | • Lack of standards for measuring performance<br>• Lack of data governance<br>• Lack of open data, issues for opening data |
| **Urban Infrastructure** | • Physical infrastructure integration<br>• Affordable housing facilities, such as water and energy supply<br>• Adoption of innovative construction techniques<br>• Connectivity, broadband, access to internet facilities<br>• Interoperability and integrated ICT<br>• Security verification tools / systems<br>• Advanced ICT, intelligent technologies in urban services<br>• Smart grid; intelligent energy management systems<br>• Use of geographic information systems (GIS)<br>• Data processing: modelling imperfect data; data exchange<br>• Data analytic capacity; business intelligence (BI)<br>• Internet of Things (IoT)<br>• Big Data | • Urban infrastructure deterioration<br>• Deficit of technological infrastructure<br>• Lack of infrastructure integration, complexity of networks<br>• Technological obsolescence, system failures, infrastructure fragility<br>• Lack of interoperability of systems and lack of integration standards<br>• Lack of security of systems, privacy violation<br>• Poor quality of ICT-based services<br>• Lack of data integration, complexity of opening and linking data<br>• Lack of data management, huge volume of data<br>• Lack of cloud and fog computing<br>• Vendor locking |

The results of paper **II** emphasise the importance of governance for SSC development as 94% of the articles included in this review mentioned at least one governance driver (63%) or barrier (60%). It is possible to observe that the factors that have been categorised as barriers correspond exactly to the lack of a driver. The full list of identified drivers and barriers and their respective references can be found in the Appendices of paper **II**[3].

[3] List of drivers and barriers and their respective references: AppendiceA-List of Drivers and Barriers and References.docx - Google Drive

## 4.2 Factors influencing the implementation of smart city initiatives

This section presents the main findings of the in-depth case studies of smart (sustainable) city initiatives performed as part of this thesis in papers **VI**, **VII**, and **VIII**. In addition, it outlines important insights of twelve smart sustainable city initiatives that have been included in article **III**.

### 4.2.1 Channels for non-emergency municipal services

This section presents the empirical findings of the cases of channels for non-emergency municipal services studied in papers **VI** and **VII**.

Paper **VI** studied the 156 Speak Porto Alegre (156 POA), which is considered an essential part of the city's strategy to transform Porto Alegre into a smarter city. The 156 POA is a unique channel that aims to attend to population demands and provide non-emergency services. It is available every day. All requests related to city services, such as traffic, tree pruning, water, sewerage, street lighting, street paving, garbage collection, tourist information, municipal taxes, among others, can be submitted via the 156 POA. The initiative started in September 1984 as a call centre (156) operating from Monday to Friday during business hours. It now operates 24/7. Since 2011, the 156 POA is the central channel for city service requests. It is important to mention that the data collection for this publication (**VI**) was performed in 2014. Back then, the service was provided mainly by phone calls and through website requests (very limited features). Currently, the service has been considerably improved (i.e., more features, more services are integrated, other contact channels are available, such as WhatsApp, etc.), and the city is in the process of implementing a new mobile app. However, the analysis of the case included in this thesis is based on the data collected in 2014, which are described in more detail in publication **VI**.

The system used for registering and forwarding the requests of citizens helped to facilitate collaboration between different city departments. Before the system, requests of citizens were handled manually, on paper. Thus, the digitalisation of the process allowed greater efficiency in service delivery (**VI**).

In sum, the findings related to the 156 POA (**VI**) confirmed that the social, environmental, economic, and political complexity within cities requires coordinated actions and an integrative vision of government services. Interviewees believe that the initiative helps the city to become smarter; however, it also needs improvements. A major challenge was related to human capacity. According to one interviewee, some public servants were not used to using the internet and emails. Moreover, a lot of data is generated through this initiative, but the data of the requests registered in the system is not being used as it could. The governance model of the 156 POA (**VI**) is more participatory than hierarchical according to the interviewees.

Similarly**,** paper **VII** delves into the Call and Information Centre 156, also known as the Curitiba Contact Centre, situated in the city of Curitiba, Brazil. Serving as a non-emergency contact hub accessible via phone, email, or chat, it provides a diverse array of information and services to the municipality's population, while integrating city departments. The initiative has been in place for over thirty years and has become an integral part of the city's daily operations.

The findings of this study indicate that governance is the main challenge of the 156 Curitiba. This issue revolves around the outsourcing of a critical city service. Similarly, in Porto Alegre, discussions centre around the relationship between the 156 POA

initiative and its service providers. Meanwhile, the Philadelphia 311 service faces concerns regarding the absence of a formal cooperative relationship between central and county authorities (**VII**).

### 4.2.2 Municipal operations centres

Paper **VIII** investigated three cities in Brazil that have set up municipal operations centres in an effort to become smarter: the Centre of Operations Rio (COR) in Rio de Janeiro, the Integrated Centre of Command (CEIC) in Porto Alegre, and the Centre of Operations at Belo Horizonte (COP-BH) in Belo Horizonte. The paper proposed a multidimensional understanding of municipal operations centres, which was based on empirical evidence of the centres. The model is illustrated in Figure 6.

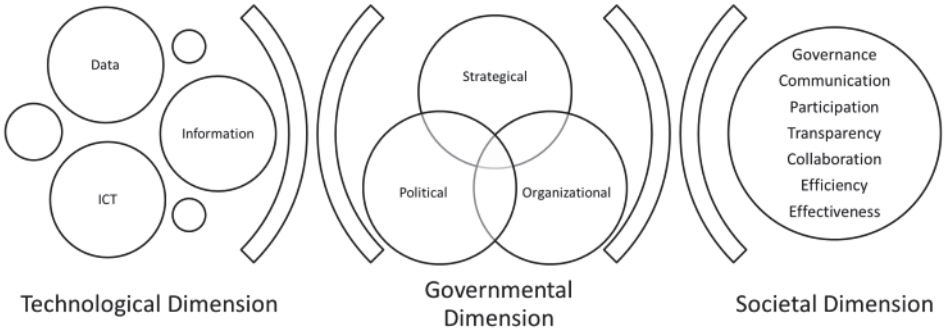


*Figure 6. Multidimensional model for municipal operations centres (Source **VIII**, p. 23)*

The technological dimension includes ICT factors and government data. The societal dimension is represented by governance factors that emerged from the empirical analysis. The governmental dimension is defined by strategic factors, organisational, and managerial, political, and institutional aspects.

One of the research questions of this study aimed to identify how municipal operations centres improved accountability. Among the findings of the analysed initiatives there is a notable improvement in the government's capacity to oversee institutions affiliated with the centre and responsible for delivering public services, thereby reinforcing the commitment to quality and increasing public satisfaction (i.e., improving accountability) (**VIII**).

### 4.2.3 Insights from twelve smart sustainable city initiatives

Regarding the insights provided by the SSC cases included in article **III**, some of the drivers of the initiatives are related to resource savings, provision of information for decision-making, and strategies for socio-economic digital development, and innovation ecosystems.

One of the characteristics of a smart sustainable city is public-private-partnerships (PPP). The findings of **III** have shown that cities engage multiple stakeholders in their initiatives and promote cooperation arrangements with the private sector, academic institutions, and other cities and countries. However, most initiatives have the government of the municipality as the lead organisation, whereas private companies are the major partners developing assistance roles. In terms of approach, top-down remains the most commonly implemented approach. Bottom-up initiatives can be either citizen

driven (cases of Santiago and Montevideo) or pushed by technology (cases of Vienna, Copenhagen, Gdańsk, and Barcelona).

The best practices detected in the initiatives included in article **III** can be summarised as follows:

- Governance and ICT: Integrated data exchange; integration and coordination platform for urban systems; methodologies and tools for creating real-time collaborative applications; new municipal government data model; connectivity deployment initiatives; observatory of performance of the IT sector.
- Fostering innovation: Innovation and living labs; exhibitions where companies, innovators, municipalities, universities, and small and medium-sized enterprises (SMEs) participate, present their products and SC services; open data; citizen innovation initiatives based on ICT; research and development (R&D) activities; interventions and applications systems initiated by citizens; availability of public open data inspiring the creation of solutions.

## 4.3 Main factors influencing smarter sustainable cities

Regarding the empirical cases, the governance model identified in papers **VI**, **VII**, and **VIII** refers to a hierarchical structure with a collaborative and participative decision process. These initiatives hinge upon interdepartmental collaboration and cooperation, facilitating the exchange of information and resources. The findings acknowledge the indispensability of interdepartmental and interorganisational meetings in advancing the initiatives.

The main challenges of governance that were identified in the empirical cases of **VI**, **VII** and **VIII** included government agencies in metropolitan areas not being subordinated to a single entity and their willingness to collaborate and share information being mainly motivated by common needs and interests. This shows that a change in mindset is required. Each person/employee from each agency and department that is involved in the initiative needs to absorb the innovations in service provision as conditions to improve the service quality. Service integration requires cooperation and coordination of multiple authorities from different government levels, and this is a big challenge to be faced. Moreover, the limited autonomy in some cases is a challenge related to the current structure of the municipalities.

The channels for non-emergency services (**VI, VII**) contribute to a more efficient, effective, transparent, and collaborative city management. The governance mechanisms identified in the channels for non-emergency services (**VI**, **VII**) included the establishment of committees of services involving the vice mayor and secretariats to check which demands need more attention. Moreover, the development of a service level agreement (SLA), to be often reviewed, is seen as a tool to enhance the necessary interdepartmental collaboration.

Regarding municipal operations centres (**VIII**), the governance mechanisms identified included the establishment of an integrated environment facilitated by the centres, which leads to enhanced efficiency in public services, allowing agencies to allocate resources more effectively and expand service inspections; the definition of an action framework (including a communication plan) and operating protocols; and a crisis room used to operationalize coordination and facilitate collaborative decision-making processes. To deal with the challenges related to human resource, it defined strategic actions in the management model, including capacity building and training of government agents.

The governance mechanisms that have been identified in the SSC cases of article **III** include strategy definition, procedures for monitoring and assessment, PPPs, strong cooperation between science, public, and private sectors, clear definition of roles and responsibilities, and the creation of a new role named Chief Data Officer (CDO).

Building upon the findings of paper **II**, which identified 57 drivers and 63 barriers, the analysis conducted in article **III** led to the definition of 30 sustainability challenges, as illustrated in Figure 7.

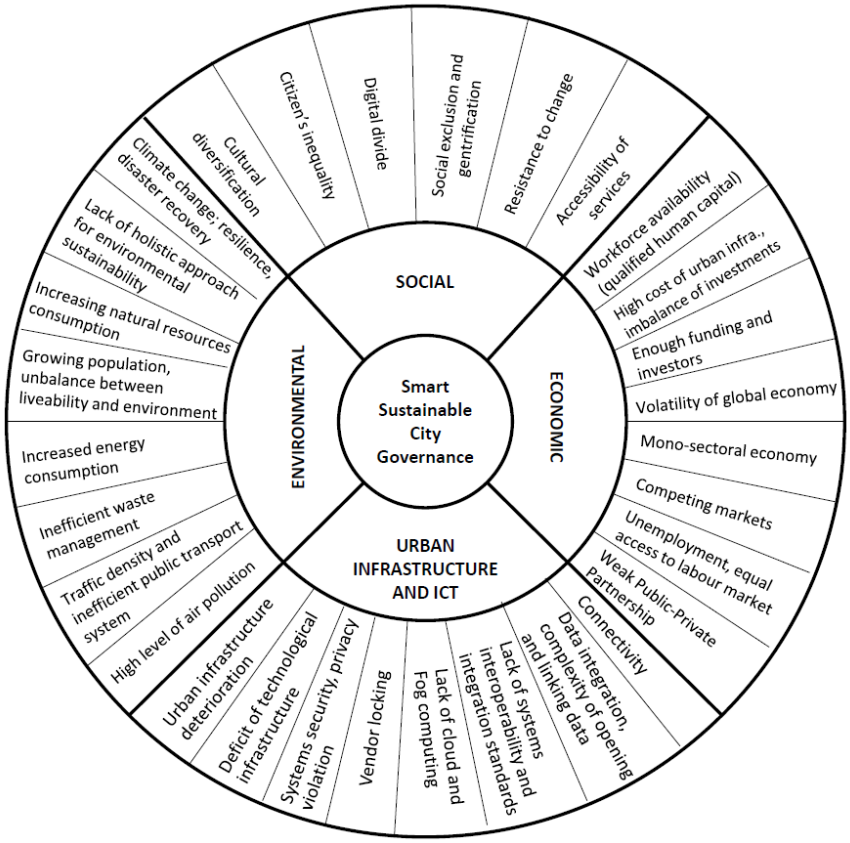


*Figure 7. Sustainability challenges for SSC development (Source **III**, p. 8)*

These sustainability challenges served as the basis for the development of the SSC roadmap proposed in article **III**, which will be detailed in the subsequent chapter.

# 5 Governance and capacity development

This chapter focuses on smart sustainable city governance and the strategies for capacity development, addressing the third research question of this doctoral thesis. The first part of the chapter introduces the SSC roadmap as a tool for addressing sustainability challenges and building governance capacity, as developed in article **III**. The second section presents the case of the Urban Learning Centre, as studied in paper **V**.

## 5.1 SSC governance roadmap

The SSC governance roadmap proposed in article **III** was formulated based on the findings of paper **II** (as outlined in section 4.1) and the insights derived from 12 use cases of SSC initiatives (as presented in section 4.2.3). This roadmap comprises 11 key governance conditions categorised into three primary phases: planning (preliminary activity); implementation; and adoption, monitoring, and evaluation, as depicted in Figure 8.

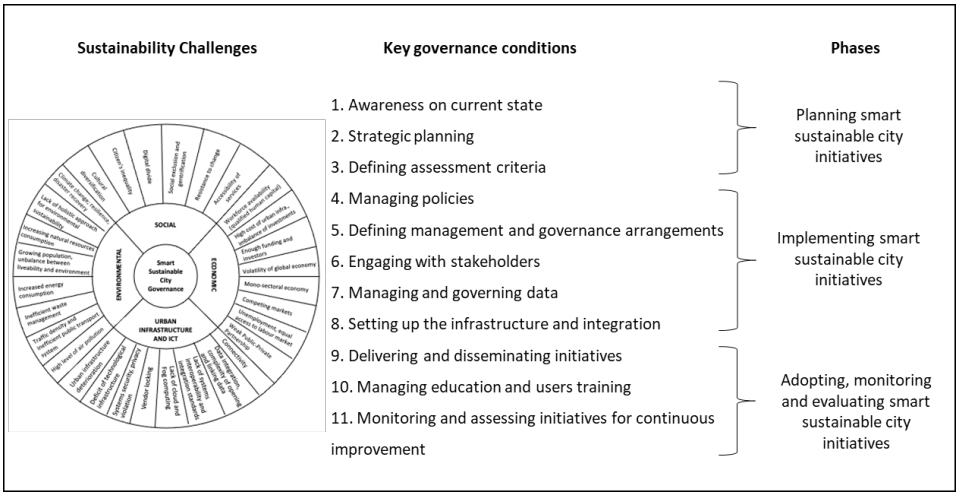


*Figure 8. Smart sustainable city governance roadmap (Source: **III**)*

Each key condition is elaborated with corresponding steps or recommendations; however, the process of developing SSC initiatives follows a continuous and adaptable approach, encompassing nonspecific key conditions that can be tailored to the city's context. Therefore, the linear representation of the conditions outlined below is a conceptual simplification (**III**).

**1. Awareness of the current state**: 1.1 definition of stakeholders, 1.2 understanding the context, 1.3 needs assessment, and 1.4 risk management.

*Defining stakeholders* refers to the identification of internal and external actors, since involving groups of stakeholders is important for the success of the initiatives (Axelsson & Granath, 2018) and to guarantee a multidisciplinary background.

Critically, *understanding the context* includes the analysis of the political situation, societal problems, and local governance challenges; mapping of the solutions and capabilities in place; understanding organisational structure, processes, and interactions; and external environmental scanning with stakeholders.

*Needs assessment* reflects the perception of the importance of local needs, which may set the aims and values of the initiatives. Those are often related to social drivers, which include various aspects of life such as community needs and the public provision of urban services, innovative healthcare and sanitation facilities, education facilities to elevate the literacy rate and to generate workforce as well as accessibility and social inclusion initiatives to minimise digital divide. Finally, *risk management* deals with learning from previous errors and assessing possible risks (Park, 2018), including risks related to technology, organisation, and the external environment (Ullah et al., 2021).

**2. Strategic planning**: 2.1 developing a vision for SSC development, 2.2 planning human resources capacities, 2.3 infrastructure planning, 2.4 financial planning, 2.5 planning partnerships, and 2.6 seeking for approval and commitment.

*Developing a vision for smart sustainable city development* relates to setting the workplan and defining medium and long-term visions. Initiatives should have roles and responsibilities defined and documented to set expectations, including a leader responsible for promoting and monitoring the initiative's performance. Those aspects are to be addressed when *planning human resources capacities*.

*The planning of infrastructure* will vary depending on the context of application, since cities in more developed economies tend to have the basic infrastructure for implementing the initiatives already in place, while cities in developing economies may need to invest more in technology to implement such initiatives (**II**). Moreover, it is also important to plan strategies to integrate existing technologies (Pereira et al., 2020).

Related to the economic challenges identified in the literature and in the SSC cases (**II, III, VII**), *defining a financial plan* is necessary due to the high costs of urban infrastructure. Therefore, prioritising investments to balance hard infrastructure (physical, hardware, sensors, systems) and soft infrastructure (capabilities) is recommended. Likewise, scholars have mentioned the option of looking for funding and investors through partnerships (**II**, **III**).

*Partnerships* between public and private organisations should be planned since the early stages (Ibrahim, Adams, et al., 2015; Ismagilova et al., 2019; Koppenjan & Enserink, 2009). In addition, scholars have mentioned the importance of promoting alliances between emerging industries (Keshvardoost et al., 2018; Lee et al., 2014).

Finally, *seeking for stakeholders' approval and commitment* (political, societal, business) is another recommendation, which includes ensuring that the strategic ambition is supported by long-term term policies (Bolívar & Meijer, 2016; Fernandez-Anez et al., 2018; Keshvardoost et al., 2018) and that cooperation across organisational boundaries is established for the implementation of SSC initiatives (Brorström et al., 2018).

**3. Defining assessment criteria**: 3.1 defining key performance indicators (KPIs) (what will be checked), 3.2 defining assessment tools (how the KPIs will be checked), and 3.3 defining a performance evaluation plan (who will check the KPIs and when).

While still in the planning phase, cities should define the assessment criteria to be used in the monitoring and assessment of SSC initiatives, including KPIs. Regarding the *definition of KPIs,* the targets should be defined to check the progress of initiatives. This step is followed by the selection and use of *monitoring and assessment tools* to achieve the main evaluation goals that have been defined. Next is the *definition of the performance evaluation plan.*

The evaluation plan is like a strategy, which includes the responsibilities (who) and the timeframe (when) regarding the performance evaluation process. The literature offers good sources that can be used for a better understanding of KPIs in the context of SSC.

For instance, Huovila et al. (2019) have provided a summary of SSC indicators, and the recent study of Sharifi et al. (2024) has investigated interlinkages between smart cities and the SDGs. The SDGs can be used as a reference for defining KPIs.

**4. Managing policies**: 4.1 identifying existing policies, and 4.2 reviewing, updating, creating, integrating, and evaluating policies.

*Identifying existing policies* is the first step due to the multiplicity of policies and programmes at different levels of government (local, regional, national) (Bednarska-Olejniczak et al., 2019; Caragliu & Del Bo, 2019; Nam & Pardo, 2011b; Praharaj et al., 2018; Vilajosana et al., 2013) and ensuring alignment between them.

Therefore, for *creating policies*, a multidisciplinary team should be involved to understand context-related challenges (Kovacic, 2018). Finally, the process of creating policies should not be centralised; the adoption of participatory governance paradigms (e.g., joined-up governance, network governance) as well as collaboration across government departments and agencies is recommended (Alawadhi & Scholl, 2016).

**5. Defining management and governance arrangements**: 5.1 establishing a governance model, and 5.2 management of capacities.

The *governance model* is defined by the clear allocation of roles and responsibilities and may include the designation of a leader (also denoted as a champion) (Brorström et al., 2018; Ibrahim et al., 2017; Kramers et al., 2014; Lee et al., 2014; Van Winden, 2008; Vilajosana et al., 2013). One of the findings of the SSC cases included in **III** concerns the risk of discontinuity of initiatives with the next municipal administration. Therefore, it is important that the assignment of responsibilities is within the civil service to avoid situations where the transitions of political leadership put an end to an initiative (Ben Letaifa, 2015).

It is also important to consider that the administrative structure of cities is frequently organised in isolated silos (operational nodes), which is why governance arrangements should ensure internal coordination and cooperation within the city's agencies (Aina, 2017; Brorström et al., 2018; Kogan & Lee, 2014; Tachizawa et al., 2015). Enabling information sharing and integration between municipal agencies is crucial for a collaborative governance (Viale Pereira et al., 2017).

*Management of capacities* is a transversal aspect that includes human resources, urban infrastructure, and financial resources. From an economic point of view, an important enabler is related to the effective management of urban resources (Zhang et al., 2019), which aims to avoid waste and to maximise economic benefits. Other authors referred to the sustainable management of resources as circular economy or collaborative consumption (Barns, 2018; Esmaeilian et al., 2018).

Regarding financial capacity, the high cost of urban infrastructure for SSC development (including both operational and maintenance) was strongly stressed by academics. For instance, lack of funding and the challenges of attracting investors were pointed out (Aina, 2017; Angelidou et al., 2018; Ibrahim, Adams, et al., 2015; Ibrahim, Al-Nasrawi, et al., 2015; Kramers et al., 2016; Silva et al., 2018; Yadav et al., 2019).

In addition, scholars have criticised the imbalance on investments regarding hard infrastructure (physical, hardware, sensors, systems) and soft infrastructure (capabilities) (Ahvenniemi et al., 2017), meaning that sometimes cities invest in technology but not in human capacity for adopting that technology.

**6. Engaging stakeholders:** 6.1 engaging citizens, 6.2 engaging internal stakeholders, and 6.3 engaging external stakeholders.

The SSC is an interdisciplinary concept that connects different disciplines and multiple stakeholders. *Engaging stakeholders* may tackle economic challenges by promoting innovation ecosystems and creating living and urban labs to help the development of SSC initiatives. The use of crowdsourcing is also an alternative way to foster urban innovation as it helps to generate new ideas serving as an engagement platform (Angelidou et al., 2018; Lee et al., 2014; Niforatos et al., 2017; Schuurman et al., 2012; Vakali et al., 2017; Yarime, 2017).

Stakeholders' collaboration can be internal (cross-sector) or external, resulting in partnerships and approaches like the 'triple helix model' (public-private-academia partnership) or even the 'quadruple helix' (public, private, university, and citizens) (Martin et al., 2019). The FinEst Centre for Smart Cities described in article **I** is a good example of the triple helix model. Furthermore, to deal with multiple stakeholders (including citizens) good communication (Joshi et al., 2016) and feedback channels (Lee et al., 2014) are necessary.

*The engagement of citizens* can be facilitated by online tools but also in traditional offline initiatives, which requires creating mechanisms to allow citizen participation and co-creation besides defining a clear communication plan. Since public participation is a crucial aspect for the sustainable development of a city, it is important to understand the reasons for the participation or non-participation of citizens in local initiatives (Bednarska-Olejniczak et al., 2019).

*Engaging internal stakeholders* can also be understood as cross-sector collaboration and can be facilitated by coordination mechanisms, requiring the establishment of horizontal structures to foster collaboration. Strategy definition could facilitate work between multiple stakeholders (Keshvardoost et al., 2018) and helps create synergy among different city departments (Lee et al., 2014).

*Engagement of external stakeholders* relates to the establishment of partnerships. This requires a partnership overview, the definition of the legal framework, and consideration for strategic alignment. Furthermore, it is recommended to use formal / ad-hoc forums to map conflicts, and to adopt techniques to prepare and provide training to city partners (Keshvardoost et al., 2018).

**7. Managing and governing data:** 7.1 ensuring appropriate data management, 7.2 establishing a data governance strategy, and 7.3 defining security and data privacy policies.

The need of data sharing across different systems was strongly stressed in literature (Bibri, 2018b; Yarime, 2017; Yeh, 2017). Nevertheless, there are some challenges to overcome to make efficient use of data (**II**).

*Data management* comprises some technical aspects in terms of collecting, normalising (modelling imperfect data), and processing data to transform it into knowledge. In addition, it includes ensuring real-time data analytics and the interoperability of systems that should be capable of aggregating information from several systems and devices. The lack of data quality can affect data-based decision making and, consequently, the performance of urban services (Sta, 2017). Some scholars also stressed the urgency of an 'enterprise data management' in the public sector (Harrison et al., 2018), and the importance of observing roles and responsibilities related to data management (Vilminko-Heikkinen & Pekkola, 2019).

Questions as to who owns the data, which data can be used, and who is responsible for ensuring data quality should be addressed under the *data governance strategy*. Data governance requires defining which data should be used, when, and by whom,

determining the owner of the data, ensuring compliance with data protection regulations and data privacy policies. In addition, as more and more systems are (or should be) connected and more data is exchanged, it increases the need of ensuring system security and protecting sensitive data (Allam & Dhunny, 2019; Bennati & Pournaras, 2018; Caragliu & Del Bo, 2019; Fernandez-Anez et al., 2018; Keshvardoost et al., 2018; Khan et al., 2017; Lee et al., 2014).

**8. Setting up the infrastructure and integration:** 8.1 implementing the infrastructure of systems and devices, and 8.2 ensuring interoperability and system integration.

The implementation phase of smart sustainable city initiatives involves the configuration of the technological infrastructure and integration with existing solutions and architecture. There are several applications of artificial intelligence (AI) that could benefit the development of SSC, such as AI for education, environment, health care, policy, mobility, and sustainability (Allam & Dhunny, 2019).

Moreover, authors have mentioned the application of advanced ICT and developments in remote sensing, which allows the usage of satellite data for monitoring cities almost in real-time (Aina, 2017; Bibri & Krogstie, 2017a; Gowri Shankar Rao et al., 2018; Jat & Saxena, 2018; Mokoena et al., 2017; Song et al., 2017). However, to benefit from the use of those emerging technologies, cities should have a *robust infrastructure of systems and devices* that is able to capture, process, and spread data within different sources (Corbett & Mellouli, 2017; Lee et al., 2014; Rana et al., 2019). Physical infrastructure integration and optical networks to support the communication of different data centres is also required. In addition, it is important to use open sources, to facilitate the interoperability within systems and to avoid vendor lock-in.

**9. Delivering and disseminating initiatives**: 9.1 establishing good internal and external communication.

To deal with multiple stakeholders it is recommended to *establish good internal and external communication* (Joshi et al., 2016) and feedback channels (Lee et al., 2014). Therefore, it is important to investigate the communication methods being used by cities and their effectiveness in the governance process of SSC initiatives (Bednarska-Olejniczak et al., 2019).

**10. Managing education and user training**: 10.1 managing education programmes, and 10.2 providing training for users.

The lack of capacity building, including lack of investments in skills development, training, and education is one of the main barriers to the successful development and adoption of city initiatives (**II**). Therefore, cities should plan resources and *education programmes* to implement sustainable initiatives. Another benefit of *providing user training* is to minimise the risk of digital divide.

**11. Monitoring and assessing initiatives for continuous improvement**: 11.1 performance assessment, 11.2 feedback analysis and knowledge creation.

The development of city initiatives requires continuous improvement by monitoring the progress of all phases, and collecting and sharing information during their realisation. This includes *performance assessment* based on the criteria defined in the condition (defining assessment criteria) of the planning phase.

Considering the importance of citizen engagement for SSCs, they should be engaged in the evaluation of initiatives. Ideally, cities should have a dedicated team or organisation responsible for the 'monitoring' of SSC initiatives, ensuring the use of compliance and assessments tools (Garau & Pavan, 2018). Good practices can be taken

from the cases of Barcelona and Vienna (**III**), as both cities have an organisation responsible for smart (sustainable) city related initiatives and projects.

*Knowledge creation* is also part of this governance condition. The idea is to collect citizen feedback and to document the lessons learnt from the initiative's implementation. However, it is worth to mention that if the city makes use of *feedback channels*, public administrations should be able to reply and attend to the requests under a predefined service-level agreement.

The SSC roadmap serves as a foundation for enhancing local governance capacity and guiding initiatives at various stages of development. Given that the process of initiative development follows a continuous and iterative approach, governance capacities expand with each development cycle (**III**).

## 5.2 Fostering capacity development: the case of the Urban Learning Centre

Capacity development (CD) is a process for strengthening, creating, adapting, and maintaining capacity over time (UNDG, 2017). The process is illustrated below in Figure 9.

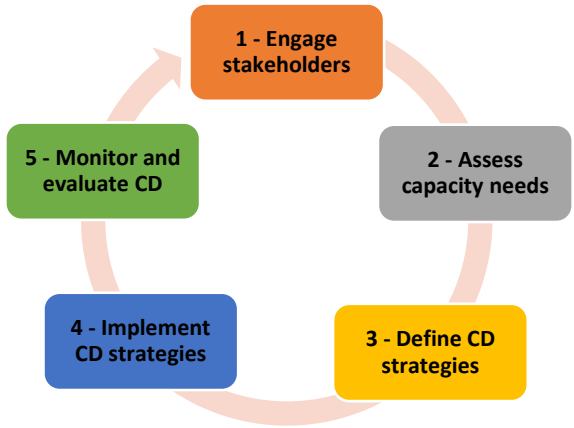


*Figure 9. Capacity development process (Source: own elaboration based on* UNDG, 2017)

Paper **V** aimed to start discussion on how to foster capacity development and continuous education in municipalities. The paper describes the development of the Urban Learning Centre (ULC) initiative, following the capacity development process illustrated in Figure 9.

The identification of the learning needs and interests of municipalities described in the paper refer to the first and second steps of the CD process (engaging stakeholders and identifying needs). The findings of **V** confirmed what has been pointed out by previous studies (Joshi et al., 2016; Kramers et al., 2014; Praharaj et al., 2018) that there is a lack of project management knowledge in the public sector.

As described in more detail in paper **V**, the results of the survey have shown that 67% of the respondents are interested in developing project management skills. Other frequently listed skills among the technical ones include funding and financing (63%), community and stakeholder engagement (50%), digital transformation (46.7%), and city planning (31.5%). In terms of soft and human skills, the topics that the municipalities are

more interested in developing include effective team collaboration (66%), creativity and innovation (64%), strategic leadership (43%), and networking and city diplomacy (37%). In addition, the results demonstrated an interest in learning about attractive financing, core skills for economic development, alternative finance and crowdfunding, community engagement and inclusion, and smarting your city (**V**). After identifying learning needs, course content was developed by project partners. More detailed information can be found in publication **V**.

In addition to the Urban Learning Centre initiative, municipalities have different possibilities to foster capacity development. To begin with, participation in capacity building projects as partners is a way to stimulate knowledge creation. As an example, the Cap4city project organised many workshops in municipalities in Brazil, Argentina, Colombia, and Chile. This project is also facilitated knowledge exchange between different universities in Latin America and Europe. There are many existing capacity building projects that municipalities could engage in.

Another way is the creation of online courses. E-learning became more popular than ever during and after the COVID pandemic. Ideally, courses should be prepared based on an analysis of the learning needs of the stakeholders (following the CD process in Figure 10). Following the example of the Urban Learning Centre (**V**), a survey to identify the needs and preferences of the stakeholders can be used to identify and assess the capacities that need to be developed.

# 6 Discussion

This chapter discusses the main findings of the doctoral thesis, answering the three research questions that guided this study. The first question focused on building an understanding of smart sustainable cities. The second question investigated the factors influencing the development of smarter sustainable cities. Finally, the third question focused on capacity development for smarter sustainable cities.

Reflecting on the first research question of this thesis regarding **how a systematic overview of smart city research and innovation can contribute to the concept of smart sustainable cities**, it suggests several potential contributions.

The findings of article **I** show that the concept of the smart city has not become more rigidly defined from a scientific perspective over the past decade; rather, it has evolved in the opposite direction. Given the absence of a strictly defined research domain for the concepts of the 'smart city' or 'smart sustainable city', these terms have been applied to various types of developments, ranging from the simple adoption of ICTs to the complex application of emerging technologies. Concurrently, there are research and innovation efforts being conducted globally that contribute to the advancement of smart (sustainable) cities without explicitly adopting the term 'smart city'.

Hence, one key finding is that rather than attempting to provide rigid definitions for smart cities or smart sustainable cities, the crucial focus lies in framing these concepts within the context of the multifaceted challenges faced by cities, which require and enable cross-disciplinary research, even though the concepts continue to evolve (**I**). This finding reinforces the idea that the smart sustainable city as a form of practice represents a scientific challenge and requires interdisciplinary and transdisciplinary knowledge (Abella et al., 2017; Bibri, 2018a; Makhoul, 2015; Martin et al., 2019).

Paper **II** stated that 'SSC development is a complex phenomenon that needs to be addressed in a holistic way by contemplating all SSC domains to generate sustainable impacts' (**II**, p. 427). In contradiction, one of the claims made by the authors in article **I** was regarding the conceptualisation of smart cities as a phenomenon (**I**, p. 2). However, none of them should be seen as a phenomenon but rather as a movement or transformation process, as suggested in article **III** when defining the SSC as a territory in continuous transformation.

Adapting this definition of the smart sustainable city (**III**, p. 6), the following description of smarter sustainable cities is suggested: smarter sustainable cities represent territories in continuous transformation, enabled by digital technology and interdisciplinary innovation, stakeholder engagement and collaboration, constructing human, institutional and technical capacities to solve problems and create new development opportunities, to raise and maintain the quality of life in communities, and pursuing sustainable development.

Drawing upon this analysis, the following representation is suggested in Figure 10 to illustrate smarter sustainable cities.

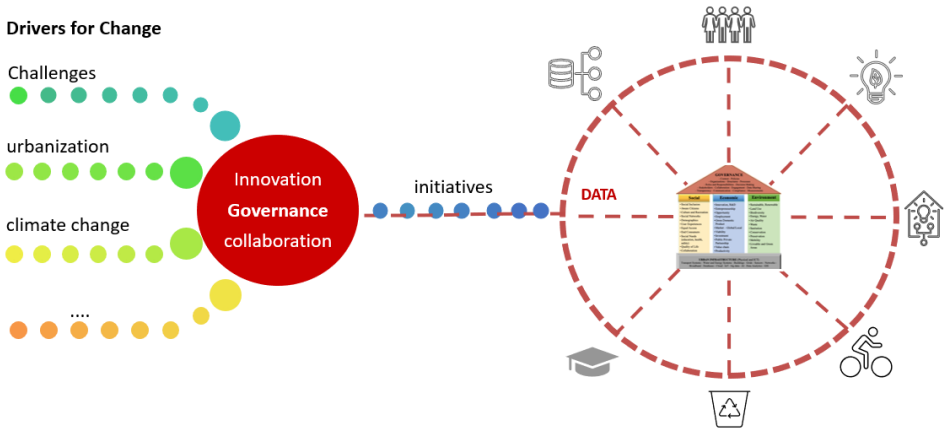


*Figure 10. Innovation and smarter sustainable cities*

The movement towards smarter sustainable cities requires innovation, collaboration, and evolving governance practices. As scholars have previously mentioned: 'a city can keep evolving to a smarter one through innovation' (Nam & Pardo, 2011b, p. 190). Adding to that, innovation should ideally be driven by urban challenges. The expected outcome of innovation is the development (or improvement) of initiatives that will benefit one or another aspect of the city, such as mobility, environment, quality of life, as the well-known six city themes suggested by the study of Giffinger et al. (2007). These initiatives can be characterised as smart, digital, sustainable, green, knowledge city initiatives, among others. The initiative's 'classification' is not what matters. The relevance relies on the integration of such initiatives with the city's system and on focusing on mitigating challenges and attending to citizens' needs. Figure 10 illustrates the initiatives integrated by data and governance.

Another important point is that even though the priority of cities when implementing initiatives should be to aim for long-term benefits (**III**), it does not mean that cities should not get involved in short-term projects. On the contrary, short-term projects can result in knowledge creation (Müür & Karo, 2023) and in business developments. Furthermore, innovation might provide short-term benefits, but at a later stage it can be institutionalised, resulting in long-term benefits (Janowski, 2015). Likewise, governance processes can be designed to foster short-term innovation, aiming to develop long-term sustainability visions (Loorbach, 2010). In this view, innovation and its short-term benefits can contribute to a smarter sustainable development.

Advancing the discussion, the focus now shifts to the development and implementation of initiatives, governance strategies, and capacity development for smarter sustainable cities. In other words, to the findings related to the second and third questions of this thesis.

The second question **investigated the drivers and barriers, as well as the main governance conditions influencing the development of smarter sustainable cities**. The SSC drivers and barriers are presented in chapter four (4.1) and the governance conditions in the first part of chapter five (5.1). The third research question focuses on identifying **strategies that can be used in the development of local governance capacity for smarter sustainable cities**, with respective findings outlined in chapter five.

Given that the governance conditions resulting from the second research question contributed to the development of the SSC governance roadmap proposed in article **III**, the main findings of this thesis are elaborated according to the phases outlined in the roadmap. The aim is to supplement it with additional insights derived from this study.

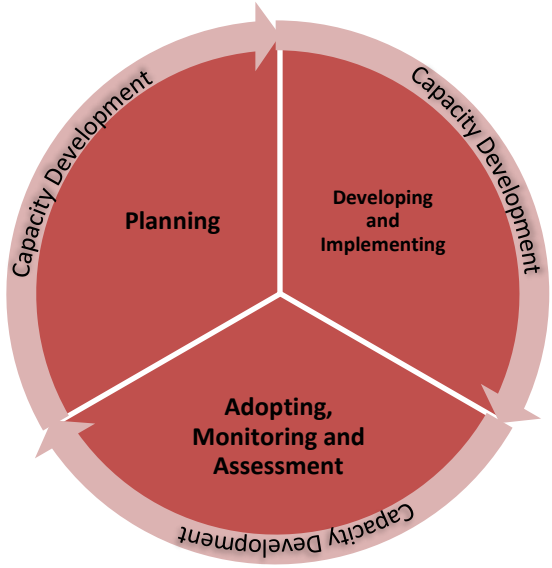


*Figure 11. Smarter sustainable city governance cycle (Source: own elaboration)*

Incorporating the results of this thesis, the following phases are suggested for a smarter sustainable city governance cycle: planning; developing and implementing; adopting, monitoring, and assessment for continuous improvement; and capacity development, as illustrated in Figure 11. The subsequent paragraphs discuss the integrated findings.

**Planning smarter sustainable cities**

Two key governance conditions are included in the planning phase: awareness of the current state and strategic planning (including defining assessment criteria). The focus lies on comprehensively understanding the current state and setting the groundwork for strategic development.

Awareness of the current state includes the identification of the city's priorities. Another important finding of the thesis regarding innovation and smarter sustainable cities is the adoption of mechanisms to identify local context and challenges prior to developing city initiatives. One approach that can be used is suggested in article **I** and that involves mapping city challenges for creating pilots. Moreover, in the development process, the end users (city residents) must be engaged from early stages (**II, III**). Another approach that can be used for identifying priorities concerns analysis through more participatory approaches involving citizens. The empirical cases show that channels for non-emergency services (**VI**, **VII**) have the potential to contribute to more inclusive participation regarding city planning.

According to empirical evidence, different aspects drive the development of SSC initiatives, which include resource savings, socio-economic digital development (**III**),

better provision of municipal services (**VI**, **VII**), integration of municipal services using ICT (**VII**, **VIII**), city monitoring and management in emergency situations and crisis (**VIII**), establishing a channel between city and citizens (**VI**, **VII**), as presented in chapter four.

It is important to mention that the planning phase does not mean just planning new initiatives, it also includes the improvement of existing city initiatives. For instance, the municipal operations centres and the channels for non-emergency services have not been created as 'smart sustainable city initiatives' and are not labelled as such. Nevertheless, they can be considered as initiatives with the potential to support a smarter sustainable development. The empirical findings of this thesis have shown that changes in how local governments respond to emergencies and daily situations of a city makes the municipal operations centres an important strategy of resilience and smart governance (**VIII**).

Another important step of this phase is strategic planning, which includes developing a vision for smart sustainable city development (or for one specific initiative). A recent study (Kociuba et al., 2023) has shown that strategic planning facilitates the development of an innovative business ecosystem and fosters a culture of cooperation among stakeholders. The empirical findings confirmed that when the initiative is part of the city's strategy, it is easier to maintain it in the long run (**III**, **VI, VII**, **VIII**).

Strategy development should also include aspects related to collaboration. It is important to consider how to best manage stakeholders and motivate them to work collaboratively in the development of long-term initiatives. Strategy adoption was recommended by scholars as strategy supports local government collaboration with the stakeholders in its ecosystems (Clement et al., 2022).

Regarding the definition of assessment criteria, which should be included in the city or initiative strategy, Yigitcanlar et al. (2019) have explained that neglecting sustainability in smart city initiatives can lead to various risks, including the prioritisation of short-term gains, marginalisation, commercial interests prevailing over environmental concerns, and ultimately materialism. For this reason, it is important to plan a way to show the sustainability benefits of the initiative, which can be done via assessment indicators.

Another challenge identified concerns the need of balancing technological advancements with social equity and environmental considerations. This demands careful planning to avoid exacerbating existing disparities and causing environmental degradation (**II**). Overcoming these challenges requires a holistic and collaborative approach involving governments, businesses, communities, and the academia to ensure the successful development of SSCs.

Article **I** highlighted the need of transdisciplinary research to be able to deal with wicked problems. Therefore, this collaborative approach should be established since the planning stage of initiatives, or, since the research and innovation performed by universities in the case of research-based initiatives.

**Developing and implementing initiatives**

The second phase of developing and implementing initiatives includes five key governance conditions related to policies, governance arrangements, stakeholders, data governance, and infrastructure integration.

The findings of this thesis have shown that governance practices are evolving overtime together with the evolution of the smart city concept and public administration reforms. As seen, since the emergence of the concept of the smart city, it has undergone several

shifts, such as moving from a focus mainly on technology to a more people-centric approach, and, more recently, to an emphasis on sustainability giving rise to the concept of the smart sustainable city.

Some of the practices observed in smart city discourse can be related to new public management principles, which focus on efficiency, targets, and tangible results. Moreover, smart cities have initially been driven by new public network-based collaboration and problem-solving, sharing similar characteristics with new public governance. In recent years, with more focus on people and sustainability (smart sustainable cities), the changes are more towards public value creation (Cordella & Paletti, 2019; Criado & Gil-Garcia, 2019; Soe & Drechsler, 2018). Smart (sustainable) cities are characterised by a new way of governing with the use of technology and the consequent increase in public administration capacity with a focus on improving the quality of life of citizens. Therefore, the importance of governance and collaboration became evident (Alawadhi et al., 2012; Goldsmith & Eggers, 2004; Rodríguez Bolívar, 2018).

Following the roadmap, the management of policies involves identifying and reviewing existing policies, and creating, integrating, and evaluating policies to align with smart sustainable objectives. The findings from the literature review (**II**) indicated that lack of policies may hinder SSC development. However, in other contexts, the barrier consists of the multiplicity of policies across different public levels, e.g., local, regional, and national. In agreement, Van Winden (2008) stated that urban governance is not just a matter of urban actors because national and regional policies, in particular concerning innovation, have a huge impact on cities.

To deal with this challenge, one of the recommendations is that when developing initiatives for SSCs, it should be aligned with existing smart (sustainable) city strategies or regional strategies to ensure their institutionalisation. Therefore, defining the institutional framework that legitimises the development of SSCs and ensuring policy alignment across government levels has the potential to improve their sustainability in the long-term (**III**). A recent study (Noori et al., 2023) suggested a policy transplantation framework that can be useful in this matter.

When looking for existing policies and strategies, as illustrated in article **I**, this 'mapping' should also include other strategies, for instance, innovation or digitalisation strategies. In other words, a city might not have a smart city or smart sustainable city strategy named as such, but it might have a strategy for innovation that can be useful for developing and implementing smart(er) sustainable city initiatives.

Engaging stakeholders is vital for buy-in and collaboration. This includes engaging citizens, internal and external stakeholders to foster a sense of ownership and participation. The empirical evidence shows that the channels for non-emergency services integrate different city agencies, foster inter-departmental collaboration, facilitate an approximation between the city and its citizens (**VI**, **VII**). Likewise, the integration of municipal agencies improved the provision and delivery of information and public services and put together different experts for dealing with complex problems and emergency situations (**VIII**). These cases are empirical evidence of ICT enabled governance (Viale Pereira et al., 2017).

As seen, multiple stakeholder engagement is one of the aspects that contributes to the development of smarter sustainable cities (**II, III**). However, multistakeholder collaboration is both a driver and a challenge as more people involved requires more capacity to coordinate (Nastjuk et al., 2022). Collaborative governance mechanisms have

been identified through the empirical cases. These include the definition of an action framework and communication plan, operating protocols, and the establishment of a crisis room used to operationalise coordination and to facilitate the collaborative decision-making process (**VIII**). In addition, the findings evidenced the establishment of committees of services and the development of a service level agreement as a tool to enhance the necessary interdepartmental collaboration (**VI**, **VII**).

Furthermore, ensuring appropriate data management, establishing a data governance strategy, and defining security and data privacy policies to safeguard sensitive information are important practices to be followed. The empirical evidence of paper **VIII** highlights the importance of data-based initiatives and open data. In terms of transparency, municipal operations centres are promoting public access to data and information generated by the city centres. The use of data to support decision-making is one of the key benefits of data-based initiatives to promote smart governance of a city. Another finding is that data crossing contributes to increased efficiency in the provision of public services through the optimisation of resources. Furthermore, the provision of government open data encourages innovation through the creation of new products and services (**VIII**).

Finally, setting up infrastructure and integration is essential, but it is also a challenge (**VI**, **VII**, **VIII**). Previous studies indicated that smart governance initiatives are usually just designed for better city management and argue for a lack of evidence regarding any increase of public participation through ICT. However, the channels for non-emergency services (**VI, VII**) can be seen as initiatives that foster participation and have the potential to bring other benefits to the city besides better city management, as argued by previous studies (see Martin et al., 2019). Important aspects related to governance that can be improved by ICTs according to empirical evidence include communication, participation, partnership and collaboration, transparency, and accountability, in addition to efficiency and effectiveness in public administration.

**Adopting, monitoring and assessment for continuous improvement**

The key governance conditions of this phase include delivering and disseminating initiatives, establishing communication mechanisms, managing education and user training, and monitoring and assessing for continuous improvement, which includes performance assessment and feedback analysis for knowledge creation.

This phase is focused on the 'appropriation' of the solution or initiative by residents, which should mitigate the lack of awareness identified in literature (**II**) and in the empirical cases (**VI**, **VII**). Therefore, cities should provide information about the initiatives and services in place using different channels to ensure social inclusion and mitigate digital divide.

Establishing internal and external communication channels facilitates the dissemination of information and fosters transparency and accountability. Additionally, implementing education programmes and providing training for citizens enhances understanding and the adoption of initiatives. Therefore, fostering a participatory approach through education, awareness, and community engagement is essential. To this end, cities can adopt different mechanisms, such as social media platforms to disseminate the initiatives.

Monitoring and assessment of SSC initiatives is a challenging process due to the collaborative characteristics of such initiatives. The empirical evidence (**VI, VII**) has shown that municipalities do not follow good practices regarding the monitoring and

assessment of its initiatives for continuous improvement. In one of the cases (**VI**), the system was not collecting feedback regarding service provision at the time of data collection.

**Capacity development**

The practice of monitoring and assessment of initiatives also supports the capacity development process. Continuous monitoring and assessment might help the identification of capacity needs. To use a practical example of municipal channels for non-emergency services, if a request is taking too much time to be executed, it is important to identify what is causing the service delay to define actions for capacity development based on the identified issue.

Likewise, feedback channels enable citizen participation for improvement. Leveraging feedback analysis contributes to knowledge creation, fostering a culture of learning and adaptability. By embracing these practices, initiatives can evolve iteratively, ensuring their effectiveness and relevance in addressing urban challenges. However, governance capacities to deal with the inputs from citizens are important to ensure that they will continue to participate and feel included. The analysis of the channels for non-emergency services evidenced that when citizens do not receive a reply, they tend to stop interacting.

According to the findings of article **III** and **V**, capacity development should be seen as a continuous process performed along the whole cycle, from planning to implementation, to the adoption phase, as illustrated in Figure 11. Moreover, stakeholders should be engaged in assessing learning needs and defining development strategies, as evidenced by the case included in paper **V**.

As seen, the smarter and sustainable development of cities requires the collaboration of many actors. Thus, municipalities should develop collaboration capabilities to facilitate urban transitions. Collaboration capability is rooted in organisational competencies and individual skills and plays a crucial role in effective governance (Soberón et al., 2023). Other necessary competencies are related to project management (**V**) and capacity to accelerate innovation, which includes creative skills, innovation-oriented institutions, broadband networks, and collaborative spaces (Komninos et al., 2014).

One strategy that can be explored further for capacity development is the establishment of innovation and research centres, like the case included in article **I**. Centres of excellence and research facilitate capacity development, foster creativity and innovation, and help to transition from strategy to impact (Hellström, 2018; Noori et al., 2021). Likewise, urban labs have the potential to co-create value, engaging users in research and development (R&D) (Komninos et al., 2013) and providing an infrastructure for knowledge exchange and learning between all these actors (**I**).

Besides the lack of operational technological workforce, the lack of IT knowledge among public authorities and policy makers is also a barrier to fostering digital transformation and implementation of smart initiatives (Scuotto et al., 2016). As governance is evolving, it is necessary to strengthen the capabilities of cities to learn and adapt to the digital age (Wei, 2021). The empirical evidence has shown that investments in technologies should be accompanied by capacity building, since the lack of investments in skills development, training, and education is one of the main challenges identified (**II**, **III**).

Adaptive governance is a challenging process that takes learning as the core value (Janssen & van der Voort, 2016). Therefore, municipal servants need to develop skills and competencies that can face uncertainty as they often need to respond to rapidly

changing environments (Panagiotopoulos et al., 2019; Pang et al., 2014). The capabilities identified in this thesis that are relevant for smarter sustainable cities include leadership capability (Noori et al., 2021), reflective-improvement, collaborative, and data analytic capabilities (Mayne et al., 2020).

Data is one of the most important resources for smarter sustainable city development. It is needed for allowing evidence-based policy making (data-driven), which can only be efficient if data is well managed and governed. The empirical findings have shown that a lot of data is generated by the initiatives (**VI**, **VII**, **VIII**); however, in most of the cases such data is not explored as it could be due to lack of capacity (including both technical and human capacity) (**VI**, **VII**).

The demand for new roles in organisational structures to deal with emerging technologies and the dynamics of cities is one of the empirical findings of this thesis. The new roles identified include those of the leader or initiative champion and the emerging role of the Chief Data Officer (CDO). A leader (or the manager) is important for creating awareness of the importance of initiatives, monitoring progress, and planning actions for improvement. A recent study by Guenduez et al. (2024) identified work practices of smart city managers that drive the transformation of cities. Their findings are aligned with the results of this thesis, as the authors mentioned the importance of establishing a vision for the future, fostering innovation and collaboration among the functions of a smart city manager.

Overall, the results of this thesis have shown that for evolving governance many areas should be developed further, not only those related to technology. As seen, a range of capacities and capabilities have been identified as important to be developed for a smarter sustainable city.

# 7 Conclusion

This doctoral thesis has endeavoured to explore the development of smarter sustainable cities by addressing the following key research questions:

1. How can a systematic overview of smart city research and innovation contribute to the concept of smart sustainable cities?

2. What are the drivers and barriers, and main governance conditions influencing the development of smarter sustainable cities?

3. Which strategies can be used in the development of local governance capacity for smarter sustainable cities?

To address these questions, the thesis relied on research contributions from eight original publications. These publications examine the development of smarter sustainable cities through different approaches, which are as follows: identifying the characteristics of smart cities based on global research and innovation (**I**), reviewing the literature to identify the dimensions and characteristics of smart sustainable cities (**IV**), analysing drivers and barriers influencing their development (**II**), exploring initiatives, such as municipal channels for non-emergency services (**VI**, **VII**) and municipal operations centres (**VIII**), investigating and analysing key governance conditions for the development of city initiatives (**III**), and studying one initiative that fosters capacity development in municipalities (**V**). By synthesizing these diverse research contributions, the thesis aims to offer a comprehensive understanding of the multifaceted journey towards smarter sustainable cities.

The first research question is addressed in chapter three. This question focused on understanding how a systematic overview of smart city research and innovation contributes to the concept of smart sustainable cities. To answer this question, research groups and centres dealing with related smart city research and innovation, including their disciplinary focus areas and research topics, were the focus of this investigation. In addition, an in-depth case study of the FinEst Centre for Smart Cities has been performed.

This analysis contributed to the understanding that neither the smart city nor the smart sustainable city can be seen as rigid concepts. The main conclusion is that instead of attempting to provide strict definitions, the crucial focus should be on framing these concepts within the context of the multifaceted challenges faced by cities, which requires interdisciplinarity and experimental methods. As a result, it is suggested to use the term smarter sustainable cities which represents cities in continuous transformation, enabled by digital technology and interdisciplinary innovation, stakeholder engagement, and collaboration.

The second research question is addressed in chapters four and five (5.1). To answer this question, first, an extensive systematic literature review comprising 169 articles was performed to identify aspects influencing the development of smart sustainable cities (**II**). This review resulted in a list of 57 drivers and 63 barriers, which have been classified according to the SSC conceptual framework previously developed by the author in paper **IV**. The findings are outlined in section 4.1 and indicate governance and ICTs as the most

important and challenging factors influencing the development of smarter sustainable cities.

In addition, empirical evidence has been collected through in-depth case studies of three cases of channels for non-emergency services (**VI**, **VII**), and three cases of municipal operations centres (**VIII**). Most of the important empirical findings are related to governance, such as cross-departmental collaboration and communication strategies, (lack of) capacity, changes in internal processes due to the adoption of ICTs, data for decision-making, among others. In terms of technology, challenges are mainly related to system integration and lack of funding resulting in obsolete infrastructures, and issues for integrating systems and data, as presented in chapter four.

Answering the second part of RQ2, the key governance conditions influencing the development of smarter sustainable cities have been identified as follows: awareness of current state, strategic planning, definition of assessment criteria, policy management, definition of governance and management arrangements, stakeholder engagement, data governance, infrastructure integration, proper dissemination of initiatives, management of education and training, and the establishment of monitoring and assessment practices for continuous improvement.

The third research question of this thesis is addressed by articles **III** and **V**, as presented in chapter five. The major contribution in terms of strategy for capacity development is the suggested SSC governance roadmap (**III**). The roadmap has been developed following design science research methodology and based on the identified antecedents that may hinder or facilitate the development of initiatives, and on the analysis of key governance aspects from 12 initiatives in Europe and Latin America.

Incorporating the findings of this thesis into the SSC governance roadmap, the following phases are suggested for a smarter sustainable city governance cycle: planning; development and implementation; adoption, monitoring, and assessment for continuous improvement; and capacity development. This governance cycle supports the development and implementation of initiatives, strengthening governance capacity to ensure the long-term impacts of the city's initiatives towards smarter sustainable cities. Moreover, according to the findings of the thesis, the necessary capacities to be developed for an evolving governance structure include those related to project management for planning, defining priorities and strategies, innovation and collaboration capabilities, and data-related capacities.

Overall, this thesis offers a comprehensive exploration of factors influencing the development of smarter sustainable cities and the complex interplay of its factors. It provides insights into evolving governance practices and capacity development. By suggesting mechanisms to address challenges and proposing actionable guidelines, this doctoral thesis contributes to the ongoing dialogue on the development of smarter sustainable cities in both science and practice.

## 7.1 Implications

The value added by this thesis is two-fold, including at the theoretical and practical level. First, a simple, yet holistic conceptual framework for smart sustainable cities is suggested in paper **IV**. This framework can be used as a starting point to understand the main dimensions and characteristics of smart sustainable cities. For instance, the SSC conceptual framework was used in paper **II** to group the identified drivers and barriers influencing the development of SSCs. The findings of paper **II** also contribute to the literature by providing an extensive list of drivers and barriers covering social, economic,

environmental, governance, and urban infrastructure aspects. This list adds to holistic studies on smart sustainable cities.

Moreover, one of the key implications of this thesis, based on article **I**, is the finding that instead of trying to provide a strict definition of smart (sustainable) cities, the important aspect is the framing of initiatives provided by the complexity of real-life challenges pertaining to the sustainable development of cities. In addition, article **I** adds to the literature which lacks an introduction to the core research and innovation agenda of smart (sustainable) cities. Another implication of article **I** is the suggestion that larger-scale smart (sustainable) cities studies and projects should not be organised as separate academic disciplines. There is a need of more interdisciplinary and more experimental approach to the development of smarter sustainable cities.

This thesis advances the knowledge regarding smarter sustainable city governance. The smarter sustainable city governance cycle can be considered as one of the main contributions of this thesis. It differs from previous smart (sustainable) city roadmaps as it highlights governance elements, such as managing policies, engaging stakeholders, training mechanisms, and capacity development, which have not been included in previous studies.

Furthermore, this thesis contributes to the literature by analysing dimensions and factors for implementing municipal operations centres and municipal channels for non-emergency services, relying on different case studies in Brazil. The cases provide insights into the technological, organisational, managerial, political, and institutional factors involved in the successful implementation of such initiatives (**VI, VII, VIII**). Furthermore, the literature lacks empirical evidence from other regions besides Europe (Mora et al., 2023), so by offering many cases from Latin America (**VI, VII, VIII** and **III**) this thesis adds to the literature by providing empirical evidence from developing regions.

Moreover, the Urban Learning Centre (**V**) contributes to the literature that needs evidence about how to strengthen municipal capacity towards sustainable development. Consequently, this thesis advances the knowledge gap between smart (sustainable) city, governance, and capacity development, providing actionable strategies and recommendations for future SSC research agenda.

In addition, another contribution is the suggestion of the term ‘smarter sustainable cities’, which emphasises the need of continuous improvement, innovation, collaboration, and evolving governance practices.

At a practical level, this thesis presents a holistic understanding of factors (social, economic, environmental, governance, and urban infrastructure) that influence the development of smarter sustainable cities. Those factors can be useful for strategic planning, resource allocation, and the identification of areas that deserve more attention.

The empirical evidence of municipal operations centres and channels for non-emergence services has shown that these types of initiatives have great potential in supporting cities in becoming smarter and more sustainable. The identified challenges pertaining to the analysed cases and the governance mechanisms that have been used by the initiatives can be useful for other cities that are planning to implement similar initiatives.

Moreover, this thesis offers an overview of global research centres dealing with smart cities and introduces the case of the FinEst Centre for Smart Cities and its initial research agenda (**I**), which can inspire the conception of similar centres in other regions. The thesis highlights the need of multidisciplinary collaboration to identify and address complex urban challenges. Additionally, article **I** introduces the Experimental Piloting Programme

as a practical example of how to develop urban challenge-based pilots. This methodology can also be adapted and adopted by other regions.

Regarding capacity development, this thesis suggests strategies to support municipalities in the development of local governance capacity to address sustainability challenges, including tools to map the learning needs of stakeholders. For instance, the SSC governance roadmap can serve as the basis for identifying the capacities needed for implementing initiatives for smarter sustainable cities. This tool can be used either to foster capacity development within municipalities and with public servants, but also to guide the development of new curricula.

In sum, this thesis possesses significant potential to assist a diverse array of stakeholders, including urban planners, policymakers, public administrators, and practitioners. By offering insights and methodologies for capacity development and highlighting crucial considerations regarding factors influencing SSC initiatives, it equips these stakeholders with tools for effective planning, development, implementation, adoption, monitoring, and evaluation of initiatives aimed at fostering long-term benefits.

## 7.2 Avenues for future research

In the light of this doctoral thesis, several topics emerge as possibilities for further studies.

While examining the development of smarter sustainable cities, this thesis provided an overview of the evolution of the concept of the smart city. However, it does not delve deeply into analysing its changes and implications within the scope of this study. Nonetheless, it prompts further investigation into the evolution of the concept, like the comprehensive analysis conducted by Janowski (2015) on the evolution of digital government and its stages (digitization, transformation, engagement, and contextualization).

Based on the findings of article **I**, two further studies are recommended. First is a deeper investigation into the type of research and innovation conducted by scholars regarding the technology implementation in urban environments incorporating different methods, such as fieldwork. Second, as the development of smarter sustainable cities requires experimentation, collaboration, and transdisciplinary knowledge, further investigation is recommended to understand existing synergies between researchers and practitioners from diverse backgrounds.

Further studies are also recommended to advance the SSC roadmap suggested in article **III**, including its empirical application. Other avenues for future studies include investigating knowledge exchange between cities, exploring methods to motivate citizen participation, and examining the outcomes and long-term benefits of smart sustainable city initiatives. Additionally, more investigation is recommended to understand how municipalities are investing in continuous learning, innovation, experimentation, and collaboration.

In terms of theory, one of the limitations of this thesis is that it did not apply one specific theoretical lens for the analysis of its results. Due to the multidisciplinary nature of smart (sustainable) cities, different concepts and frameworks from multiple fields have been investigated, ranging from management, knowledge management, capacity building and development, urban studies, environmental studies, innovation studies, urban governance, information systems, among others. Therefore, future studies are recommended. For instance, the roadmap could be analysed based on the transition management cycle (Loorbach, 2010). Likewise, there are other emerging governance

paradigms that could be explored in further studies of smart(er) sustainable cities and governance capacity, such as problem-oriented governance, which highlights the importance of building capacity and acquiring support to achieve substantial progress (Mayne et al., 2020).

Given the significance of municipal operations centres and channels for non-emergency services to support the development of smarter sustainable cities, future studies could focus on similar initiatives around the world to contextualize the results. Furthermore, the analysis of these case studies (**VI**, **VII** and **VIII**) occurred some time ago, presenting an opportunity for longitudinal studies, as recommended by Przeybilovicz & Cunha (2024). Hence, future research can explore the evolution of these initiatives over time.

# List of figures

# List of tables

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# Abstract

## Exploring the Journey towards Smarter Sustainable Cities: Capacity Development for Evolving Governance Practices

This thesis investigates the development of smarter sustainable cities, which represent innovative approaches to address urban challenges while fostering sustainability. The increasing global urban population, coupled with the urgent need to mitigate complex challenges, underscores the importance of smarter sustainable urban environments. Despite the potential benefits, the development of smarter sustainable cities demands evolving governance approaches to effectively leverage technological advancements and collaborative strategies. However, the lack of necessary capacities in local governments poses a multifaceted challenge. There remains a need to explore mechanisms that could strengthen governance capacity for the development of smarter sustainable cities. Therefore, this thesis sets out to investigate governance tools and strategies that can support such enhancement. To explore this topic, this thesis examines three main research questions:

1. How can a systematic overview of smart city research and innovation contribute to the concept of smart sustainable cities?
2. What are the drivers and barriers, and main governance conditions influencing the development of smarter sustainable cities?
3. Which strategies can be used in the development of local governance capacity for smarter sustainable cities?

To address these questions, this thesis relied on research contributions from eight original publications which investigated the development of smarter sustainable cities through different approaches. The thesis examined the multidisciplinary nature of smart city research and innovation, suggested a conceptual framework for smart sustainable cities (SSC), investigated drivers and barriers for SSC development, proposed an SSC governance roadmap, studied one case of a channel for non-emergency services as a smart city initiative and performed a comparative case study of similar initiatives. Furthermore, this thesis analysed multiple case studies of municipal operations centres and studied one initiative for capacity development in municipalities. By synthesising these diverse research contributions, this thesis aims to offer a comprehensive understanding of the multifaceted journey towards smarter sustainable cities.

The findings reveal that the initiatives for smarter sustainable cities should be guided by real-life problems and require interdisciplinarity and experimental methods. The key governance factors identified to achieve this aim include awareness of the current state, strategic planning, definition of assessment criteria, policy management, definition of flexible governance arrangements, stakeholder engagement, data governance, proper dissemination of initiatives, management of education and training, and the establishment of monitoring and assessment practices.

One of the main contributions of the doctoral thesis is the suggested smarter sustainable city governance cycle, which includes four stages: planning; development and implementation; adoption, monitoring, and assessment for continuous improvement; and capacity development. This governance cycle supports the development and implementation of initiatives, strengthening governance capacity to

ensure the long-term impacts of the city's initiatives towards smarter sustainable cities. Moreover, according to the findings of the thesis, the necessary capacities to be developed for evolving governance practices include those related to project management for planning, defining priorities and strategies, in addition to innovation and collaboration capabilities, and data-related capacities.

Overall, this thesis offers a comprehensive exploration of factors influencing the development of smarter sustainable cities and the complex interplay of its factors. It provides insights into evolving governance practices and capacity development. By suggesting mechanisms to address challenges and proposing actionable guidelines, this doctoral thesis contributes to the ongoing dialogue on the development of smarter sustainable cities in both science and practice.

# Lühikokkuvõte

## Teel targemate jätkusuutlike linnade poole: arenevate valitsemisstruktuuride suutlikkuse kasvatamine

See doktoritöö käsitleb targemate jätkusuutlike linnade arendamist, mis hõlmab uuenduslike lähenemisviiside rakendamist linnaprobleemidele, edendades samal ajal jätkusuutlikkust. Tingimustes, kus linnastumine ülemaailmselt üha kasvab ning seisame silmitsi keerukate väljakutsega, mis vajavad kiireid lahendusi, tuleb iseäranis esile targemate jätkusuutlike linnakeskkondade olulisus. Vaatamata võimalikele kasudele on targemate jätkusuutlike linnade arendamiseks vaja paindlikke valitsemismeetmeid, et tõhusalt ära kasutada tehnoloogilisi edusamme ja koostööstrateegiaid. Paraku on väljakutseks vajalike võimekuste puudumine kohalikes omavalitsustes. Seetõttu on vajalik uurida mehhanisme, mis võiksid tugevdada valitsemissuutlikkust targemate jätkusuutlike linnade arendamisel. Sellest tulenevalt on lõputöö eesmärk uurida valitsemisvahendeid ja -strateegiaid, mis võiksid seda eesmärki toetada. Selle teema käsitlemiseks esitatakse doktoritöös kolm peamist uurimisküsimust.

1. Kuidas võib süstemaatiline ülevaade targemaid linnu käsitlevatest teadustöödest ja innovatsioonist panustada targa jätkusuutliku linna kontseptsiooni?
2. Millised on peamised tõukejõud ja takistused ning peamised juhtimistingimused, mis mõjutavad targemate jätkusuutlike linnade arendamist?
3. Milliseid strateegiaid saab kasutada targemate jätkusuutlike linnade kohaliku valitsemissuutlikkuse arendamisel?

Nende küsimuste lahendamiseks toetuti selles doktoritöös kaheksale publikatsioonile, mis käsitlesid targemate jätkusuutlikumate linnade arendamist erinevate lähenemisviiside kaudu. Doktoritöös vaadeldi nutika linnaga seotud uuringute ja innovatsiooni multidistsiplinaarset olemust, pakuti välja nutika jätkusuutliku linna kontseptuaalne raamistik, käsitleti nutika jätkusuutliku linna arendamisega seotud tõukejõude ja takistusi, esitleti tegevuskava nutika jätkusuutliku linna arendamiseks, uuriti ühte juhtumit mittehädaabiteenuste kanali kui nutika linna algatuse kohta ja viidi läbi sarnaste algatuste võrdlev juhtumiuuring. Lisaks analüüsiti selles töös mitmeid omavalitsuste tegevuskeskuste juhtumiuuringuid ja käsitleti ühte omavalitsuste suutlikkuse arendamise algatust. Võttes need erinevad vaatenurgad kokku on doktoritöö eesmärk luua terviklik arusaam mitmekülgsest teekonnast targemate jätkusuutlike linnade suunas.

Tulemused näitavad, et targemate jätkusuutlike linnade algatused peaksid lähtuma tegelikust elust tulenevatest probleemidest ning toetuma interdistsiplinaarsetele ja eksperimentaalsetele meetoditele. Selle eesmärgi saavutamiseks tuvastati järgmised peamised juhtimisega seotud tegurid: teadlikkus hetkeseisust, strateegiline planeerimine, hindamiskriteeriumite määratlemine, poliitika juhtimine, juhtimiskorralduse määratlemine, sidusrühmade kaasamine, andmete haldamine, algatuste nõuetekohane levitamine, hariduse ja koolitustegevuse juhtimine ning järelevalve- ja hindamispraktikate kehtestamine.

Doktoritöö üks peamisi panuseid on nutikama jätkusuutliku linnajuhtimise tsükli väljatöötamine, mis sisaldab nelja etappi: planeerimine; väljatöötamine ja rakendamine; vastuvõtmine, jälgimine ja hindamine pideva täiustamise eesmärgil; suutlikkuse arendamine. Selline juhtimistsükkel toetab algatuste väljatöötamist ja elluviimist, tugevdades juhtimissuutlikkust, et tagada linnapoolsete algatuste pikaajaline mõju targemate jätkusuutlike linnade arendamisel.

Kokkuvõttes annab see doktoritöö põhjaliku ülevaate targemate jätkusuutlike linnade arengut mõjutavatest teguritest ja nende tegurite keerukast koosmõjust. Töös vaadeldakse arenevaid juhtimistavasid ja suutlikkuse arendamisest. Soovitades mehhanisme väljakutsete lahendamiseks ja pakkudes välja rakendatavaid suuniseid, aitab see doktoritöö kaasa käimasolevale dialoogile targemate jätkusuutlikumate linnade arendamiseks nii teaduses kui ka praktikas.

# Appendix – Publications

**Publication I**

Soe, R. M., **Schuch de Azambuja, L**., Toiskallio, K., Nieminen, M., & Batty, M. (2022). Institutionalising smart city research and innovation: from fuzzy definitions to real-life experiments. *Urban Research & Practice*, *15*(1), 112–154. https://doi.org/10.1080/17535069.2021.1998592 ETIS 1.1.

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# Institutionalising smart city research and innovation: from fuzzy definitions to real-life experiments

Ralf-Martin Soe, Luiza Schuch de Azambuja, Kalle Toiskallio, Marko Nieminen & Michael Batty

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# Institutionalising smart city research and innovation: from fuzzy definitions to real-life experiments

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**ABSTRACT**

By exploring and defining characteristics of a smart city research and innovation centre, we contribute to the discussion on smart city development capacity. To do so, using a qualitative method, we review definitions of the concept and map international groups and institutes affiliated with this domain. Our main result is an overview of global research centres dealing with smart cities. One of the key implications of this paper is that instead of a strict definition, the important aspect appears in the framing provided by the complex real-life challenges that require and enable cross-disciplinary research, even though the concept keeps evolving.

**KEYWORDS**

smart city; centres of excellence; urban research and innovation; multidisciplinary; experiments

## 1. Introduction

Smart city (SC), a constantly evolving thematic domain, appears as an umbrella term that hosts multidisciplinary research on specific domains such as mobility, energy, built environment, data, and governance. As the term implies, the essence of the theme lays in real-life phenomena and artefacts in the actively changing life surroundings for a constantly increasing number of people all over the world. Cities, as such, consist of vast amount of people and human interaction, technologies that enable constantly advancing abilities for people to perform in improved ways, as well as practices and processes for groups and communities to collaborate and coordinate mutually important activities. Conceptually, and in more precise terms, Batty et al. (2012) have described the theme addressing 'constellations of instruments across many scales that are connected through multiple networks which provide continuous data regarding the movements of people and materials in terms of the flow of decisions about the physical and social form of the city'. A more general formulation is that most smart cities' research is about how digital processes can inform physical processes or are substituting for these (Batty 2020). One may argue that the concept encapsulates a huge variety of issues to consider extending towards being fuzzy and fluid.

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At the same time as the SC concept requires constant elaboration, it offers multiple opportunities and a conceptual umbrella for researchers and innovators to connect their ideation and development efforts. This research is interested in this from different viewpoints: geographical (east–west, culturally grounded approaches), time (how has it evolved, future research), science of cities (multidisciplinarily, wicked problems, surprising researcher combinations for new innovative ideas), and lively multistakeholder–research–innovation–nexus (city–industry–academia) collaboration.

The main research question is interested in understanding the operational part of smart city research, that is, which are the actual research groups globally dealing with the concept and what are their disciplinary focus areas. The academic literature so far has focused too much on defining smart city as a phenomenon, resulting in quite a fuzzy outcome without any robust consensus on the concept. On the other hand, the literature lacks a systematic overview of who are the actual smart city research actors. Understanding these actors can help to reason the smart city as a concept and therefore contribute to the smart city literature. That is, smart city research can be conceptualised by understanding what smart city researchers actually do. As a sub research question, this paper addresses the general definition of a smart city: What is the concept and definition of a smart city? We acknowledge that such an overarching question is a broad and bold endeavour, particularly as our interest goes beyond keyword-specific research based on papers that label themselves under the domain of smart cities.

The aim of this study is to review the smart city as an evolving and broadening theme and map it with smart city-related research groups in different urban data and technologies centres globally. There are different approaches to smart and sustainable cities in different regions ranging from planned cities in Asia to co-creative ones in Europe. This paper identifies conceptual and operational characteristics for a smart city centre with combined international and regional impact. To do so, first, we perform a literature review of smart city as a keyword domain; second, we map this with established academic centres that work on SC. Thus, one contribution of the paper is an updated list of smart city research groups globally, including identification of respective themes and approaches (i.e. overview of academic centres and research groups). Furthermore, this paper provides an overview of what kind of research relates to smart city research, independent from the thematic label, and introduces a research and innovation agenda for a novel smart city centre. The practical aim of the paper is to use the learnings in the forming of a recently founded smart city centre of excellence with a significant grant funding from the European Union, not to mention the considerations of the future orientation of the centre.

The rest of this paper is structured as follows. The next section presents a review of the relevant literature on smart cities, bringing some definitions, approaches, and models. Afterwards, how this study was performed is explained. The results section shows the centres dealing with smart city-related themes. Furthermore, the in-depth case study of the FinEst Centre for Smart Cities, a rather recently established centre, is presented. The last section brings theoretical and practical implications and final considerations.

## 2. Literature review: smart city concept and its models

Since the origin of the explicit smart city literature, several conceptions of smart city have emerged, varying according to the main 'smart' characteristics (Caragliu and Del Bo 2020). A smart city strategy involves application of technology in order to

- improve environmental quality in urban space, reducing $CO_2$ emissions, traffic, and waste;
- optimise energy consumption, by building efficiency and renewable energy production; and
- increase quality of life, delivering better public and private services, such as local public transport, health services, and so on (Dameri and Cocchia 2013).

From that perspective it is no wonder that a strong critique of this technology-centric vision emerged with the publication by Hollands (2008) 'Will the real smart city please stand up?'. The heavily business-driven and deterministic approach to city making was also refuted by several other academics (Neirotti et al. 2014; Söderström, Paasche, and Klauser 2014).

The first smart city definitions were focused on the technology perspective. Technology can be seen as an enabling force for the development of new forms of intelligence and collaboration to advance the problem-solving aptitude of the city (Angelidou et al., 2018). However, recent definitions are no longer limited to information and communication technology (ICT) diffusion, being shifted more towards people and community needs (Albino, Berardi, and Dangelico 2015). Table 1 shows smart city definitions from highly cited references from different years, based on a keyword search ('smart cit*') on Web of Science and Scopus. In addition, it coupled with the back and forward method (Webster and Watson 2002) to select other relevant literature.

As seen in the examples in Table 1, a new league of smart city definitions has surfaced over the last decade (c. 2010–2020) with an emphasis on creativity, human capital, education and learning, social inclusion, and governance. In addition, it highlights the need of multiple actors and partnerships for innovation (Ferraris, Santoro, and Pellicelli 2020). With the diversification of the underlying foundations of the smart city concept, the meaning of the label itself has become fuzzy and is used in ways that are inconsistent (Praharaj and Han 2019). Likewise, there are different approaches related to the smart cities discourse (Komninos and Mora 2018). For instance, on one hand, the technology-driven approach indicates that the deployment of digital technology improves the quality of life, whereas on the other hand the human-driven approach endorses the key role of human capital and citizen skills (Kummitha and Crutzen 2017). Moreover, the planning of a smart city initiative can be top-down or bottom-up (Komninos and Mora 2018). This could be simplified by organising the definitions in Table 1 based on their emphasis on top-down (Top-down) or bottom-up (Bot-up) approaches, and technology (Tech) vs. human emphasis (Hum) – keeping in mind that human emphasis means here a mere notion of human capital or citizen skills (Komninos and Mora 2018). It can be seen that a technology-oriented bottom-up approach is missing or at least weaker than the other three. This observation has

**Table 1.** Smart city definitions and approaches.

| Smart city definition | Reference | Approach | | | |
|---|---|---|---|---|---|
| | | Top-down + Tech | Top-down + Hum | Bot-up + Tech | Bot-up + Hum |
| The vision of 'Smart Cities' is the urban centre of the future, made safe, secure environmentally green, and efficient because all structures – whether for power, water, transportation, etc., are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerised systems comprised of databases, tracking, and decision-making algorithms. | (Hall et al. 2000, 1) | x | | | |
| A smart city is a city well performing in a forward-looking way in these six characteristics [economy, people, governance, mobility, environment, and living], built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens. | (Giffinger et al. 2007, 11) | | | | x |
| A city to be 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. | (Caragliu, Del Bo, and Nijkamp 2011) | | | | x |
| A city in which ICT is merged with traditional infrastructures, coordinated and integrated using new digital technologies. | (M. Batty et al. 2012) | x | | | |
| A smart city is defined with the meaning of smartness penetrating the urban context, the role of technologies in making a city smarter, and focal domain (infrastructures and services) that need to be smarter. | (Nam and Pardo 2014, p. S2) | x | | | |
| As a concept, SC is described in various ways, but a general definition involves the implementation and deployment of information and communication technology (ICT) infrastructures to support social and urban growth through improving the economy, citizens' involvement and government efficiency. | (Yeh 2017, 556) | | x | | |
| Smart cities stand for an idea of where the city wants to be in the future and how it imagines itself transformed by taking advantage of the capabilities of digital technology and innovation networks. | (Angelidou et al., 2018) | x | | | |
| A smart city not only includes the application of ICT in its infrastructure but also has the capacity to integrate people, information, and technology in building an efficient, sustainable, and resilient infrastructure that provides high-quality services and promotes the quality of life of its residents. | (Wu and Chen 2019, 2) | | x | | |

something to do with the general requirement of *people first* in smart city discussions that started around 2005.

There is also a strong consensus of the fact that smart city discussion is very scattered and the work of defining and conceptualising it is still in progress (Albino, Berardi, and Dangelico 2015; Cocchia and Dameri 2016; Dameri and Cocchia 2013; Fernandez-Anez 2016; Mora, Bolici, and Deakin 2017; Ojo, Dzhusupova, and Curry 2016). There is a plethora of very different academic formulations of the smart city concept. Actually, the style of those formulations could be called more description than definition.

The language game of smart city (Praharaj and Han 2019), or to be more precise, *labelling* games and fuzziness of the definitions, can also be interpreted to arise partly from the belief that technical solutions would be all we need to mitigate urban problems

in a smart city. However, when the later smart city discussions have enlarged from technical niches to fields such as social capital, everyday-life and governance, settings to be solved and needed toolboxes have of course become more complicated.

Instead of trying to formulate one more definition of the concept of smart city, the discomfort could be alleviated by the statement of Giffinger and Lü (2015, 12) that actually all corresponding strategic discussions and efforts are more or less focusing on three core dimensions, introduced by Nam and Pardo (2011):

(1) *Technology* and its mediated services making infrastructure more efficient;
(2) *People* in the context of social learning for strengthening human infrastructure and collective decision-making;
(3) *Institutions* in the modified context of governance for institutional improvements and the citizens' engagement.

To put it even more concise, ' . . . the concept of "Smart City" is evolving as a specific approach to mitigate and remedy current urban problems between urban competitiveness and sustainability' (Giffinger and Lü 2015).

When shifting from conceptualisation challenges to academic spread, Mora, Bolici, and Deakin (2017) have collected bibliographical statistics from over 1000 English publications and so-called grey literature, published 1992–2012 and having words *smart city* or *smart cities* in title, abstract, or in a keyword list. They also calculated the shares of citations the collected publications got during the period. Until 2002 writings done by American universities – typically in collaboration with corporates and consultant companies, especially IBM and Forrester Research, ruled the statistics of publications – and citations (IBM got 9% of total amount of citations). The subjects of their writings were dominated by technical solutions with rather narrow scope. Also, publications or citations from Asia, mostly Japan (Hitachi) and India (Tata group), were rather corporate-driven, although being not very influential among smart city literature (0.82% of total amount of citations). From 2002 onwards, especially from 2008 to 2010 on, European universities and more holistic scopes of smart cities really took off. Their study showed Europe as the main contributor to the smart city research as 52% of source documents were produced by organisations located in Europe and they had the greatest impact; then North America also had a great contribution (16.6% of production and 24.4 of citations), whereas Asia had a good contribution (23.3%) but smaller (10.3%) impact (Mora, Bolici, and Deakin 2017).

The amount of the academic European activity, from the end of the first decade of the twenty-first century, also made the whole smart city discussion to grow more than 10 times bigger than it was a couple of decades earlier. Respectively, the amount of smart city researchers grew during the same period from less than 200 people to a community ten times larger (Mora, Bolici, and Deakin 2017). The community is probably even bigger than that, since the environmental reasons. Around 2010, there was a rise in popularity of the smart city concept (or its near equivalents) also as a top-level political initiative. During 2009, in addition to smart cities, the need to build the actual ecologically healthy cities (Eco-Cities) got general top-level political awareness in France and in the UK. Even more effective eco-city projects started in Abu Dhabi and in China (Joss 2010). Consequently, since 2010 the European Union has used 'smart' to

qualify sustainability projects and actions in the urban space (Dameri and Cocchia 2013), as for example, the programme *Smart Cities and Communities* from 2012. This has enormously expanded the usage of 'smart' among the academics and the urban developers who use European English as their professional language.

## 2.1 *Two smart city models*

The fuzziness between how smart city is defined in the literature versus what researchers are doing has a mutual share of two models: 'planned tech-oriented cities' versus 'improving the existing ones'. Whichever way the smart city concept is understood and implemented in different parts of the globe, it is always heavily connected to local political, cultural, and living condition, as is noted in the following two main models.

### 2.1.1 *Model 1: planned pop-up techno-cities*

While the idea of a city is rather mature in the US and European Union, there are not many opportunities for total technology-driven cities (techno-cities) in the Western countries. An enforcing exception to the rule is PlanIT valley that was about to be built in Portugal during the early 2010s but ceased because of funding problems. The most recent cases also show that the privatisation of cities is happening in very focused topics and in very small-scale pilots, for example, Volkswagen electrifying the transport modes of the little Greek Island, Astypalean.[1]

Due to global urbanization, a demand for creating smart cities has emerged, including in populated countries like India and China. The volume of people moving to cities is huge, and urban administrations cannot handle all social and infrastructural problems arising from this, partly semi-legal, intra-national migrancy. Furthermore, the rapid economic growth in China has caused environmental disasters, hence the term eco-city instead of smart city. The national solution for these problems has been to give cities greater independence from the national government (Caprotti and Romanowicz 2013).

Globally, it seems that Asian (and Arabian) countries are using a variety of smart city concepts as an accelerated possibility to modernise their cities. In practice that means how to cope with very rapid urbanisation, environmental and especially urban air and water quality problems. The implementation of these aims is heading quite precisely towards the way the existing Western cities are organised. These kinds of 'pop-up techno-cities' are not just trying to reach European basic-level conditions, they are also utilising Western urban planning ideologies such as modernism and even futurism, more precisely, Howardian Garden city, Le Corbusian/Futuristic and modernist techno-city, panoptic control rooms, and city dashboards. Conceptually, they are combinations of futuristic technocratic solutions and mid-twentieth-century idea of a city that all functionalities can be planned. It is no wonder that the general *ideals and models* of pop-up techno-cities in Asia and Arabia are rooted in Western urban ideals since typically the Western companies and even public administrations are strongly involved in those projects. Although some of the most challenging projects have failed because of high-level political and funding issues, many of them really are finalising – probably faster than any Western infrastructural large-scale project. However, the amount of people and companies is lagging far behind from the originally planned

figures. For example, the national flagship development Tianjin has – 10 years after the beginning of the project – a gross 100,000 residents, although the plan was 350,000. More successful case, technically, was South Korean Songdo, located near Incheon airport and 60 km from the capital city Seoul. From the European perspective, the above-described model of a smart city raises several questions. First, what is actually a city? Can it be simply the physical buildings, streets, and other technical infrastructure? Furthermore, a smaller version of the Asian pop-up techno-cities, Masdar city in the United Arab Emirates, near Abu Dhabi, already has urban structure, sun and wind power heavily utilised in air conditioning and electricity systems, and in the electric bus system, etc. However, the number of residents and companies is lagging heavily behind the planned figures – some thousand residents combined, only.

One bundle of reasons is the strong emphasis on supply-based technology and city-level efficiency, instead of the actual liveability and sociability among human beings. Tianjin was built on formerly toxic wasteland – not a very enticing fact for those who can choose where to live. More concretely, the newly constructed residential buildings in these – supposedly – apolitical eco-cities are so expensive that only upper-middle-class people can afford them. That is quite challenging in countries with high percentage of poor, some amount of elite, but very thin middle classes.

### 2.1.2 *Model 2: improving the smartness and governance of existing cities*

When demographical, cultural, and social issues are not solved, but their types and volumes are more or less matured, there is also a smart city concept related to those conditions. Smartness is only added and developed to existing infrastructural and social structure. This kind of exchange happens between Europe and Northern America. The concept of smart city can be seen boosted by the American academics' admiration of the European type of urban planning that takes the development of existing – European – cities and their social structure as a starting point.

The development process is typically such that public authorities of a city, perhaps supported by some national resources, are enabling, encouraging, or even procuring new services or functions to be created by private sector. Instead of providing covering public funding, the public resources are used to reformulate regulations, technical platforms, data hubs, Research & Innovation (R&I) programmes, or a combination of those. Thus, existing cities are only improved by the new, say, ICT services and governance practices.

The most important urban subsystems in the European smart city discussions, and, rankings, have been sustainability in energy and carbon savings, and especially in the transport system, for example, innovations in public transport, or in car-sharing and bicycling. This ranking interest is actually an important activity in European and North American smart city discussions. It promotes the cities, that is, shows that these cities are worth investments, in other words willing to have new jobs, new taxpayers, and new tourists. However, on a more abstract level we could also say that the phenomenon of these lists is a way of pondering the real, or at least most successful concept of the smart city.

According to Manville et al. (2014) who surveyed all European cities having population more than 100,000, virtually all Nordic Member State cities can be characterised as smart cities, as can most cities in Italy, Austria and the Netherlands, and approximately

half of British, Spanish and French cities. Germany and Poland have relatively few smart cities. Eastern European countries generally have a lower incidence of smart cities than the rest of EU-28' (Manville et al. 2014, 38). National or international smart city initiatives, having typically some kind of an environmental angle, are heavily funded by the European Commission (Manville et al. 2014).

In Europe, also big IT companies, such as IBM, Cisco, and Siemens, offer their remarkable legacy, resources, and practical products for the public planning, to an extent even *pro bono* in early phase planning. However, in Europe there are planning traditions and laws demanding local people to be invited into the societal, or local, discussions, especially so in the Nordic countries. A growing topic in European smart city discussions is the inclusion of citizens. One emerging example of that is the way personal data is supposed to be handled in the West. Compared to Asia this really makes a difference, having a dramatically different idea of individual rights and personal data. However, European democracy makes the decision-making process much slower than in Asia or Arabian countries. We can safely assume that it is precisely this cultural difference that pushes Western companies to offer their planning and implementation services for grateful governments in Asia, India, and Arabian countries.

## 3. Understanding smart cities through the lenses of research

Previous projects have shown that some public governments lack capacities to accelerate development of smart cities (Ardito et al. 2019; Ferraris, Santoro, and Pellicelli 2020), and for this to happen, it is important to involve different stakeholders. As a part of the 2010s' social and human intervention to formerly very techno-oriented smart city discussions, management studies and multistakeholder approach are offering a perspective that is relevant when positioning academic units related to the concept.

The concept of triple helix (e.g. Etzkowitz and Leydesdorff 1997) emphasises the collaboration between state, company, and university. Especially thinking of tech-oriented smart city projects, usually the initiative is 'driven and guided by public governments or Multinational Enterprises (MNEs), while the coordination is often multistakeholder driven and followed by university team's engagement' (Ferraris, Belyaeva, and Bresciani 2020, 165).

According to Ferraris, Belyaeva, and Bresciani (2020), the recent trend of smart innovation should be seen also from the multistakeholder dimension. It is important to understand the 'cause and consequence of stakeholder relationships and interactions in a network, as a stakeholders' causal scope' (Shams 2016, 676) to be able to generate sustainable innovations (Ferraris, Belyaeva, and Bresciani 2020). Thus, university can play an enhanced role in innovation in smart cities and in increasingly knowledge-based societies, acting not only as technology and knowledge transfer favouring the economic development but also operating as an intermediary and facilitator between the other components of the ecosystem in multi- and interdisciplinary ways (Del Giudice, Carayannis, and Maggioni 2017).

Since it is hard to capture the volume and certain vagueness of academic research on smart cities, and the actual implications in cities, one way to understand the smart city movement is to look at the most important sources of smart city research, the research groups, and centres around the world. Using a qualitative method based on expert

analysis of secondary data, first we mapped global research groups that work within the research domain of smart cities and identified the main academic centres dealing with urban informatics, smart cities, big data, and related fields. Since we are interested in more consolidated research units, we involved centres that have been in place over 5 years with minimum amount of around half-dozen researchers involved. The initial list of the centres derived from a report to the UK Economic and Social Research Council Cities Expert Group (Batty 2013), slightly updated by Townsend (2015). In our approach, we mapped and introduced these research groups, focusing on the ones that were active as of May 2021. Thus, this part of our study is based on the authors' internal evaluation with involvement of a global key expert in this field (Michael Batty from UCL-CASA) and detailed analysis of secondary data such as web pages.

The second part is an in-depth case study of the FinEst Centre for Smart Cities, a rather recently established centre that has been selected as it has a substantial research agenda and is one of the rare ones which is actually labelled as a smart city research centre. In this part, we studied the research and innovation agenda of this centre. In total, more than 40% smart city publications (out of a pool of over 100) were analysed with an overview of how large-scale research-based smart city pilots are planned and implemented. The aim of the FinEst Centre is to initiate long-term smart city research and innovation activities in collaboration with technology universities in Estonia and Finland, Estonian Ministry of Economic Affairs and Communications and Forum Virium Helsinki. The FinEst Centre is organised around five streams – Smart Mobility, Smart Energy, and the Built Environment – tied together by streams of Urban Analytics and Data, and Smart City Governance (Soe 2017). The FinEst Centre was initiated in December 2019 when it received 32 million euros 8-year start-up grant from the European Commission and Estonian Government to set up an independent smart city research and innovation centre.

## 4. Results: centres dealing with smart city-related themes

The first part of this section introduces and discusses the mapping of smart city-related centres. The second part is devoted to the in-depth case study of the FinEst Centre for Smart Cities.

### 4.1 *Overview of centres dealing with smart city-related themes*

By 2010, a small number of smart cities centres (in need of a better term) had been established to pursue an agenda related, first and foremost, to big data, real-time sensing, new forms of automation, as well as informing much of the science that had been developed for cities so far. As an example, the Centre for Advanced Spatial Analysis (CASA) has slowly moved towards this area as it began as a GIS centre, set up in UCL in 1995, as a group that could research geographic information systems and spatial analysis, but always with a strong city focus, their vision is to play a central role in the approach they call *science of cities*. CASA is less geared to computer science and more to urban applications. In contrast, the Senseable Cities Lab was set up in 2004 in the Department of Urban Studies and Planning (DUSP) at MIT, and its focus has been on networks and big data pertaining to streets and transport systems as well as

extending into a variety of simulations of mobility. The Media Lab, also at MIT, has to some extent been at the forefront of smart cities research since it was founded, in 1985, with several groups dealing with cities in terms of media, energy, visualisation, and design.

In 2005 and 2006, two other significant centres were founded, showing the range of interest in smart cities at this point: the Urban Scaling group at the Santa Fe Institute (SFI) and the Urban Informatics research lab at the Queensland University of Technology (QUT). The Santa Fe Institute, which was founded in 1984 as the first research institute dedicated to the study of complex adaptive systems, created in 2005 the *Cities, Scaling and Sustainability* research group with an interdisciplinary approach and quantitative synthesis of organisational and dynamical aspects of human social organisations, with an emphasis on cities. The work at Santa Fe continues, and there are strong links there to several areas of the social and policy sciences that take complexity theory and apply it to urban questions. While the QUT Urban Informatics group was created in 2006 and is more involved in the study, design, and practice of urban experiences across different urban contexts.

Since roughly 2010, the focus on smart cities has emerged; once smartphones became the dominant way in which individuals began to capture and manipulate their personal data, many centres have been set up to progress research on the types we have alluded to in the above discussion. Chief amongst the centres in terms of size are those in Chicago and in New York. The Urban Center for Computation and Data (Urban CCD), created in 2012 in Chicago, came from computer science and is strongly concerned with big data, sensing, and the development of projects involved in real-time streaming. Recently the urban science initiative at the University of Chicago, which is based on the Mansueto Institute for Urban Innovation, has joined Urban CCD while the Center for Spatial Data Science is also linked. Thus, the centre has also been getting involved in wider urban science issues. This seems to be a feature of all the centres. Although they may begin in one area, they tend to expand their focus, or at least be sympathetic to other disciplinary domains. This is important to provide a good context to smart city research and many centres appear to recognise it.

In fact, we can date the genesis of what we are calling here smart cities research centres with the Bloomberg Challenge which was set up in 2010–2011 to attract science centres to New York City, two of which subsequently became smart cities foci, namely the Center for Urban Science and Progress (CUSP) in NYU which begun in 2012, and Cornell Tech, which took longer to become established and opened in 2017. CUSP has also been limited by the fact that in NYU there are other programmes, in particular the Wagner School of Public Policy and at the Marron Institute which is much more focussed on the growth of cities. On the other hand, CUSP has also clones in England at Kings College and Warwick University.

There are three other groups that are significant in size. In the UK, there is the Urban Big Data Centre in the University of Glasgow (UBDC), jointly funded by the Economic and Social Research Council (ESRC) in 2014. UBDC is based at the University of Glasgow, but the centre has associates at University of Illinois at Chicago, University of Bristol, University of Edinburgh, University of Reading, University of Sheffield, and University of Cambridge. Their focus is primarily on assembling and integrating big data that pertains to cities, but there are a variety of projects involving urban science,

transportation, and the wider issues of privacy in data for smart cities. UBDC's key research strands are urban impacts of COVID-19; education and skills; housing and neighbourhoods; transport and infrastructure; and urban governance. In the University of Edinburgh, the Edinburgh Futures Institute is based more on digital humanities than on digital cities, but there are several important themes that relate to innovative uses of computers in cities.

There are a few significant centres funded from scratch which focus on urban science, the governance of smart cities, questions of big data, and issues such as mobility. The National University of Ireland's Programmable City Group at Maynooth has perhaps the strongest links from smart cities technologies to urban social and spatial structure and how this map into governance. This is a centre set up from scratch with European Research Council funding, and it runs alongside the National Centre for Geocomputation at Maynooth. Nevertheless, the groups are working with the City of Dublin on various technical problems involving dashboards and control systems.

A centre founded in 2015 is the Imperial College's Urban Systems Lab (USL) which has grown out of various initiatives devoted to urban transportation planning and energy studies. This centre has eight thematic research areas including low carbon operation and resource efficiency; resilience and adaptability; systemic quality of service; sensing, simulation, and modelling; economic performance; advanced materials and processes; health, well-being and quality of life; and business models and innovation. Another one is the ETH Zurich Future Cities Lab located at the National University of Singapore (note that the Senseable Cities also have a presence in the same location as part of the SMART Programme). The ETH Future Cities Lab has moved into a new phase (Future Cities II) with more emphasis on building, energy, sustainability, and regeneration with more focus on mobility.

Noting other initiatives in academia that not only cover smart cities but extend to spatial analysis, modelling, and other features of urban research, in Australia, there are two significant initiatives besides the previously mentioned QUT Group. These are at the University of New South Wales (UNSW) City Futures Research Centre, created in 2005, and there is the longer-standing group at the University of Wollongong, the SMART Infrastructure Facility, which brings together experts from fields such as rail, infrastructure systems, transport, water, energy, economics, modelling, and simulation, providing 30 state-of-the-art laboratories to facilitate this important research.

In continental Europe, several groups have emerged a little more slowly than those in the Anglo-American countries. In particular, the effort begun in Amsterdam in 2015. The AMS Amsterdam Institute for Advanced Metropolitan Solutions was cloned from and is linked to the Senseable Cities Lab at MIT and has fairly similar projects involving mobility, autonomous vehicles, as well as being developed on a background of geospatial and building technologies. The centre involves a partnership with Universities of Delft, Wageningen, Amsterdam, and Eindhoven. Eindhoven and Delft have substantial presence in the built environment, digital governance, and transport areas. A related development is at the Open University of the Netherlands that seems to build on various regional science initiatives. In Switzerland at ETH and Lausanne, there are various groups.

In Spain, there are several new approaches to urban planning based on smart cities. The municipality of Barcelona is iconic in that not only is the city labelled as being smart – it also provides resources to research itself. There are also a set of groups in urban science, such as those in Palma de Majorca, and there are some groups in transport modelling. In Austria, there is the Institute of Spatial Planning in Vienna at TU Wien. In Italy, there are some groups in Rome, Bologna, Torino, Milano, and Brindisi. What this overview shows is that there is a vast array of groups who deal with cities and are sympathetic to smart cities technologies, big data, and modelling, but do not specifically see themselves as smart cities centres per se. Furthermore, several e-government research groups working in the cross-field between public administration and Computer Science research have entered the field of smart cities. For example, the United Nations University's Operation Unit on Policy-Driven Electronic Governance (UNU-EGOV) based in Guimarães, Portugal.

In Germany, there do not seem to be any distinctive centres as such because the focus on cities is more social and policy-driven and what effort there is on smart cities is related to tech and business models for automating cities. There is a large German effort in this area which is ongoing but does not seem to be linked to academia.[2] In France, there are some powerful urban science groups centred around the Cities group at the Sorbonne and Barthelemy's group at Institut de Physique Theorique (CEA) and Centre d'Analyse et de Mathematique Sociales (EHESS). In addition, UrbanAI group is in the vanguard of a dedicated initiative dealing with big data and AI.

In East Asia, there are a variety of initiatives in China and Japan, but these are harder to identify as they do not seem to be very focal centres. There are many initiatives and centres for smart cities research in China, and all the key universities have a presence. If we begin with Hong Kong, at the Chinese University there is the GIS centre which is university wide and ranges from remote sensing to transportation, while this is also an Institute for the Future Cities which draws together a range of technologies and applications wider than smart cities *per se* but include them. A new Smart Cities Institute has been formed during the last two years in the Hong Kong Polytechnic University with strong focus on big data, visualisation, urban informatics, and various kinds of sensing. In mainland China, there are almost too many smart cities initiatives to define, but the academic centres that stand out are the Beijing City Lab which is attached to Tsinghua University and the spatial mobility group in Peking University. In Japan, there is a country-wide GIS network which is based on the Centre for Spatial Information Science in the University of Tokyo, and this has been in existence since the late 1980s. This embraces urban informatics and well as GIS and now big data and various types of analytics. It is in fact quite strongly orientated towards urban planning and policy.

In North America, we have already mentioned research groups at NYU, and in Chicago, but there is a cluster of groups in Boston based on the strong focus there on media and networks. In addition, in New York, there is a presence of sorts at Columbia University centred around Urban Planning and Computer Science although these appear to be somewhat separate, and the urban lab has changed its focus to a Center for Spatial Research. The data science focus is within a programme dealing with big data, and it is badged as smart cities, but it is important to see the effort in perspective. There are other institutes in Columbia such as the Earth Institute which have significant

links to smart cities research, in particular, and cities research, more generally. The City University of New York has a transportation centre while the Geography Department at Hunter College in CUNY has a long-standing interest in GIS and urban modelling. In addition, there is a Smart Cities Smart Government Research – Practice Consortium as a part of the Center for Technology in Government (CTG) – University at Albany, State University of New York. There do not seem to be strong groups in Los Angeles, but there are various research centres such as that at Oak Ridge on Urban Dynamics that are beginning to populate the smart cities space. At Harvard too, there are several initiatives in cities, and it is worth noting that in the US there is extensive interest and research into the digital economy, its organisation, questions of data and copyright, and IPR all of which are key to thinking about the implications of data streaming and sensing in smart cities. There are many other initiatives in the US, but most of these are focussed on transportation centres that are quite well developed and in geospatial centres that are associated more directly with spatial analysis, spatial statistics, GIS, and quantitative geography, all loosely defined as geospatial analysis. In South America, there is interest from GIS and transportation groups, but so far we have not identified any major centres. Of course, this survey is very impressionistic and, in this sense, nowhere near complete. It merely provides a glance but not a definitive summary in any sense.

As we have argued throughout this paper, this is inevitably an incomplete snapshot in time with respect to the evolution of research centres involving smart cities. How a smart cities centre is developed depends on the local context, cognate areas in other departments, and of course funding. Very few centres have been set up directly, but those that have appear to have worked better than looser associations of already established interests. A more comprehensive table of academic centres and institutes dealing with smart cities-related themes is available in Appendix A, including the location of the centre, brief description, and website links. Some of them are more like research institutes, a few of them are labelled as centre of excellence.

We argue here that what is needed as a next step is a more detailed worldwide review of larger initiatives. Last but not least, we need to consider how the ideas might impact on the grand challenges noted above, in terms of the way climate change, ageing, inclusion, energy, housing, health, mobility, the future of work, and education and learning all impinge on the ways in which we can make our cities smart. These in themselves pose challenges that any new centre needs to address as it develops, especially how to make interconnections between different disciplines in facing these actual challenges of cities globally.

### 4.2 *A case of FinEst Centre for Smart Cities*

One of the core ideas of mapping other smart city centres globally in the previous section is to learn how to set up new ones. This is the case of FinEst Centre that has been established in December of 2019, enabling rather multi-topic academic activities combined with versatile innovation projects with cities, companies, and other stakeholders. The centre has been initiated under the substantial European Unions's strategic H2020 program's *Spreading Excellence and Widening Participation* call for *Teaming* projects. Thus, the FinEst Centre draws from knowledge transfer from the more

developed Finnish R&I culture to the rapidly developing Estonian R&I culture. As a joint effort, the FinEst Centre involves approximately 40 researchers from the two technology universities in Estonia and Finland.

The FinEst Centre has five academic domains (Governance, Data, Built Environment, Mobility, and Energy) that are covering the identified and timely smart city topics. Each domain (stream) involves researchers from two technology universities in Estonia and Finland, some working directly at the FinEst Centre whereas most of them being affiliated to the centre via affiliation structure.

#### 4.2.1 *Overview of FinEst Centre research performed*

Academic research and publishing is often done in siloed disciplines. However, within smart city studies, even paradigmatically different academic domains can find common ground and lots of explicit synergies through discipline-agnostic challenges from real-life surroundings. The FinEst Centre researchers have published over 100 publications during the first and half operative year. This indicates good opportunities for multi-disciplinary research. For instance, urban lightning is studied in the Built Environment stream (BE) as a source of urban light pollution. In Smart Governance (Gov), the lightning of public places in cities is a matter of public procurement. Furthermore, urban public lightning is also a technical platform for local WLAN connections, data, and electric power, which makes the public urban lightning not just a Smart Energy issue but also an Internet of Things (IoT) matter for the Urban Analytics & Data stream (Data). The potential content, paradigmatic orientation, and potential data types of those five domains are depicted in Table 2.

The IoT topics are handled in the published papers so far by Data from the perspectives of fault-tolerant frameworks, thinking especially of their security and resilience issues. One of the main concerns of the IoT-related studies is the interoperability and standards for different systems. Methodological focus has been in software engineering addressing agile software development methods in conjunction with Development-Operations (DevOps).

IoT is utilised in Mobility context as different communication relations between (physical and informative) infrastructure, vehicle, and (energy) grid. In the published papers, the studied relations are mostly that of Vehicle-to-Infrastructure, Vehicle-to-Grid, and Infrastructure-to-Infrastructure, not to mention human understandings of them. Data and IoT perspectives are central also in machine learning, in the papers related to self-driving vehicles – and the human understandings of the Self-driving Vehicles (e.g. Soe and Müür 2020).

Potential threats of Mobility-as-as Service (MaaS) concept are strongly Governance issues, in Mobility critics of MaaS, since this concept simply requires national laws, priorities of public authorities, and capitalistic business logics to be changed, to make it successful. Mobility is also referring to a democratic knowledge transfer when handling the relation of urban planning and transport issues. This public participation is in the strong interest of BE that has developed a data collection method called Public Participation Geographic Information System (PPGIS) to enable to collect systematically experiences of people in certain geographical spots and areas. BE studies not just humans (such as how social media is affecting urban planning) but also larger biodiversity.

**Table 2.** Main tasks and aims of the five research streams of the FinEst Centre.

| Stream | Smart City Governance | | |
|---|---|---|---|
| Expected to do | Study and develop holistic theories and models of urban governance, new data frames for the substance streams (Smart Mobility, Smart Energy, Built Environment) | | |
| Paradigmatic orientation | From narrow techno-orientation to broader holism | | |
| Potential sources and subjects of data | Theories/models of city-led innovations, sustainable transitions, citizen-government co-production, cross-border frameworks | | |
| **Stream** | **Smart Mobility** | **Smart Energy** | **Built Environment** |
| Expected to do | Domain-specific data production, based on substantial understanding of public policies, value networks and business models, etc., that would enable the actual data streams | | |
| Paradigmatic orientation | From modes of transport to urban mobility system(s) | From centralised energy supply to smart grids and local demand management | From human-oriented to life-oriented urban planning |
| Potential sources and subjects of data | *Humans in cars, transit, last mile, cross-border<br>*Cargo in different vehicles<br>*Self-driving vehicles in interactions with infrastructure, other vehicles, etc. | *District heating/cooling<br>*Energy flows in nearly Zero-Energy Buildings<br>*Local energy production<br>*Market prices | *Lightning and outdoor conditions<br>*Experienced quality of built environment<br>*Co-created scenarios<br>*Biodiversity and green infra<br>*Collaborative urban planning processes |
| **Stream** | **Urban Analytics & Data** | | |
| Expected to do | System of Systems (different stakeholders' systems can interchange data through standardised APIs so that both ends understands data similarly) | | |
| Paradigmatic orientation | Enabling working Internet of Things systems through standardisation, harmonisation, and realistic business models | | |
| Potential sources and subjects of data | Data harmonisation [semantic and syntactic interoperability, visualisations of data flows, APIs, widgets, security, authentication and billing function, new revelations of IoT functions and processes, and cross-border urban data platform (shared between Helsinki and Tallinn)] | | |

Energy papers are rather focused, but more broadly taken they can be divided into consumption and production of energy. Their main idea is to study (and support) new flexible and dispersed ways of energy production that would react smoothly to changing demand, instead of the traditional model of monolithic energy production that is all then consumed. The consumption side deals mostly with metering 'buildings', especially 'nearly zero emission buildings' heating, geothermal aspects, and ventilation. Production-side emphasis is in demand-based, smaller-scale, microgrid production. However, they also note that currently renewable energy sources still need nuclear power production as a levelling function.

Former and current research topics are of course the background of deep academic research also in smart city studies. However, in over 50 grant proposals FinEst Centre researchers have done during their first and half year, one can see several extensions. One extension is that of geographical. From the European smart city, the current smart city knowledge is planned to be transfered to Africa, rural European areas, or to Southeastern Asia. Another extension is topical, towards healthiness in cities. Third is mostly within the mobility, including the governance of urban airspace (drones), experience of urban tourists, climate change, last mile issues, and artificial intelligence. The last one is common also with Energy that proposes AI to be used also when studying digital twins. Climate change, energy consumption, and carbon neutrality are

also connected to master's degree education that would then concentrate on smart cities. Last but not least, digital resilience of smart cities is one new topic in the proposals.

### 4.2.2 *Urban challenge-based experiential pilots*

On one hand, efficient academic research is conducted within silos, as seen above where the five academic domains were organised into five respective research streams. On the other hand, these silos should be able to collaborate, especially when approaching practical problems of cities. An example of how the FinEst Centre is approaching the problems arising from cities is handled in Figure 1.

The FinEst Centre conducts a significant part of its research via large-scale experimental pilots, whereas a pilot is defined as the process of developing a new knowledge-based solution to an urban challenge. Pilots are focused on finding solutions in one of the streams or combining different streams. This approach goes beyond academic specialisations as pilots are exclusively urban challenges triggered based on the input received from local governments in Estonia. The aim of the large-scale pilots is to prototype research-based solutions especially for small- and medium-size cities around the world. The promotion of demonstration projects as pilots and living labs are recommended as a way to help reducing stakeholder issues concerning the implementation of innovative smart city projects (Ferraris, Santoro, and Pellicelli 2020).

The first phase of the realisation of the Experimental Piloting Programme was the mapping of the future urban challenges. For this, 35 Estonian local governments were surveyed and interviewed in the summer of 2020 with a goal to identify and rank top 10 urban challenges that the municipalities are facing in 5–10 years within the domains of the FinEst Centre. These 10 challenges were decided upon in a consensus meeting with local government representatives in fall 2020.[3] The second phase of the pilot realisation was an open call for R&I ideas to the challenges determined and selected in the first phase. In total, 71 ideas were submitted out of which four were selected as large-scale pilots[4] in December 2020. It is important that the pilots have to face broadly agreed-upon future challenges of local governments and the idea proposal process of pilots is fully


**Figure 1.** Smart city piloting programme phases.

open and participatory to everybody globally. The selected R&I pilots are coordinated by a joint team of researchers and cities with each pilot implemented in at least two cities. Thus, the cities serve as experimental testbeds for research and innovation ideas.

## 5. Theoretical, practical implications, and final considerations

In this analytic review of existing smart city research, a mismatch between conceptualisation of smart city and actual smart city research is pointed out. Our literature review shows that there is no rigid research domain as 'smart city', there is only a broad discussion on how smart city could be defined without any clear consensus on that. The definition of smart city ranges from smart city seen as software-driven (e.g. Washburn and Sindhu For 2010), people-and-community needs driven (Albino, Berardi, and Dangelico 2015), to very broad integrative frameworks combining a variety of domains like economy, people, governance, mobility, environment, and living (e.g. Giffinger 2007). More recently, a concept has developed a wider idea, involving also climate-related goals (Caragliu and Del Bo 2020). Everything combined makes smart city now a multi-interdisciplinary concept involving close to everything related to city environment, from spatial technologies (e.g. GPS) and agriculture (vegetable-friendly cities).

A different picture can be drawn when analysing what kind of research smart city-related centres actually do (even when neglecting what kind of actual implications cities have: geographical and cultural, not to mention political issues lead to hugely different solutions in Western vs. Asian-Arabian cities). Thus, if it is difficult to define smart city research via concept itself, it can be achieved via analysing the research groups and centres labelled under the domain of smart cities. When grouping the centres in the fields of urban informatics, smart cities, big data, and related urban science, only half-dozen centres are focused on smart cities by their name. All other examples mapped, over 50 centres, do not pop up when using the keyword of smart city, although they make a significant contribution to the field. For example, the UCL-CASA that began as a GIS centre and was set up in 1995 as a group that focuses on geographic information systems and spatial analysis has a strong smart city focus. Similarly, the Senseable Cities Lab at MIT, the Urban Scaling group at the Santa Fe Institute, and the Urban Informatics research lab at the Queensland Institute of Technology clearly contribute to the field of smart cities research. Interestingly, few established centres have future cities in their name instead of using 'smart' (Future Cities Lab University of Strathclyde; Future Cities Lab: ETH Zurich Singapore Centre; Institute for Future Cities CUHK). Thus, smart city studies are not yet institutionalised, although they certainly form a movement, as Batty puts it (Batty 2020). In practice, according to a few follow-up meetings to this research project with selected smart city research units, research groups contributing smart city discussions only seldomly study smart city topics as their full-time job.

When zooming into one smart-city focused recently set up centre as a case study (FinEst Centre), we indicated that the centre conducts basic research and pilots that are usually not labelled under the smart city directly, at least not using the keywords. Our analysis of approximately 40 research papers claimed to be in the field of smart cities, indicating that these are mainly contributing to the smart city-relevant fields, such as transport, ICT, public administration, civil engineering, robotics, architecture,

environment, energy, etc. Similarly, none of the selected smart city large-scale research-based pilot ideas have smart city in their name. In many cases, the only smart city label comes from the affiliation, not by title nor abstract nor content. Interestingly, in the case of innovation-closer activities, performed via experimental smart city pilots, the research disciplines are in continuous mix. The FinEst Centre addresses its large-scale smart city pilots to the actual challenges of local governments that often are not interdisciplinary. In research and innovation centres, it is important to enable fruitful collaboration between rather steady academic discipline-silos and more rapidly changing urban challenges.

However, as the case of FinEst Centre shows, the research-driven university unit can also be the actual driver in smart city projects. In the context of triple helix model, it can initiate and provide projects that invite (even by making them to compete with each other) cities, companies, and people to participate. Especially small cities and companies having not much urban developing resources of their own are happy to participate. Bigger cities with multi-siloed urban development sectors are of course more complicated to collaborate with. Thus, even the mere facilitation from university is still needed. An interesting question is, what is the role of multinational companies in this kind of setting? Are they willing to participate even if they perhaps cannot convert the focus of the project as they wish but simply adopt it?

One of the limitations of this study is related to the dependence on the expert judgements (e.g. Michael Batty from UCL-CASA) and secondary data such as webpages and internal documents of FinEst Centre. As a follow-up study, it would make sense to collect primary data from the selected centres listed in annex either in form of questionnaire and or interviews.

For future research, there is a need to dig further in understanding what kind of research is performed by researchers in the interplay of technology and urban environment, instead of applying mere keywords-basedanalysis. In the case of scientific research, the term 'smart' could be used as merely one alternative of many concepts dealing with technological dsevelopment of cities. The concept of smart city has not become more rigid from the scientific perspective over the past decade, rather the opposite. Cities have faced a significant digitalisation over the past years, and thus smart cities are not the future concept anymore but are slowly becoming a *de facto* reality. Thus, the borders between advanced cities and smart cities are getting blurrier – this is a somewhat similar but slower process than how landline phones and then analogue mobile phones have transferred into smartphones over the past three decades, making smartphones *de facto* standard.

Although the amount of research on the hype term *smart city* has been increased substantially, the literature still lacks an introduction to the core research and innovation agenda of the phenomena which was proposed in this paper. If critically analysed, most of the papers state that the concept of smart city is vague and there is no agreement on definition among scholars. This is fundamentally true – there is no absolute shift towards a theory as smart city. More than that, smart city is a movement that connects several urban technology researchers and practitioners. From the academic perspective, smart city is more like a glue that can combine different ideas from different disciplines under one very broad umbrella. Although the number of separate disciplines under the umbrella is big, the emphasis of them tends to be in

technology-oriented ones. This could be one of the reasons for the general public indifference against the concept of smart cities. Thus, more emphasis on severe societal, cultural, and economic approaches, especially which of critical consumer and critical technology studies, might improve the acceptance of smart city movement. Our findings also implicate that larger-scale smart city studies should not be organised as separate academic disciplines. Instead, they should be built on real-life problems, even the wicked ones. In practice, this means more interdisciplinary and more experimental approach to the development of smart cities.

## Notes

1. https://www.volkswagenag.com/en/sustainability/engagement/smart-sustainable-island.html
2. https://www.kfw.de/stories/economy/innovation/smart-cities/
3. www.taltech.ee/en/smartcity
4. http://www.finesttwins.eu/projects

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## Appendix A: a list of academic centres that have some focus on smart cities research

| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Urban Informatics Centre – Queensland University of Technology (QUT) Design Lab | https://research.qut.edu.au/designlab/groups/urban-informatics/ | Australia – Brisbane | The Urban Informatics group in the QUT Design Lab examines, communicates, and designs responses to how people, place, and technology come together to create urban experiences. Urban informatics is the study, design, and practice of urban experiences across different urban contexts that are created by new opportunities of real-time, ubiquitous technology and the augmentation that mediates the physical and digital layers of people networks and urban infrastructures. The group was founded in 2006 by Professor Marcus Foth. Since then, we have rapidly evolved into an internationally leading research and development team. | 2006 |
| AURIN Program, University of Melbourne | http://aurin.org.au/ | Australia – Melbourne | Established in June 2010, the Australian Urban Research Infrastructure Network (AURIN) is an initiative of the Australian Government under the National Collaborative Research Infrastructure Strategy (NCRIS) and associated programmes. We provide the data and tools to allow you to make evidence-based decisions quickly and confidently, and we can help you get in touch with world-leading urban experts right here in Australia. Themes: spatial data infrastructure and analytical methods for urban and regional research and planning, urban intelligence | 2010 |

(*Continued*)

(Continued).

| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| City Futures Research Centre – University New South Wales (UNSW) | https://cityfutures.be.unsw.edu.au | Australia – Sydney | Based in the Faculty of the Built Environment at UNSW since 2005, the City Futures Research Centre has developed into a national leader in scholarly applied urban research. In 2012, the centre was assessed by the Australian Research Council as the only Australian university research concentration in urban planning and related research rated at level 5 – 'well above world standard'. Focus: urban analytics, housing, urban well being, urban data, decision support: They have the CityBlog, VityViz, CityDash, CidyData | 2004 |
| Smart Cities and Infrastructure Research Cluster (SCIC) – UNSW | https://www.be.unsw.edu.au/research-centres-and-clusters/smart-cities/about-us | Australia – Sydney | The Smart Cities and Infrastructure Cluster (SCIC) seeks to promote and advance the efficient design, planning, and delivery of urban environments, infrastructure, and properties through the use of spatially integrated information and smart technologies. | 2014 |
| SMART Infrastructure Facility – University of Wollongong Australia | http://smart.uow.edu.au/ | Australia – Wollongong | Smart cities focus with respect to energy, transport, infrastructure, demography, social simulation, geomatics, but wider than cities. One of the largest research institutions in the world dedicated to helping governments and businesses better plan for the future, SMART brings together experts from fields such as rail, infrastructure systems, transport, water, energy, economics, and modelling and simulation, providing 30 state-of-the-art laboratories to facilitate this important research. | 2009 |
| Institute of Spatial Planning Vienna University of Technology | https://www.srf.tuwien.ac.at/start/EN/ | Austria – Vienna | As part of the Institute for Spatial Planning at TU Wien, this research unit considers its responsibilities in two main areas: (1) theoretically and methodologically sound spatial research and corresponding approaches to solutions to political and planning challenges as well as (2) offering didactically clearly structured learning offers on theories and methods as well as on the assessment of planning strategies within an evidence-based understanding of planning. | 2000 |

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| Centre | Web address | Location | Brief description | Established date |
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| Geneva UN Charter Centre of Excellence on Smart and Sustainable Cities in Vienna | https://www.oier.pro/global-programs/excellence-center/ | Austria – Vienna | The UN Geneva Charter Centre of Excellence on Smart and Sustainable Cities, managed by the Organization for International Economic Relations (OiER), was established in 2018 as a global framework serving as a multistakeholder city/industry platform for active collaboration of the private, public, and finance sector, as well as cities and civil society, to co-act and implement innovative smart and sustainable urban solutions. | 2018 |
| Beijing City Lab (BCL) | http://www.beijingcitylab.com/members/ | China – Beijing | The Beijing City Lab (BCL) is dedicating to studying, but not limited to, China's capital Beijing. The Lab focuses on employing interdisciplinary methods to quantify urban dynamics, generating new insights for urban planning and governance, and ultimately producing the science of cities required for sustainable urban development. The lab's current mix of planners, architects, geographers, economists, and policy analysts lends unique research strength. | 2012 |
| Institute of Space & Earth Information Science (IEIES) – The Chinese University of Hong Kong | www.iseis.cuhk.edu.hk/eng/ | China – Hong Kong, Shatin | Institute of Space & Earth Information Science (ISEIS) was established in 2005. It was developed on the base of the Joint Laboratory for GeoInformation Science (JLGIS) of Chinese Academy of Sciences & The Chinese University of Hong Kong. ISEIS consists of three major units: research, education and training, and technology development. | 2005 |
| Institute of Future Cities CUHK – The Chinese University of Hong Kong | http://www.iofc.cuhk.edu.hk | China – Hong Kong, Shatin | Institute of excellence, a leading multi-disciplinary research Institute in Asia with significant impacts on academic research and urban theories and practices including policy, plans and design especially in Hong Kong, mainland China and Asia. Themes: Sustainability, smart cities, digital applications, urban design | 2014 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing (LIESMARS) | http://www.lmars.whu.edu.cn/en/ | China – Wuhan | In 1989, the laboratory began construction on the basis of the National Key Disciplines of Photogrammetry and Remote Sensing and Geodetic of Wuhan Technology University of Surveying and Mapping. The State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University (LIESMARS) is the first state key laboratory in the field of surveying and mapping in China. The current research institutes are: Research Institute of Aerial and Space Photography; Research Institute of Remote Sensing Information Processing; Research Institute of Geospatial Information Systems and Services; Research Institute of 3S Integration and Network Communication; Research Institute of Navigation and Location-based Services. | 1989 |
| FinEst Centre for Smart Cities (FinEst Centre) | www.finesttwins.eu | Estonia and Finland | The FinEst Centre focuses on mobility, energy and built environment glued together by governance and urban analytics & data. The FinEst Centre develops the cross-border knowledge transfer infrastructure through real-life pilots. | 2019 |
| Spiekermann & Wegener (S&W) Urban and Regional Research – University of Dortmund | www.spiekermann-wegener.de/ | Germany – Dortmund | Spiekermann & Wegener City and Regional Research (S&W) was founded as a research-oriented planning office in 2001. It is a long-standing urban modelling group affiliated to University of Dortmund. | 2001 |
| Ubineum – Living the future | https://ubineum.de/netzwerk.html | Germany – Zwickau | The ubineum is the successful and interdisciplinary specialist centre for everything to do with future living in Zwickau and serves as a milestone on the way to the 'All Electric Society' – the emergence of electricity, mobility, and digitality. The fusion of the real and information technology world and the implementation of innovative energetic sector couplings result in intelligent infrastructure systems, cost-efficient energy systems, and sustainable mobility concepts in the ubineum. | 2017 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Center for Collaborative Research (CCR) for Scientific Modeling, Application, Research, and Training for City-centered Innovation and Technology | https://www.smartcity.ui.ac.id/ | Indonesia | The Center for Collaborative Research (CCR) for Scientific Modeling, Application, Research, and Training for City-centered Innovation and Technology (abbreviated as SMART CITY) is led by University of Indonesia. CCR SMART CITY encourages the use of interdisciplinary approaches in its work, collaborates on a global scale, and creates scientific and technological innovations as response to facing urban challenges, including the adoption of green technology; information technology in urban administration, services, and governance; reliability of urban infrastructure; and the rapidly declining quality of life, health, and general well-being. | 2017? |
| Information Technology Development Center of Iran (MAGFA) | https://www.oier.pro/news/iranian-smart-cities-center-of-excellence-development-opportunity-for-next-generation-smart-cities-in-iran-94/ | Iran | Information Technology Development Center of Iran (MAGFA) in partnership with the Presidential Center for Progress and Development of Iran has established Iranian Smart City Excellence Center. The Center is Iran's official representative in the global network of Excellence Centres set up around the world for Sustainable Smart Cities implementation. | 2019 |
| National Centre for Geocomputation (NCG) – National University of Ireland Marynooth | http://ncg.nuim.ie/ | Ireland – Maynooth | Since its inception in 2004 with the support of Science Foundation Ireland and centred in Maynooth University, the NCG has become firmly established as a leading centre for research in the field of Geocomputation, applying computational methods to large spatial data sets from acquisition to analysis, modelling, and visualisation. | 2004 |
| Geosimulation and Spatial Analysis Lab – Tel Aviv Uni | https://www.geosimlab.org/ | Israel – Tel Aviv | Based on high-resolution GIS and big data on human and institutions' spatial behaviour, we model the complex geographic system as collectives of decision-makers who define system's spatio-temporal dynamics and evolve themselves. Current Research: Smartcard and Cellular data analysis, Modelling Urban Fires, Modelling urban Sprawl, Modelling urban traffic, Modelling urban parking, and Modelling Traffic Accidents. | 2000 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| City Center – TAU Research Center for Cities and Urbanism – Tel Aviv University | https://en-urban.tau.ac.il | Israel – Tel Aviv | TAU City Center – Tel Aviv University's Research Center for Cities and Urbanism is a unique interdisciplinary centre that brings together the many TAU researchers – faculty members, graduate, and postgraduate researchers – who study various aspects of cities and urbanism. The Center's interests include urban theory and its application in city planning, urban design, management, and policy formulation. Among the Center's goals are research, global connections, local cooperation, accessible knowledge, and teaching. | 2015 |
| Center for Spatial Information Science (CSIS) – University of Tokyo Urban Engineering | www.csis.u-tokyo.ac.jp/english/ | Japan – Tokyo | In 1998 it was established as the Center for Spatial Information Science. CSIS was established as an internal joint-use facility by the University of Tokyo. It can be used by researchers from various faculties and research institutions within the university for their respective research works. CSIS does not concentrate on one specific field but encourages lateral research connections. | 1998 |
| United Nations University Operating Unit on Policy-Driven Electronic Governance (UNU-EGOV) | https://egov.unu.edu/ | Portugal – Guimaraes | UNU-EGOV, part of the United Nations University (UNU) and based in the city of Guimarães, north of Portugal, is a think tank dedicated to Electronic Governance; a core centre of research, advisory services and training; a bridge between research and public policies; an innovation enhancer; a solid partner within the UN system and its Member States with a particular focus on sustainable development, social inclusion and active citizenship. UNU-EGOV strives to cement its role as an international reference of excellence in this area, bringing together multidisciplinary and multicultural teams around complex problems and emerging challenges. | 2014 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| The Smart Cities Research Center (SCRS) | https://www.kict.re.kr/menu.es?mid=a20210010000 | Republic of Korea | In June 1983 KICT was established as a private foundation, and in July 2017 SCRS was designated as a government-funded research institute under the National Research Council of Science & Technology of the Ministry of Science and ICT. SCRS is a leading innovative interdisciplinary service to integrate construction industry and intelligent information technologies to resolve the urban problems. SCRC main roles are research and development of smart city services and technologies including human-centric policy design and strategic planning; developing the Smart City Living Lab and related convergence services and researching on cooperation among citizens, industries, and the government, as well as other countries related to smart city businesses. | 1983 as foundation and 2017 as a centre |
| SMART Innovation Centre – Singapore-MIT Alliance for Research and Technology | https://smart.mit.edu/ | Singapore | Established in 2007, SMART is MIT's first research centre outside of Cambridge, MA ,and its largest international research endeavour. The SMART Innovation Centre operates under the Singapore-MIT Alliance for Research and Technology (SMART) and is funded by the National Research Foundation (NRF). The SMART Innovation Centre identifies and nurtures a broad range of emerging technologies including but not limited to biotechnology, biomedical devices, information technology, new materials, nanotechnology, and energy innovations and will act as a catalyst to create a fertile environment for faculty and student entrepreneurship to grow. | 2007 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Singapore-ETH Centre (SEC): Future Cities Laboratory (FCL) | https://fcl.ethz.ch/ | Singapore | The Singapore-ETH Centre was established in 2010 by ETH Zurich – The Swiss Federal Institute of Technology and Singapore's National Research Foundation (NRF), as part of the NRF's CREATE campus. As ETH Zurich's only research centre outside of Switzerland, the centre has strengthened the research capacity of ETH Zurich to develop sustainable solutions to global challenges in Switzerland, Singapore, and the surrounding regions. Set in Asia, in a rapidly urbanising region, the Singapore-ETH Centre aims to provide practical solutions to some of the most pressing challenges on urban sustainability, resilience and health through its programmes: Future Cities Laboratory (FCL), Future Resilient Systems (FRS), and Future Health Technologies (FHT). | 2010 |
| Lee Kuan Yew Centre for Innovative Cities – Singapore University of Technology and Design | http://lkycic.sutd.edu.sg/ | Singapore | The Lee Kuan Yew Centre for Innovative Cities (LKYCIC) was established in September 2012 as one of the research centres of excellence in the Singapore University of Technology and Design (SUTD). LKYCIC is only one of two institutions in Singapore that carry the name of our founding father Lee Kuan Yew. A focus on urban innovation and future cities, ageing, and technological innovation. | 2012 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| The Institut Municipal d'Informàtica (IMI) Barcelona | https://ajuntament.barcelona.cat/imi/es/el-instituto | Spain – Barcelona | The Municipal Institute of Information Technology (IMI) is a local independent Barcelona City Council body that was set up in 1990 to provide Barcelona City Council and the public companies under its wing with all their Information and Communication Technology Services. Tasks: It takes part in the design and implementation of Barcelona City Council's ICT strategy; it offers advice and support in all the City Councils projects or programmes requiring an information and telecommunication systems strategy; it promotes and implements technological projects for Barcelona City Council. | 1990 |
| Spatial Economics Group – VU (Vrie University) | https://sbe.vu.nl/en/departments-and-institutes/spatial-economics/index.aspx | The Netherlands – Amsterdam | Regional science and GIS group with extensive research into smart cities, transport, and spatial visualisation. The Department of Spatial Economics, at the School of Business and Economics of VU Amsterdam, is engaged in economic problems in which space plays a prominent role. The Department of Spatial Economics offers insights and applications in urban, regional, transport, and environmental challenges from a primarily economic perspective, often enriched through multidisciplinary collaborations. | 1990 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| AMS Amsterdam Institute for Advanced Metropolitan Solutions | https://www.ams-institute.org/ | The Netherlands – Amsterdam | Amsterdam Institute for Advanced Metropolitan Solutions (AMS Institute) is a public–private institute founded in 2014 by Wageningen University & Research (WUR) and Delft University of Technology (TU Delft), together with Massachusetts Institute of Technology (MIT). The three core pillars of the institute are Research & Valorization, an Education Program, and a Value platform. The research portfolio revolves around applied technology in themes such as water, energy, waste, food, data and mobility, and integrating these themes to create an innovative, sustainable and just city. AMS Institute is involved in over 100 projects that focus on securing a city that is innovative, sustainable and just. | 2014 |
| Department of the Built Environment – Information Systems in the Built Environment (ISBE) | https://www.tue.nl/en/research/research-groups/information-systems-in-the-built-environment/ | The Netherlands – Eindhoven | The ISBE Group carries out research and education in the field of information systems used for the engineering and management of the built environment, into which they are embedded. Research Project: Triangulum (Manchester, Eindhoven, Stavanger). In the Triangulum project an exploitation and replication framework is developed for smart city solutions across the domains of energy, transport and ICT. Research Labs in at TU/e: ht.tps://www.tue.nl/en/research/research-labs/ | 1990 |
| Expertise Centre for Urban Dynamics and Sustainability – Faculty of Geosciences – Utrecht University | https://www.uu.nl/en/organisation/faculty-of-geosciences/laboratories-and-collaboration | The Netherlands – Utrecht | Transport and GIS group with strong interests in planning support systems and application of models to plan-making. The Utrecht focus areas link fundamental research to a social mission. Together with its partners, Utrecht University has made plans to tackle 20 key societal challenges. For this purpose, the university allocated 26 million euros for the period between 2018 and 2022. | 1995 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| The Martin Centre for Architectural and Urban Studies – University of Cambridge | www.martincentre.arct.cam.ac.uk/ | UK – Cambridge | The Martin Centre for Architectural and Urban Studies – the research arm of the Department of Architecture – was founded by Professor Sir Leslie Martin in 1967 as the Centre for Land Use and Built Form Studies, and formally became The Martin Centre in 1974. It is one of the traditional urban modelling groups with focuses on urban energy, resources, and urban design. | 1967 |
| Cambridge Centre for Smart Infrastructure and Construction (CSIC) – University of Cambridge | http://www-smartinfrastructure.eng.cam.ac.uk/ | UK – Cambridge | Cambridge Centre for Smart Infrastructure and Construction (CSIC): an Innovation and Knowledge Centre funded by EPSRC, Innovate UK and Industry Partners, CSIC is a world-leading centre in the development of smart infrastructure and data-driven solutions to enable smarter whole-life asset management decisions, for both new infrastructure and existing assets. Annual Report 2020 available: https.://www-smartinfrastructure.eng.cam.ac.uk/files/csic_02072020.pdf | 2011 |
| Warwick Institute for the Science of Cities (WISC) – The University of Warwick | http://www.wisc.warwick.ac.uk | UK – Coventry | Partner institution with CUSP, focusing on Data Science-Analytics, Sensors, Social Media Health, Intelligent Infrastructure, Urban Resilience, Energy. Through the Warwick Institute for the Science of Cities, Warwick brings its own strengths in areas including Data Science and Analytics, visualisation, data mining, machine learning, data streaming and on- and off-line analytics; Sensor and Wireless Networks; Social and Media Networks, smarter analysis of textual data and text mining of data drawn from social media and using social informatics to learn more about the 'mood' of urban citizens and organisations relating to the issues that surround them; Science and Technology for Health, Urban Resilience; Data Management and Privacy; Energy Solutions, etc. | 2012 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Institute for Future Cities – University of Strathclyde | http://ifuturecities.com/ | Uk – Glasgow | The Institute for Future Cities is a multidisciplinary research unit based within the international, award winning University of Strathclyde. They work with commercial, civic, and academic partners across the world to understand better the challenges faced by cities as places to live and work, and to help unlock the potential of cities to provide innovative ways of enhancing their quality of life. Their strength lies in their ability to respond quickly and agilely to the changing needs of cities and to help promote socially progressive and inclusive urban development. Crime, heritage, and energy as well as health, resilience, and the urban observatory involving data analytics and visualisation. | 2010 |
| Urban Big Data Centre (UBDC) – University of Glasgow | http://ubdc.ac.uk/ | Uk – Glasgow | The Urban Big Data Centre (UBDC) is a research centre and national data service based at the University of Glasgow that promote the use of big data and innovative research methods to improve social, economic, and environmental well-being in cities, established in 2014. In its first phase – up to January 2019 – it was funded by the Economic and Social Research Council (ESRC), as part of the UK's national data infrastructure, focused on developing big data resources and urban analytics methods for a wide range of potential applications and users. UBDC is now jointly funded by the ESRC and the University of Glasgow as a research centre up to January 2024. As well as continuing to pioneer the science of urban analytics, the Centre will work closely with government and industry to ensure the benefits of that research are maximised. They provide data services and support urban research. UBDC's key research strands are Urban Impacts of COVID-19; Education and skills; Housing and neighbourhoods; Transport and infrastructure; Urban governance. | 2014 |

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| Centre | Web address | Location | Brief description | Established date |
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| Technology & Innovation Centre – University of Strathclyde | https://www.strath.ac.uk/research/technologyandinnovationcentre/ | UK – Glasgow | Our new Technology & Innovation Centre opens doors to new areas of research, innovation and technology development, all aimed towards creating new possibilities, new levels of dynamic collaborations and productive outcomes. Together, we'll work on solutions to challenges in enabling technologies and the low carbon economy, including low cost, greener power and energy; renewable technologies; photonics and sensors; advanced engineering; pharmaceutical manufacturing nanoscience. | 2015 |
| Leeds Institute for Data Analytics (LIDA) – University of Leeds | http://www.lida.leeds.ac.uk/ | UK – Leeds | Established in 2014, with major investments from the UK Research Councils and the University of Leeds, LIDA has developed state of the art physical and IT infrastructures to raise the bar in standards of data quality, access, protection, and exploitation. Over 90 research centres, programmes, and projects are now based at the Institute and our infrastructure also supports in excess of £75 million research across the university. | 2014 |
| Consumer Data Research Centre – University of Leeds | https://www.cdrc.ac.uk/about/ | UK – Leeds | The Consumer Data Research Centre (CDRC) was established in 2014 with funding from the UK Economic and Social Research Council and brings together world-class researchers from the University of Leeds, UCL, University of Liverpool and the University of Oxford. Research: Health and Wellbeing, Urban Mobility, Retail, Population, Housing and Infrastructure, Crime and Emergency Services, Ethical and Sustainable Consumption. | 2014 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Center for Spatial Analysis and Policy (CSAP) – University of Leeds | www.geog.leeds.ac.uk/research/csap/ also the Leeds Institute for Data Analytics | UK – Leeds | The Centre for Spatial Analysis and Policy builds on that tradition by developing innovative ways of looking at the world to understand business, society, and the environment at different spatial scales and by providing applied or policy-related analyses of geographical behaviour. Our research: quantitative geography. Our particular research interests include population dynamics, migration, geodemographics, retailing, education, crime, and health. | 1970, 2005, 2013 ? |
| Centre for Advanced Spatial Analysis (CASA – UCL) | www.casa.ucl.ac.uk www.blogs.casa.ucl.ac.uk www.spatialcomplexity.info | UK – London | The Centre for Advanced Spatial Analysis (CASA) is an interdisciplinary research institute focusing on the science of cities within The Bartlett Faculty of the Built Environment at UCL. Established as a GIS centre with focus, on visualisation, modelling and simulation, spatial data, and urban morphology. They seek to examine and offer solutions to the problems of resource efficiency and effective planning and governance shared by all cities. Their vision is to play a central role in the science of smart cities – applying it to city planning, policy, and architecture in the pursuit of making cities better places to live. | 1995 |
| Centre for Transport Studies (CTS) – Imperial | http://www.imperial.ac.uk/transport-studies | UK – London | The Centre for Transport Studies (CTS) carries out teaching and research in a broad range of aspects of transport studies. Principal areas of research include Intelligent transport systems (ITS); Transport operations; Transport and the environment; Railway operations and management; Transport economics; Positioning, navigation and geomatics; Travel demand modelling; Air traffic management; Transport safety; Logistics; Urban engineering systems. | 2000 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Urban System Lab (USL) – Imperial | https://www.imperial.ac.uk/urban-systems-lab/ | UK – London | The Urban Systems Lab (USL) was formed in October 2015 and has eight linked thematic research areas: Low carbon operation and resource efficiency; Resilience and adaptability; Systemic quality of service; Sensing, simulation and modelling; Economic performance; Advanced materials and processes; Health, well-being and quality of life; Business models and innovation. | 2015 |
| The Alan Turing Institute | https://www.turing.ac.uk/ | UK – London | The Alan Turing Institute is the national institute for data science and artificial intelligence, with headquarters at the British Library. It was created as the national institute for data science in 2015. In 2017, as a result of a government recommendation, we added artificial intelligence to our remit. | 2015 |
| Connected Places CATAPULT – Urban Innovation Centre | https://cp.catapult.org.uk/about-us/ | UK – London | Designed to be a collaborative hub for businesses, academics, city leaders and entrepreneurs to connect, develop, and create smart city solutions, the Urban Innovation Centre is currently home to the Connected Places CATAPULT and some of the world's best urban innovators. The Connected Places CATAPULT operates at the intersection between public and private sectors and between local government and transport authorities. In the last five years alone we have worked on 25 projects (and counting) in cities worldwide – most recently the £2.52 M Urban Links Africa programme funded by the Global Challenges Research Fund to work with six innovation-based city markets across Kenya and South Africa. Working with multiple HMG departments and global institutions we open the door to the Catapult Network on the global stage. | 2015 |
| Oxford Internet Institute (OII) – University of Oxford | www.oii.ox.ac.uk/ | UK – Oxford | The Oxford Internet Institute was founded as a full department of the University of Oxford in 2001. The Institute is a multidisciplinary research and teaching department of the University of Oxford, dedicated to the social science of the Internet. | 2001 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Smart Cities Smart Government Research-Practice Consortium – CTG – University at Albany | https://www.ctg.albany.edu/projects/smartcitiesconsortium/ | USA – Albany – New York | The Smart Cities and Smart Governments Research-Practice Consortium is a robust global smart cities research community that focuses on innovations in technology, management, and policy that change the fabric of the world's cities. Through networking and connected research, the Consortium shares ideas, new knowledge, research, and practice innovations in the interest of increasing opportunities for all who live, and work, in these cities. | 2015 |
| UrbanSim – AI for Smarter Urban Development (OPUS Group U Cal Berkeley) | http://www.urbansim.com | USA – Berkeley, CA | UrbanSim is a simulation platform for supporting planning and analysis of urban development, incorporating the interactions between land use, transportation, the economy, and the environment. Story: The UrbanSim modelling methodology was designed by Paul Waddell and developed over the course of many years and six National Science Foundation grants. It has been released as open source software and continuously improved and re-engineered as its usage has grown among planning agencies that needed rigorous methods to analyse the potential impacts of alternative transportation plans, and alternative land use plans, to evaluate their effectiveness, and by researchers in over 70 countries that have leveraged it to advance their research. In 2017 we launched UrbanCanvas Modeler, the world's first cloud-based urban simulation platform. | 2008 |
| Urban Center for Computation & Data (UrbanCCD) – University of Chicago | http://urbanccd.org/ | USA – Chicago | A research initiative at the University of Chicago and Argonne National Laboratory. Focus on Big Data and Computing, sensing and instrumentation, spinning off from Argonne National Labs, moving into urban growth and change and visualisation. | 2012 |
| Senseable City Lab – Massachusetts Institute of Technology (MIT) | http://senseable.mit.edu/ http://senseable.mit.edu/livesingapore/ | USA – Massachusetts | Sensing and visualisation in cities. LIVE Singapore is part the SMART (Singapore-MIT Alliance for Research and Technology) through various departments in particular DUSP (Urban Studies and Planning). | 2004 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| MIT Norman B. Leventhal Center of Advanced Urbanism (LCAU) | https://lcau.mit.edu/ | USA – Massachusetts – Cambridge | Emerging focus on urban issues informed by ICT applications to multiple social and physical urban problems. The MIT Norman B. Leventhal Center for Advanced Urbanism is committed to fostering a rigorous design culture for the large scale; by focusing our disciplinary conversations about architecture, urban planning, landscape architecture, and systems thinking, not about the problems of yesterday, but of tomorrow. The MIT Norman B. Leventhal Center for Advanced Urbanism has been established at the initiative of the Dean and department Chairs of the School of Architecture and Planning and reflects a renewed drive to excellence in urbanism. Current research areas include: Climate + Urbanism, Environment + Urbanism, Technology + Urbanism, and Global + Urbanism. | 2012 |
| Data-Smart City Solutions – Harvard Kennedy School | http://datasmart.ash.harvard.edu/ | USA – Massachusetts – Cambridge | Data-Smart City Solutions Research focus is the intersection of government and data, ranging from open data and predictive analytics to civic engagement technology. They seek to promote the combination of integrated, cross-agency data with community data to better discover and preemptively address civic problems. This website and their broader work are housed at the Ash Center for Democratic Governance and Innovation at Harvard Kennedy School (https://ash.harvard.edu/), the pre-eminent voice for innovation in government. | 2013 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| City Science – MIT Media Lab. | https://www.media.mit.edu/groups/city-science/overview/ | USA – Massachusetts – Cambridge | A synthesis of work being done on sensing, participation, social physics, visualisation, and urban economics through the Media Lab. Founded in 1985, the MIT Media Lab is one of the world's leading research and academic organisations. Unconstrained by traditional disciplines, Media Lab designers, engineers, artists, and scientists strive to create technologies and experiences that enable people to understand and transform their lives, communities, and environments. The City Science research group (Ariel Noyman, City Science group, MIT Media Lab) proposes that new strategies must be found to create the places where people live and work in addition to the mobility systems that connect them, in order to meet the profound challenges of the future. | 2012 (MIT Media LAB 1985) |
| Spatial Information Design Lab – Columbia University | https://entrepreneurship.columbia.edu/resource/spatial-information-design-lab/ | USA – New York City | The Spatial Information Design Lab was founded in 2004 as an interdisciplinary research unit in the Graduate School of Architecture, Planning and Preservation at Columbia University. It's a Lab supporting visualisation and GIS related to projects in New York City and urban research | 2004 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Marron Institute of Urban Management – New York University | https://marroninstitute.nyu.edu/about | USA – New York City | Established from an initiative by NY City Mayor to establish science campuses in the City; this is one of several initiatives at NYU. The NYU Marron Institute conducts innovative applied research, working with cities to take on critical challenges of urban living. Started with a generous gift from Donald B. Marron, the Institute operates on a model of academic venture capital in which the faculty who run research programmes receive seed funding. Faculty members use seed funds to develop their programmes, hire research staff, and build portfolios of externally funded projects that have the potential to improve outcomes in cities. Currently, the Marron Institute has four major research programmes focused on urban planning, environmental health, civic analytics, and public sector performance and innovation. | 2011 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| CUSP – Center for Urban Science and Progress – New York University | https://cusp.nyu.edu/ | USA – New York City | New York University's Center for Urban Science and Progress (CUSP) is a unique research centre that uses NY City as its laboratory to help cities. CUSP's research and educational initiatives seek to improve city services; optimise decision-making by local governments; create smart urban infrastructures; address challenging urban issues such as crime, environmental pollution and public health issues; and inspire urban citizens to improve their quality of life. History: In 2012, New York City challenged top institutions around the world to design an applied science campus that would make the city a world capital of science and technology, as well as dramatically grow its economy. New York University and NYU-Poly, along with a consortium of world-class universities and some of the foremost international tech companies, proposed CUSP, a new kind of academic centre that functions in collaboration with the city itself. The proposal was accepted, and on 23 April 2012 Mayor Bloomberg announced the launch of CUSP. | 2012 |
| Cornell Tech – Cornell University | http://tech.cornell.edu/ | USA – New York City | Established as part of the NY City Science Campus Initiative, partnered with Technion focusing on engineering and health education. Cornell Tech is a revolutionary model for graduate education that fuses technology with business and creative thinking. Cornell Tech brings together like-minded faculty, business leaders, tech entrepreneurs, and students in a catalytic environment to produce visionary ideas grounded in significant needs that will reinvent the way we live. Research: Human-Computer Interaction (HCI) & Social Computing, Security & Privacy, Artificial Intelligence and Robotics, Data & Modelling, Law and Policy. | 2012 |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Data Science Institute (SCI) – Columbia University | http://datascience.columbia.edu/smart-cities | USA – New York City | About the research centre: aim to develop, monitor, and improve infrastructure, buildings, transportation routes, the power supply, and everyday activities in crowded, urban environments. DSI Focus Areas include Climate, Health Care, Social Justice, Business and Finance, Foundations of Data Science. Their research detects and counteracts problems with ageing urban infrastructure, improves smart grid technology, calculates and communicates optimal transportation routes under congested traffic conditions, and deploys ubiquitous sensing devices. Drawing on Columbia's strengths in computer science, statistics, and industrial engineering and operations research, DSI was launched in 2012 to unite our expertise and a University-wide interest in this revolutionary approach. | 2012 |
| Rudin Center for Transportation Policy & Management – NYU Wagner | https://wagner.nyu.edu/rudincenter | USA – New York City | The Rudin Center for Transportation Policy and Management at NYU's Wagner School seeks to improve the flow of people and goods in the New York metropolitan area. We draw upon scholars, graduate students, and public officials who participate in our public forums and shape our research. We also prepare emerging leaders in the transportation field, explore how new technologies will influence mobility, and study how emerging patterns of work will affect locational preferences. Areas of Focus: NYC, global, equity, micromobility, technology, climate change, preparing leaders, economic development, etc. The Rudin Center was named in recognition of a gift from Lewis Rudin and receives support from leading firms in transportation, finance, and communications. | |

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| Centre | Web address | Location | Brief description | Established date |
|---|---|---|---|---|
| Cities, Scaling & Sustainability – Project of Santa Fe Institute (SFI) | http://www.santafe.edu/research/cities-scaling-and-sustainability/ | USA – Santa Fe – New Mexico | The Santa Fe Institute (SFI) is an independent, nonprofit research and education centre that leads global research in complexity science. In 2005, the SFI's cities, scaling, and sustainability research was created with an interdisciplinary approach and quantitative synthesis of organisational and dynamical aspects of human social organisations, with an emphasis on cities. An important focus of this research area is to develop theoretical insights about cities that can inform quantitative analyses of their long-term sustainability in terms of the interplay between innovation, resource appropriation, and consumption and the makeup of their social and economic activity. | 2005 |

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# Drivers and Barriers for the development of Smart Sustainable Cities

## A Systematic Literature Review

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## ABSTRACT

The term Smart Sustainable City (SSC) has been gaining popularity due to the growth of initiatives to address urban problems towards sustainable development. SSC can be considered as a combination of sustainable city and smart city, and some variance between the concepts may be expected. As this is a modern term, the literature falls short of studies presenting factors that hinder and/or facilitate the complex phenomenon of SSC development. Therefore, this paper aims to analyse scientific studies to identify aspects that influence the progress of smart sustainable cities. The methodological approach undertaken was a systematic literature review that included 169 papers. The results offer a comprehensive list of 57 drivers and 63 barriers, classified according to five main dimensions of a smart sustainable city, which are the three sustainability pillars (society, environment, and economy), combined to governance, and urban infrastructure. The findings revealed 'governance' as the most significant domain for SSC development, and multi-stakeholder engagement as one of the main challenges. This study shows that SSC is not a research field itself, but an interdisciplinary concept, contributing to academics, government, and policymakers for eradicating potential interferences in the development of smart and sustainable cities.

## CCS CONCEPTS

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

## KEYWORDS

sustainable city, smart city, challenges, enablers

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## 1 INTRODUCTION

The proliferation of smart initiatives brought new terms such as "smart city" and "sustainable city"; the first is related to the use of technology to improve urban services, whereas the second attempts for sustainable development [1]. Some academics have defended the adoption of the term "Smart Sustainable City (SSC)" [2–5], which can be understood as a combination of "smart city" and "sustainable city" [6]. Similarly, Höjer and Wangel [7] suggested that SSC should be seen as an aggregate concept that connects three parts: smart, sustainable and cities, in a way that cities could be sustainable without the use of technologies, or cities could use Information Communication Technologies (ICT) without contributing to sustainable development, but only when the three aspects are combined that we have a SSC. According to them, "A Smart Sustainable City is a city that meets the needs of its present inhabitants, 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 where this is supported by ICT" [7] (p. 10). A key aspect is that the use of technology in SSC should be as means to achieve better quality of life and long-term impacts.

Research on smart sustainable cities can be considered in its "initial stage" [8, 9] and full of unexplored opportunities [3]. The development of SSCs is a complex phenomenon [10–12] that requires a holistic analysis; however, the majority of previous studies in this domain are focused on the technology side [13]. Furthermore, little effort has been made to investigate drivers, enablers, challenges and barriers for SSC development [6]. Few examples of related previous studies are focused on one region, for instance the identification of enablers affecting SSC development in the Indian context [14], SSC challenges faced in the Arab region [15], and the recent study of Khan et al. [16], which identified critical challenges faced by private and government organizations in Pakistan. Furthermore, there are available studies focused on smart cities drivers and barriers (not smart sustainable cities), as is the work of Guedes et al. [9], which identified potential smart city drivers, and [17, 18], which identified barriers for the implementation of smart city initiatives in India. Nevertheless, remains a need for an extensive and holistic review to outline both enablers and challenges influencing smart sustainable city development.

Considering the lack of studies outlining a synthesis of aspects that influence the progress of smart sustainable cities, the central question that guides this study is: "What are the main enablers and challenges for the development of Smart Sustainable Cities?". The methodological approach includes a systematic literature review. The enablers and challenges identified in the literature are classified

according to the SSC conceptual model developed by Azambuja, Viale Pereira and Krimmer [6], which represents a smart sustainable city as an interplay of five main domains: the three pillars of sustainability (social, economic and environmental), urban infrastructure and governance.

The remainder of this paper has the following structure: The next section details the methodology implemented in this study; the third section presents the results of this study. The fourth section discusses the research findings and the last section concludes the discussion and explains the limitations of this study.

## 2 METHODOLOGY

This section explains the methodology of the literature review performed to identify factors that enable or hinder the development of smart sustainable cities (section 2.2) and briefly introduces the SSC conceptual framework (section 2.1) applied to classify the literature.

### 2.1 Conceptual Framework

This study considers a smart sustainable city a combination of "sustainable city" and "smart city". The term first term can be understood as a new attitude that balance its goals with the principles of sustainable development [1, 19], it is about people, natural system, learning, social changes and balanced conditions on a long-time horizon [19]. On the other hand, the term smart city is usually related to the use of technology and changes in services based on innovative approaches [19]. Thus, the addition of the word "sustainable" to the term smart city brings the idea that the benefits of smart sustainable city' initiatives should improve the quality of life now and should also last for future generations.

As suggested by Azambuja, Viale Pereira and Krimmer [6], a smart sustainable city is a territory that is able to balance the three sustainability pillars (social, economic and environment), making use of urban infrastructure and having the governance on the top of the model. In their model [6], the urban infrastructure dimension, which includes urban ICT and physical infrastructure, is set as the ground layer of the smart sustainable city to connect all necessary infrastructure to deliver city services. This base dimension is often referred as the built environment and digital layer of a smart city. In the middle of the model, the three dimensions social, economic, and environmental represent the sustainability of the city; and on the top is the governance domain, which is responsible for the coordination of all city elements to ensure that all domains are being considered to reach sustainability. This comprehensive model shows that a smart sustainable city extends the smart city concept. SSC is an interdisciplinary concept that comprises different domains where technology serves as a means and not as a goal itself. According to a recent study [20], the improvement of quality of life of urban residents and the enhancement of city functioning can be achieved through activities covering the five dimensions suggested by Azambuja et al. [6]. Thus, this model was used in this study to guide the identification and classification of potential challenges and enablers for the development of SSCs.

### 2.2 Method

The methodological approach used to answer "What are the main enablers and challenges for the development of Smart Sustainable Cities?" was a systematic literature review, which is recommended when the domain of study demands an association of different academic disciplines [21]. This methodology helps to summarize evidence in an accurate way [22] and is more reliable than traditional narrative reviews in the sense that the literature is selected using a transparent and reproducible process, which increases the methodological rigor and minimizes bias [23]. To accomplish the systematic literature review, it was taken into consideration the recommendations of the new version of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses—PRISMA 2020 Statement [22], which provides updated reporting guidance for systematic reviews. In addition, it was considered the guidelines of Wolfswinkel, Furtmueller and Wilderom [24], which suggest a five-step method for reviewing the literature. The step-by-step method applied in this research consists of the steps described in the following paragraphs and illustrated in Figure 1.

The first step was dedicated to defining the research plan, the inclusion and exclusion criteria. Considering the aim of this review, the author defined the keywords and the set of inclusion and exclusion criteria to be used. As this study aimed to identify aspects related to the development of smart sustainable cities, the term "smart sustainable city" and its variations (e.g., sustainable smart city, smart and sustainable city, etc.) were used. This selection distinguishes the present research from other studies that searched for the word "smart city" (without the word sustainable). The inclusion criteria were determined as academic journal articles and conference papers available online in full-text and published in English, which are relevant to the study aim and to answer the research question. Examples of relevant papers are studies mentioning driving forces, enablers, challenges, barriers, technologies, and tools used (ICT), innovations, and smart governance aspects. The exclusion criteria were defined by publications that did not mention any factors impacting the SSC development or papers presenting insufficient description of the investigation methods or results validation (i.e., weak methodology).

The second step was the search itself. The search task of relevant studies for review was undertaken in May 2019 using Scopus and Web of Science. The query string used in the databases was: (("smart sustainable cit*") OR ("sustainable smart cit*") OR ("smart and sustainable cit*") OR ("sustainable and smart cit*") OR ("smart sustainability")). The search allowed for instances of the keywords in the article title, abstract and keywords list. Since SSC is a multi-domain field, the journals were not limited to one specific area. Furthermore, neither starting publication date nor end date was introduced in the search. The query resulted in 221 records in Scopus and 193 records in Web of Science, totalizing 414 records. Figure 1 summarizes the literature identification, screening, and inclusion process through the PRISMA flowchart.

The third step was the selection of the literature sample. When doing a systematic literature review, the first step of the selection phase is to look for double items; therefore, the author manually checked the total list of 414 records obtained in the search phase to eliminate duplicates, resulting in 271 unique records. After the identification phase, the screening phase aimed to verify the records according to the inclusion and exclusion criteria prior defined. The document type and the availability online and in English were

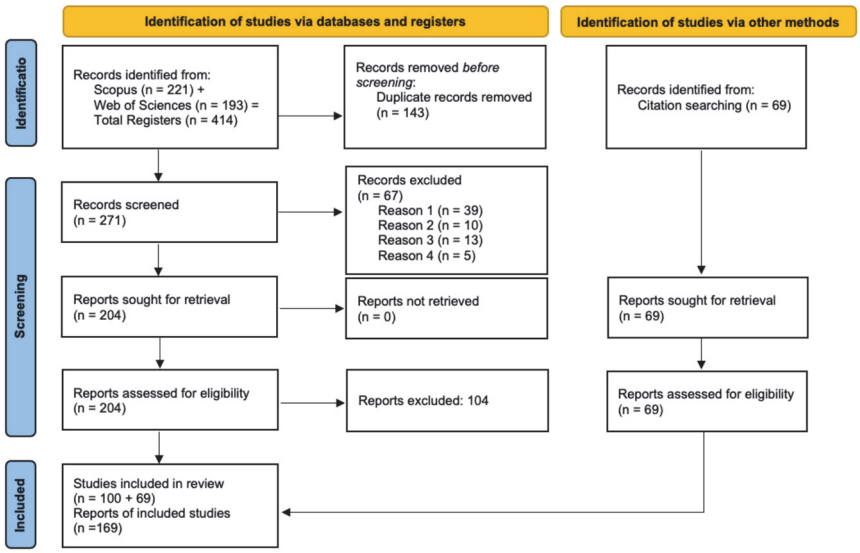


**Figure 1: Literature search and selection from the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) flowchart.**

verified. After removing books, book chapters or book reviews (exclusion reason 1, 39 records), conference reviews/proceeding lists (exclusion reason 2, 10 records), editorials, notes or news (exclusion reason 3, 13 records), and records not available online and in English (exclusion reason 4, 5 records), 204 papers were assessed for eligibility. The full texts of these initially screened articles were then read against the research aim. This resulted in 100 eligible articles. Following the forward and backward method [24, 25], 69 publications were added for a better understanding of the SSC development process. With the inclusion of the additional literature through citation searching, the total number of studies included in the review reached 169 records.

After searching and selecting the sample of articles, they were analysed and classified in papers containing enablers, drivers and/or barriers, challenges, etc. In addition, the drivers and barriers were coded according to SSC dimensions (governance, social, environmental, economic, and urban infrastructure), with the support of the NVIVO Software. If one paper mentioned an aspect of more than one dimension, it was included in more than one category. The SSC conceptual framework presenting the SSC domains and its characteristics (see 2.1) was used as a point of departure to organise the results; however, the scheme was updated and enlarged during the research analysis. Codes were inductively derived throughout the analysis stage, characterizing an iterative process to identify key aspects to consider [24, 26]. Various reviewing cycles were applied, classifying the drivers and barriers into sub-categories.

The last step performed in this review was the structure of the content, or in other words, the writing up and the presentation of the findings in the format of a literature review paper. The findings were summarized in two tables, one for drivers and one for barriers. Each table presents the list of factors (driver or barrier) coded during the analysis of the paper (classified according to the SSC domain) and their references.

## 3 DRIVERS AND BARRIERS FOR SMART SUSTAINABLE CITY DEVELOPMENT

This section brings aspects that could facilitate or hinder the development of SSCs. Table 1 lists the 57 drivers and 63 barriers, grouped into the SSC dimensions SSC dimensions: social, economic, environment, governance, and urban infrastructure[1].

The drivers and barriers classified under the social dimension embrace aspects related to people and communities. Authors indicated the importance of the provision of urban services [13, 27–29] such as education facilities to elevate the literacy rate and to generate workforce [30–36]. Community development, promotion of collectivism and volunteering were also mentioned [27, 28, 37]. In terms of barriers, citizens are not aware of what is happening nor of the importance of their participation, consequently, the lack of citizens' participation is a barrier for SSC development. Further, citizens do not trust on government [38, 39], fact that hinder their support to smart initiatives.

The economic factors refer to aspects of financial, innovation, employment, management of resources and related aspects. Innovation ecosystems, and the creation of living and urban labs were highly mentioned by academics. Another enabler is the use of

[1]The list of drivers and barriers containing more details and their references is available in Appendice A.

**Table 1: Drivers and Barriers for Smart Sustainable City development.**

| SSC dimension | Drivers | Barriers |
|---|---|---|
| Social | Public provision of urban services | Lack of citizen participation |
| | Innovative healthcare and sanitation facilities | Lack of trust |
| | Education to elevate the literacy rate | Lack of social awareness |
| | Accessibility and social inclusion | Cultural diversification |
| | Social responsibility, informed citizens, knowledge sharing | Citizen's inequality |
| | Community development, collectivism, volunteering networks | Digital divide |
| | Participative and engaged citizens | Resistance to change |
| | | Social exclusion and gentrification |
| | | Unavailability of services for different communities |
| | | Lack of connection between technological and social infrastructure |
| Economic | Innovation, urban labs, Research and Development (R&D) | High cost of urban infrastructure, imbalance of investments |
| | Crowdsourcing | |
| | Knowledge and shared-based economy, portfolio-thinking | Lack of funding and investors; short time horizon of investments |
| | Sustainable management of resources, circular economy | |
| | Partnership formation, multisector synergies | Volatility of global economy |
| | Promotion of social and human capital | Mono-sectoral economy |
| | Workforce availability (skilled and non-skilled) | Competitiveness (local against regional and international markets) |
| | Attract and retain workforce, flexibility of the labour market | |
| | Urban attractiveness | Unbalance between competitiveness and quality of life |
| | Tourist attractive projects | Unemployment, lack of equity access to labour market |
| | | Lack of qualified human capital |
| | | Weak Public-Private Partnership |
| | | Inefficiency of resource management |
| Environmental | Energy related: renewable resources, saving initiatives, smart systems | Climate change |
| | | Growing population, unbalance between liveability and environment |
| | Water related: monitoring quality, efficiency of water usage | |
| | Pollution prevention and reduction | Increasing resource consumption |
| | Air pollution monitoring, emission control systems | Scarcity of resources, loss of biodiversity and natural habit |
| | Smart waste management | Lack of resource sharing |
| | Recycling | Lack of holistic approach for environmental sustainability |
| | Availability of environmental standards | Lack of knowledge on how ICT can decrease energy consumption |
| | Environmental projects and green initiatives | |
| | Quality of urban space, land use planning | High level of air pollution |
| | Mobility related: efficient transport systems, cycle paths | Inefficient waste management |
| | Smart building, Responsive Building Envelope (RBE) | Traffic density and inefficient public transport system |
| Governance | Transparency and openness | Lack of planning; lack of vision and strategy |
| | Citizen empowerment, interactive and participatory services, co-production, co-creation, bottom-up approaches | Lack of project management |
| | | Lack of capacity (HR) |
| | Information and knowledge sharing, communication channels | Lack of IT knowledge among city planners |
| | Supportive government policies, political will and synergy | Lack of operational capability |
| | Urban planning: strategy and vision definition | Lack of capacity building (training) |
| | Context adaptation, analysis of current situation, flexibility | Structure issues: isolated silos; lack of internal cooperation |
| | Capacity planning (i.e., infrastructure, cost, and human resources) | Structure issues: complexity of organizational structures |
| | | Lack of alignment, conflicts of interests |
| | Clear definition of roles and responsibilities | Lack of knowledge and information sharing |
| | Leader / champion: dedicated organization / person for SSC initiatives | Lack of engagement opportunities |
| | | Poor Public-Private Partnership |
| | Key Performance Indicators (KPIs) definition; monitoring / assessment | Centralized decision-making process, top-down approach |
| | | Political instability and complexity |
| | Collaborative decision-making; participatory governance models | Lack of political will and support |
| | | Lack of transparency and trust |
| | Stakeholders' engagement: internal (cross-sector), and external | Lack of regulation and legislation |
| | Align and manage conflicts of interests | Inability of policies |
| | Data-driven decision-making and availability of real-time data | Multiplicity of policies and programs |
| | Urban proactiveness for service provision | Lack of standards for measuring performance |
| | Data governance: data quality, data sharing and data privacy policies | Lack of data governance |
| | | Lack of open data, issues for opening data |

**Table 1:** *Continued*

| | | |
|---|---|---|
| Urban Infrastructure | Physical infrastructure integration | Urban infrastructure deterioration |
| | Affordable housing facilities, such as water and energy supply | Deficit of technological infrastructure |
| | Adoption of innovative construction techniques | Lack of infrastructure integration, complexity of networks |
| | Connectivity, broadband, access to internet facilities | |
| | Interoperability and integrated ICT | Technological obsolescence, systems failures, infrastructure fragility |
| | Security verification tools / systems | |
| | Advance ICT, intelligent technologies in urban services | Lack of systems interoperability and lack of integration standards |
| | Smart grid; intelligent energy management systems | |
| | Use of Geographical Information Systems (GIS) | Lack of systems security, privacy violation |
| | Data processing: modelling imperfect data; data exchange | Poor quality of ICT-based services |
| | Data analytic capacity; Business Intelligence (BI) | Lack of data integration, complexity of opening and linking data |
| | Internet of Things (IoT) | |
| | Big Data | Lack of data management, huge volume of data |
| | | Lack of cloud and Fog computing |
| | | Vendor locking |

crowdsourcing as an alternative way to foster urban innovation as it helps to generate new ideas serving as an engagement platform. Other perspective of economic enabler is related to an effective management of urban resources, mentioned by Zhang et al. [40] as 'cleaner production', which aims to avoid waste and to maximize economic benefits. Moving to the economic barriers, the high cost of urban infrastructure was strongly stressed by academics. In addition, authors criticized the imbalance on investments regarding hard infrastructure (physical, hardware, sensors, systems) and soft infrastructure (capabilities) [2].

Environmental aspects are related to the use of renewable energy sources, smart waste management, land use planning, pollution control and prevention. The literature presents cases of initiatives highlighting the 'ecologic' side of SSCs with the potential of using modern technologies for lower resource consumption and carbon emission [41], and the benefits of using renewable energy sources [42]. In terms of barriers, ensuring environmental sustainability and building eco-friendly environment are challenging aims.

Moving to the governance dimension, SSC governance should be transparent [28, 43, 44], make use of open government approaches [28, 45–47] and should empower and engage citizens since the design of (interactive) services [45, 48]. Knowledge and information sharing were also mentioned as good practice [19, 49] to foster open and collaborative environments [45]. Likewise, many papers mentioned the involvement of multiple stakeholders and the creation of partnerships and cooperation. Among the list of governance barriers are the lack of planning, lack of communication, lack of leadership to run smart developments effectively. As a consequence, the uncoordinated implementation of initiatives might result in isolated efforts creating the risk of putting projects on hold due to the lack of resources [28]. Another range of challenges refer to the complexity of organizational structures and political issues. Frequently, the administrative structure of cities is organized in isolated silos (operational nodes) occasioning a lack of internal coordination and cooperation within city's agencies.

In terms of urban infrastructure drivers, scholars stated that specialized technologies like big data through IoT, and big data processing through AI bring emerging promises for city's design and management [50]. Allam and Dhunny [51] mentioned applications of AI that could benefit the development of SSC, such as AI for education, environment, health care, policy, mobility and sustainability. However, in order to benefit from the use of those emerging technologies, cities should have a robust infrastructure of systems and devices that are able to capture, process and spread data within different sources [18, 45, 52], and physical infrastructure integration, optical networks to support the communication of different data centres.

## 4 DISCUSSION

As seen, the drivers and barriers identified in this study are not exclusive from one or another dimension, confirming the interplay among the SSC dimensions. The literature highlights the "overlap" of dimensions. For example, the barrier "lack of skilled people" can be either classified under the social dimension [15] or under the economic one [44]. Similarly, the barrier "lack of investments in IT training" was categorised [18] as an economic challenge due to the high cost of IT; nevertheless, the lack of capacity (capabilities, skills) is classified in this review as governance issue. Connecting urban infrastructure and governance, authors are concerned with the existing lack of technologically comprehensive human resources. For instance, Yarime [53] highlights the need of creating capacity for data management. The lack of IT knowledge is considered as a capacity issue, thus, is a governance-related aspect. Besides the need of operational IT workforce, scholars mentioned the lack of IT knowledge among public authorities and policy makers [54] in order to help the digital transformation.

The results of this study emphasise the importance of governance for SSC development. Almost all the papers analysed (94%) mentioned at least one governance driver or barrier (63% mentioned drivers and 60% barriers). Some challenges correspond exactly to the lack of an enabler. For instance, some scholars indicated "information and knowledge sharing" as driver for SSC success, whereas other authors underlined that the lack of information sharing results in conflicts of interests and lack of engagement [55]. Another important governance aspect is political instability. One way to

mitigate consequences of this challenge is the definition of a city vision and the creation of a strategic planning for that is not directly associated to any political party [56] in order to have a sustainable (long-term) initiative. Another governance aspect is the use of policies, which must contemplate multidomain aspects related to mobility, health, security, and education [13]; stimulating social inclusion and innovation to drive economic growth [57].

Most studies have a technological focus, due to the "smart" aspect of SSCs. Among the 169 analysed papers, 140 (83%) mentioned at least one urban infrastructure driver or barrier. The results show that the SSC academic literature centres more on ICT than on urban physical infrastructure; however, infrastructure aspects are related. Furthermore, some aspects identified as drivers may cause side effects. For instance, big data can support the design, monitoring and service provision [19]; nevertheless, the city infrastructure should be in line with the use of these technologies, being a challenge.

## 5 CONCLUSIONS

Through an extensive systematic literature review comprising 169 articles, this study addressed the question of "What are the main enablers and challenges for the development of Smart Sustainable Cities?". In this investigation, it was possible to identify 57 drivers and 63 barriers that influence the progress of SSC, which were classified according to the main SSC domains (social, environmental, economic, governance, and urban infrastructure). The findings show the nuances of SSC are not generally applicable to smart cities. The addition of the word "sustainable" to the term smart city creates the idea of something that meets the needs of the present without compromising the ability of future generations. Furthermore, this study confirms that SSC is not a research field itself, but a concept that connects different disciplines.

Reflecting the number of identified factors and the number of references mentioning each SSC domain, 'governance' can be considered as the most significant domain for smart sustainable city development followed by 'urban infrastructure, 'environment, 'social', and 'economic'. The findings indicated a relation between many identified drivers and barriers, suggesting that many SSC challenges could be avoided or overcame with good governance practices. Moreover, the SSC development is a complex phenomenon that needs to be addressed in a holistic way by contemplating all SSC domains to generate sustainable impacts.

In terms of contribution, this review contributes to the gap of holistic studies investigating factors impacting the development of SSC offering a comprehensive list of drivers and barriers. Therefore, it has the potential to help different stakeholders, such as decision makers, public administrators, and practitioners in the identification of aspects to consider when developing SSC initiatives that can create long-term benefits.

This study has embedded some limitations. First, the data collection for the systematic literature review was performed in Spring 2019. Nevertheless, the author performed the same search in Spring 2021 to verify if the papers published between May 2019 and May 2021 were mentioning novel drivers and/or barriers that were not included in the initial results. A sample of 20% of those new papers were checked and no expressively new driver nor barrier was found, meaning that the study reached data saturation [58]. Thus, this data collection limitation does not affect the results of this research, confirming its relevance. Second, the literature search covered only peer-reviewed journals and full conference papers indexed at Web of Sciences and Scopus. Third, the author used a conceptual framework to guide the identification and classification of potential factors that affects the development of SSC, which covers five domains; however, there might be other models that could indicate a different set of factors that were not covered by the selected SSC framework. In addition, the identified aspects were not analysed in detail, and future work could perform a deeper analysis and prioritization of them. The recognized drivers and barriers could be evaluated further to find out their causal relations in smart sustainable city development. Lastly, one aspect labelled as an enabler could also be a barrier when there is a "lack of" such aspect, and this situation may vary considering different contexts.

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# A APPENDICES

The full list of identified drivers and barriers and their respective references can be found in the following link:

https://drive.google.com/file/d/1zKT-GpXMTkEyqULD2s-DFw6W3sYMbCm6/view?usp=sharing

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# Smart Sustainable City Roadmap as a Tool for Addressing Sustainability Challenges and Building Governance Capacity

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**Abstract:** Building smart sustainable cities initiatives requires governance capacity, which is constantly challenged by a diversity of actors and the transformation towards a digital society; however, the process of identifying the conditions for building a smart sustainable city (SSC) is not straightforward. As an attempt to map the key governance conditions, the goal of this study is to suggest guidelines for the development of SSC initiatives in the format of a generic roadmap. This research applies design science research methodology and builds the roadmap based on identified antecedents that may hinder or facilitate the development of SSC initiatives from a systematic literature review and the analysis of key governance aspects from 12 smart city initiatives in Europe and Latin America. This paper builds its results through a four-step approach including: (1) defining the main concepts and dimensions within the smart sustainable city context; (2) identifying sustainability challenges for the development of smart sustainable city initiatives; (3) analysing key governance aspects from smart sustainable city initiatives; and (4) designing an actionable research-based roadmap and practical recommendations. The resulting roadmap contains 11 key governance conditions for developing strategies for smart sustainable city initiatives that were classified into three main phases: (1) planning; (2) implementing; and (3) adopting, monitoring, and evaluating. In terms of contribution, this research provides a tool to support the development of initiatives, addressing sustainability challenges and strengthening governance capacity to ensure the long-term impacts of smart sustainable cities.

**Keywords:** smart sustainable city; governance; sustainability challenges; governance capacity; roadmap; design science research



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## 1. Introduction

Smart sustainable cities (SSC) characterise the progression on the application of digital technology and innovative solutions by the cities to address the needs of their populations and pursue sustainable socio-economic development. The urban development that drives SSC requires a strong capacity for public governance to support the planning, designing, and management of the ongoing transformations of the city, which are enabled by technological innovation [1]. The current literature highlights the need for understanding the complex process of developing smart sustainable city initiatives and addressing the insufficiency of tools to support stakeholders [2], the lack of strategic planning for initiatives, and the scarcity of a city agenda for guiding their implementation [3–6]. In addition, Sarv and Soe [7] have identified a knowledge gap between smart city theory and implementation from the perspective of an existing situation versus the related long-term strategy, and their results indicate that the current plan of a middle-sized European capital city differs from the goals set out in their smart city strategy.

A smart sustainable city is associated with the application of emerging technologies and digitalization of governments; however, the success of innovation in local government

requires more than just the focus on technology [6,8], and should seek for a balance between three dimensions—city policy, city management and technology [7]. Additionally, because the aspects of a city are multidomain [9,10], it requires a holistic strategy to become smart, connecting the main sustainability pillars (social, economic, and environmental), and addressing, for instance, the six dimensions of smart cities grouped by Giffinger [11] as follows: Smart Economy, Smart Mobility, Smart Governance, Smart Environment, Smart People and Smart Living. SSC have the potential for overcoming urban problems, and governance plays a key role in fostering sustainable development [12]; however, policymakers and smart city-related stakeholders lack research-based practical recommendations to support the planning and implementation of smart sustainable city initiatives and the definition of actionable long-term strategies towards sustainable development.

In order to bridge this gap and contribute to improving the governance capacity and understanding of the necessary aspects to develop SSC initiatives, this paper aims to answer the following research questions: What are the conditions to build smart sustainable cities initiatives to address sustainability challenges? As well as how to build local governance capacity for smart sustainable cities development?

One way to help the understanding and development of complex processes is the use of roadmaps. Road mapping is a flexible process for creating guidelines, which can be used to support different types of strategic aims such as, for instance, planning, supporting communication, and assessing projects [13]. Considering the benefits of roadmaps, this research intends to develop a smart sustainable city roadmap to serve as the basis for building local governance capacity and to guide the development of smart sustainable city initiatives by means of a design science research (DSR) methodology. The methodology followed a four-step approach including: (1) defining the main concepts and dimensions within the smart sustainable city context; (2) identifying sustainability challenges for the development of smart sustainable city initiatives; (3) analysing key governance aspects from smart sustainable city initiatives; and (4) designing an actionable research-based roadmap and practical recommendations.

The purpose of this paper is to advance the knowledge gap between smart sustainable city development and governance capacity, providing a path for urban planners and policymakers in addressing local governance and sustainability challenges as well as to provide recommendations for a future research agenda of SSC. This research seeks to define the phases and conditions for the development of SSC initiatives, considering governance and sustainability aspects, that will ultimately support cities in the process of becoming smart and sustainable. This paper is organised in four sections: 1. Introduction; 2. Methodology; 3. Results and discussion (constructing and discussing the roadmap); and 4. Conclusions, implications, and limitations.

### *1.1. Smart Sustainable Cities*

Smart sustainable cities are able to combine social, urban and technological aspects [14]. SSC symbolise the latest stages towards smart, digital, intelligent and sustainable systems and can be understood as a constant transformative process grounded on the collaboration of multiple stakeholders to pursue socio-economic development and to build human, technical and institutional capacities [15].

We build our understanding of SSC based on the conceptual framework proposed by Azambuja, Viale Pereira and Krimmer [16], including the three pillars of sustainability as balancing social, economic, and environmental dimensions to improve quality of life, in addition to the urban infrastructure dimension—which embodies the physical infrastructure and urban information and communications technology (ICT) in order to integrate all city aspects—and governance as the overarching dimension. The social dimension refers to the provision of city services to citizens, guaranteeing the quality of life, enhancing social participation, communication with citizens, education, decreasing the digital divide for reaching sustainability, etc. [15–17]. The economic dimension addresses challenges to the economic sustainability understood as "a city with a healthy, dynamic and responsible economy" [15].

The environmental dimension covers issues related to the protection and restoration of the natural environment, green buildings, energy savings, creating better spaces to live, and the adoption of ecological practices to protect the environment [10,15,17,18].

A smart sustainable city is built upon the urban infrastructure—the physical infrastructure comprising roads, transportation, factories, buildings, subways and more, and ICT infrastructure—urban ICT assets comprising local area networks (LAN), servers, databases, software, open-source software, geographic information systems (GIS) and more [16]. The literature also distinguishes two domains of SSC projects: hard—the essential role of digital technology, and soft—technology understood as an enabler in education, culture, policy, and innovation [19]. According to Grimaldi and Fernandez [20], effective management of human capital leads to developing the "knowledge city" where the education sector substantially supports urban development, and policy implementation.

Finally, above all the mentioned dimensions, the governance dimension addresses the administrative capability to manage the cities' resources, people, policies and stakeholders, designing and implementing legal regulations, as well as providing compliance mechanisms and processes in a standardized and continuous manner [16,17]. This comprehensive model shows that a smart sustainable city extends the smart city concept. The SSC is an interdisciplinary concept that comprises different domains where technology serves as a means and not as a goal in itself. According to a recent study [21], the improvement of the quality of life of urban residents and the enhancement of city functioning can be achieved through activities covering the five dimensions suggested by Azambuja et al. [16]. Thus, those dimensions were used in this study to guide the identification and classification of potential challenges and enablers for the development of SSC.

### *1.2. Governance of Smart Sustainable Cities*

Governance aspects are amongst the most important drivers for the development of cities [22]. Governance can be understood as the process of governing, which can be subdivided into different dimensions, such as structures and procedures [23]. It includes programmatic directions, budgetary and resource allocations, interactions with external actors as well as with different internal organizations, agencies, and departments [18]. These directions are usually described in formal institutions like policies, laws and regulations [23].

Governance is defined as the interaction and collaboration of different stakeholders in the decision-making process [24,25]. It represents the way cities organize internally with a strong focus on the empowerment of citizens, open government and collaboration, co-design and co-production, continuous improvement, acceptance and use of solutions, and the management of smart city stakeholders' motivations [26].

There are different governance paradigms, from the traditional and bureaucratic, to participatory and platform governance [27]. Speaking of urban governance, it is important to mention that it is not a matter of urban actors only, it requires actions from many actors [28], thus, the more appropriate paradigm for smart sustainable cities is one with a stronger focus on participation. In brief, participatory governance incorporates concepts of joint-up government, network governance and collaborative governance, including disclosure of information, citizen participation and monitoring [27]. Platform governance includes relationships of empowerment, coordination, value creation by citizens and collaboration [27].

In addition, smart governance can be defined as the use of collaborative governance and ICT-based tools to make better decisions by governments [29]. When bringing this concept to the smart sustainable city context, the focus is on the citizens' needs, making use of ICT to collect, integrate and analyse data to be used as input for decision making, engaging multi-stakeholders and using collaborative approaches [16]. The importance of governance is emphasized by the above-mentioned authors as the overarching component of SSC, providing the tools for ensuring socio-economic development and control over the environmental aspects of the city. Overall, smart sustainable city governance encompasses social norms, stakeholders, policies, partnerships, practices, data and information for

balancing the sustainability pillars by making use of urban infrastructure and information communication technologies to govern the smart sustainable city [16,17].

### *1.3. Existing Smart (Sustainable) City Roadmaps*

Roadmaps are vision tools used for different purposes so as, for instance, to facilitate the communication between different stakeholders. Phaal et al. [30] analysed around 40 roadmaps in order to suggest a classification of roadmaps in terms of their format and purpose. Regarding their graphical format, we can find roadmaps bars, graphs, flow charts indicating objectives, actions and outcomes, layer(s), tables, pictorial demonstrations, or text. Concerning their purpose, the most common roadmaps are used for planning, including the planning of capability, knowledge, integration, products, strategy, long-term, programmes and processes [30]. Likewise, an SSC roadmap should be able to offer an overview of the goals and objectives of the transformation route of cities, and to indicate the necessary activities and milestones to achieve the vision of the city for becoming smart and sustainable [31]. The review on existing smart city-related roadmaps resulted in a list of available roadmaps and their respective phases as presented in Table 1.

**Table 1.** Main phases of existing smart-city related roadmaps.

| Roadmap | Roadmap Main Phases | Reference |
| --- | --- | --- |
| An integrated service-device-technology roadmap for smart city development | 1—Preliminary activity<br>2—Development activity<br>3—Follow-up activity | [32] |
| European Platform for Intelligent Cities (EPIC) Roadmap for Smart Cities | 1—Vision phase<br>2—Plan phase<br>3—Design phase<br>4—Build phase<br>5—Deliver phase<br>6—Operate phase | [33] |
| SSC 6-step Transition Cycle | 1—Set the vision for the SSC venture<br>2—Identify SSC targets<br>3—Achieve political cohesion<br>4—Build a SSC<br>5—Measure the city progress<br>6—Ensure accountability and responsibility | [34] |
| Smart Sustainable City Transformation Roadmap | 1—City Vision<br>2—City Readiness<br>3—City Plan<br>4—City Transformation<br>5—Monitoring and Evaluation<br>6—Sustain Change | [35] |
| Six-step pathway for the implementation of responsive building envelope (RBEs) | 1—Define purpose of response<br>2—Identify scale and interdependency<br>3—Identify functionality<br>4—Identify trigger and control<br>5—Identify interactions and requirements<br>6—Identify technological solutions | [36] |
| Participatory Planning Approach Towards Smart Sustainable City Development | 1—Define problems and give them a level of importance<br>2—Identify goals for smart city development<br>3—Recommend development plan for short-term, medium-term, and long-term planning by formulating projects on platform of technology and innovations | [37] |
| Participatory planning for local sustainability guided by the Sustainable Development Goals (SDGs) | 1—Localizing SDGs<br>2—Data synthesis<br>3—Analyzing possible futures<br>4—Community engagement, objectives, and validation | [38] |

Source: own elaboration.

When analysing existing smart city roadmaps, most of them are focused on technology implementation, the so-called Technology Roadmap (TRM), as, for example, the roadmap

suggested by Lee et al. [32]. Others are addressing just one dimension of SSC, and not providing a holistic perspective. To illustrate, the specific roadmap suggested by Taveres-Cachat et al. [36] is focused on the implementation of a responsive building envelope (RBE) in projects. Only a few attempts can be considered as a holistic SSC roadmap, such as the 6-step cycle for "becoming" a SSC, developed by the ITU-T Focus Group [34] and the transformation roadmap of Ibrahim et al. [35], which proposed a new approach grounded on the Theory of Change.

A novel model, recently created by Bibri and Krogstie [39] for data-driven SSC, offers a strategic guide for transformation towards sustainability in the context of big data [39]. Other roadmaps are focused on participatory planning towards SSC development [37] and on participatory planning guided by the Sustainable Development Goals (SGDs) [38], which demonstrates an approach to co-create a local sustainability plan using the SDGs for a rural community aiming to align bottom-up local needs with top-down global goals.

The analysis of existing roadmaps showed alignment with Lee et al. [32], who explained that the road mapping phases can be broadly grouped into three main stages: preliminary activity, development, and follow-up. Another observation is that the available tools do not highlight important governance aspects. For instance, there is no phase for establishing and managing the creation of partnerships, or a phase for integrating new systems and to provide training mechanisms, which are key enablers of SSC [40,41].

## 2. Materials and Methods

In this paper, we followed the design science research (DSR) methodology, a research paradigm focused on the development of an artefact to solve a problem [42], with a focus on the relevance and rigour cycles proposed by Hevner [43]. Artefacts can be constructs (vocabulary and symbols), models, methods and instantiations (implemented and prototype systems), being developed in a search process that collect existing applicable knowledge from the knowledge base (guaranteeing rigor to the research) with the purpose of developing a solution to a defined problem [42]. In this study, the overarching problem consists of identifying the conditions for implementing smart sustainable cities initiatives through a governance perspective and the artefact is the SSC roadmap.

As part of the design science research process, the first step of this study consists of a preliminary literature review on smart sustainable cities to identify the main concepts that can guide the development of the SSC roadmap (see Section 2.1). The second step includes a systematic literature review to identify drivers and barriers for the development of smart sustainable city initiatives (see Section 2.2). In a third step, 12 smart initiatives were analysed to identify important governance aspects based on secondary data (see Section 2.3). This empirical analysis was combined with the data gathered in the literature review and supports the evaluation of the research outcome through the complementary analysis of real-world cases, forming the relevance cycle approach. The smart sustainable city governance roadmap and the guidelines for strengthening smart sustainable city governance capacity, the fourth step of the method, constitutes the final contribution of this paper to the knowledge base as part of the rigor cycle. This step included a survey and a workshop to collect feedback from experts to improve the quality of the suggested roadmap (see Section 2.4).

The method and results of the four steps are sequentially presented below. Figure 1 illustrates an overview of those steps.

### *2.1. Step 1: Defining the Main Concepts and Dimensions within the Smart Sustainable City Context*

Method. The literature background built the base for conducting the data collection and analysis. To describe the context, the research gap was identified and the most significant literature was documented that shapes the smart sustainable city topic, then a preliminary literature review was performed based on relevant references in the field and building on the preliminary framework developed by Azambuja et al. [16] (Section 1.1). To

identify and document the important aspects pertaining to governance paradigms, smart governance models and their main components, and relevant references addressing the governance aspects of SSC were reviewed and summarized (Section 1.2). Finally, a review on existing smart city roadmaps supported the preliminary definition of generic roadmap phases to be contextualized in the smart sustainable city domain (Section 1.3).

Results. The outcomes of Step 1 are presented in Section 1.1. Table 2 contains our main definitions, which resulted from the literature review.

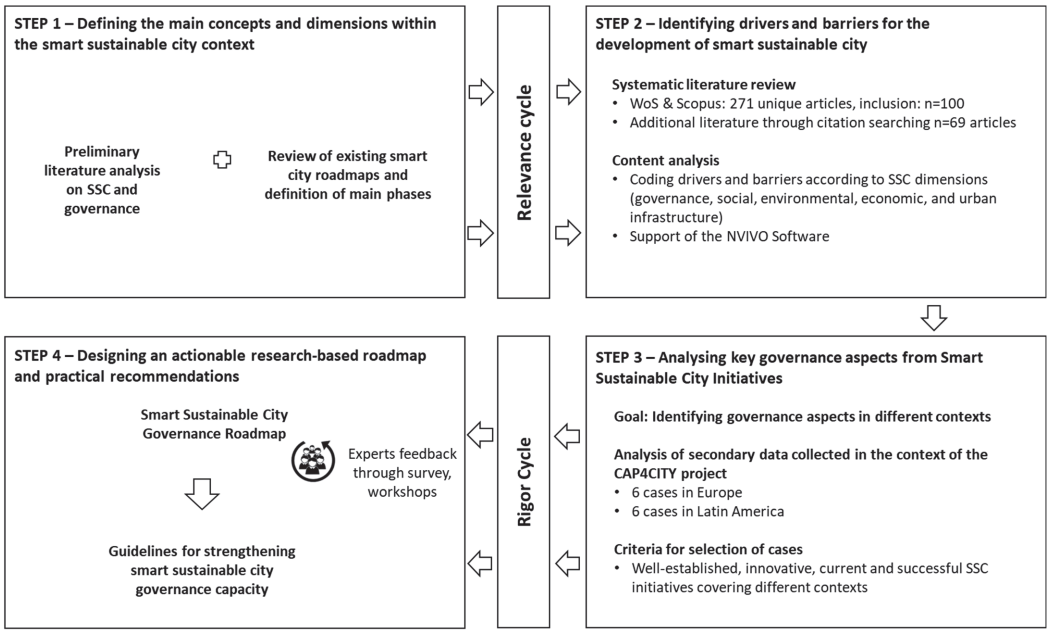


**Figure 1.** Overview of the four-step approach for developing a SSC roadmap.

**Table 2.** Main Concepts.

| Key Concepts | Definition |
|---|---|
| SSC | Smart sustainable city can be defined as a territory (urban and rural) in continuous transformation, enabled by digital technology and innovation, stakeholder engagement and collaboration, constructing human, institutional and technical capacities to solve problems and create new development opportunities, to raise and maintain the quality of life in communities, and pursuing sustainable development. |
| SSC Governance | Governance plays a key role in balancing the social, economic, and environmental dimensions of sustainable development and the use of the urban infrastructure, as well as the information and communication technologies to connect the elements of a region towards the development of sustainable and smart cities, communities, or territories. Ultimately, the governance of a SCC includes the definition and realization of locally appropriate paths to the development of smart solutions and the management of long-term relationships with stakeholders within and across government, business and societal sectors including citizen participation and co-decision-making in public affairs. |
| SSC Roadmap | A smart sustainable city roadmap is usually comprised of the following main phases: planning SSC initiatives (defining purpose, vision, plan, targets, etc.); implementing SSC initiatives (designing, building, implementing, integrating); adopting, monitoring, and evaluating initiatives (monitoring and assessing, communicating, and sustaining). |

Source: own elaboration.

### *2.2. Step 2: Identifying Sustainability Challenges for the Development of Smart Sustainable City Initiatives*

Method. The identification of main drivers and barriers for the development of smart sustainable cities was performed through a systematic literature review approach based on the PRISMA 2020 Statement [44] and the five-step method for data analysis proposed by Wolfswinkel, Furtmueller and Wilderom [45]. The first step was dedicated to defining the research plan, the inclusion and exclusion criteria. The second step was the search of relevant studies for review undertaken in May 2019 using Scopus and Web of Science. The query string used in the databases was: ((“smart sustainable cit*”) OR (“sustainable smart cit*”) OR (“smart and sustainable cit*”) OR (“sustainable and smart cit*”) OR (“smart sustainability”)), resulting in 271 unique records (the asterisk is used to retrieve variations of the term “city”). The full text of 204 eligible articles were first analysed, resulting in 100 eligible articles. An additional 69 publications were added for a better understanding of the SSC development process following the forward and backward method [45,46], resulting in 169 records. Using the NVIVO Software, the drivers and barriers were coded according to the SSC dimensions (governance, social, environmental, economic, and urban infrastructure). A total of 57 drivers and 63 barriers were found in the analysis of the 169 papers, mentioned, respectively, by 149 and 109 records. The results of the systematic literature review, which included 169 papers, are detailed in [47]. Combining the drivers and barriers from the social, economic, environmental, and urban infrastructure dimensions and translating those results into the context of the roadmap development, we defined 30 challenges of smart sustainable city development. Finally, the governance conditions included in the roadmap emerged from 118 papers that mentioned at least one governance driver or barrier.

Results. The literature review showed that there is still a lack of studies interrelating all smart sustainable city domains. Approximately 20% out of the 169 analysed papers addressed SSC in a holistic way, mentioning social, economic, environmental, governance, and infrastructure aspects. The dimension that accounted for more drivers and barriers was the governance domain, followed by urban infrastructure. Among the 169 analysed papers, 118 (70%) indicated a driver or barrier of the governance dimension, 103 (61%) of the urban infrastructure dimension, 76 (45%) of the environmental dimension, 63 papers (37%) of the social dimension, whereas 58 papers (34%) mentioned a driver or barrier of the economic dimension. Based on the list of 57 drivers and 63 barriers, we defined 30 sustainability challenges that guided the SSC governance roadmap, as illustrated in Figure 2.

### *2.3. Step 3 Analysing Key Governance Aspects from Smart Sustainable City Initiatives*

Method. Secondary data of initiatives from the CAP4CITY project (ERASMUS+ CAP4CITY Project on Strengthening Governance Capacity for Smart Sustainable Cities. Available at https://www.cap4city.eu/home/ access on 19 November 2021) database was analysed to complement the results gathered from the literature. The criteria used for selecting the cities was defined by the CAP4CITY project partners. Each project partner selected local cases of well-established, innovative, current, and successful SSC initiatives covering different contexts, from Latin America and Europe. For the current study, six initiatives from Europe and six from Latin America were analysed. The instrument used to collect data and to describe the SSC related initiatives was based on the instrument designed by Estevez, Lopes and Janowski [15]. The focus of analysis was on the governance aspects including “who” participated in the initiative (stakeholders), the approach, and best practices (evidence) to consider when developing the SSC governance roadmap.

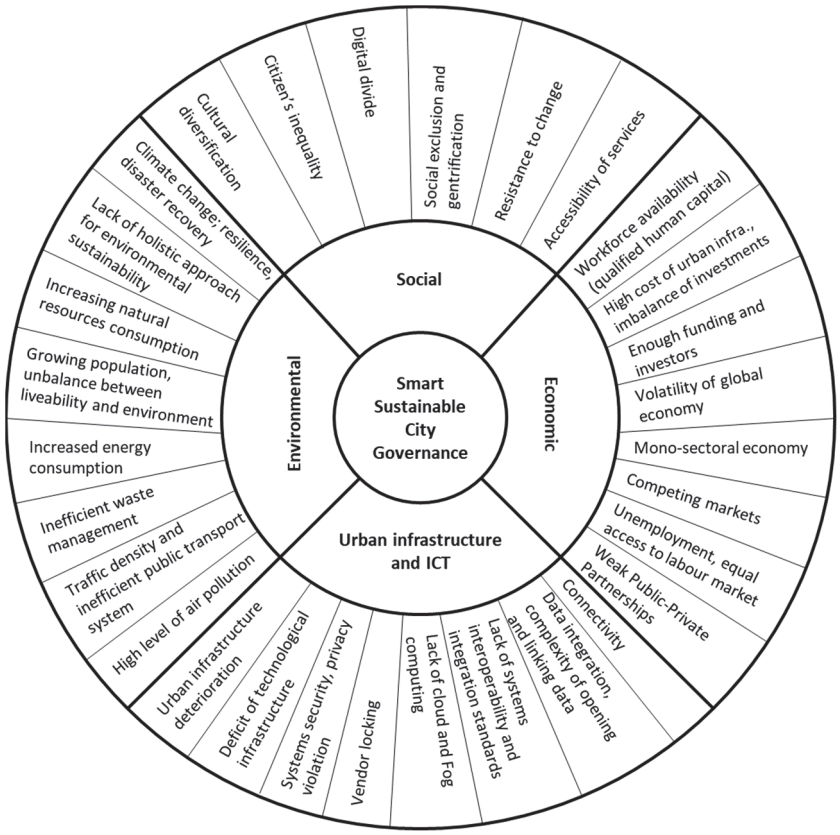


**Figure 2.** Sustainability challenges for SSC development. Source: own elaboration based on [47].

Results. Most of the cities engaged multiple stakeholders in their initiatives and promoted cooperation arrangements with the private sector, academic institutions and other cities and countries. The majority of initiatives had the government of the municipality as the lead organization; however, private companies, categorised as Industry, were the major partners developing assistance roles. Regarding the approach, top-down remains the most implemented approach. Bottom-up initiatives can be either citizen driven (in the cases of Santiago and Montevideo), or technology pushed (in the cases of Vienna, Copenhagen, Gdansk and Barcelona). In terms of the leading organization, most leading organizations were governmental ones, confirming one of the challenges found in the literature that the approach to SSC implementation is, in its majority, a top-down approach [48]. Table 3 summarizes the findings and presents some key aspects to consider for the design of the roadmap.

**Table 3.** Overview of South American and European SSC initiatives.

| SSC Initiative | Approach | Stakeholders (L = Leader P = Partner) | Evidence/Best Practice for the Roadmap |
|---|---|---|---|
| Vienna | Bottom-up; Top-down | Government: 2 L 15 P<br>Industry: 3 P<br>Academia: 6 P<br>Non-governmental organization (NGO): 3 P | Strategy definition; monitoring and assessment process; cooperation between science, public and private sectors; living labs |
| Copenhagen | Bottom-up; Top-down | Government: 1 L 2 P<br>Industry: 1 P Academia: 2 P | Integrated city data exchange; energy insight allowing households and business to see how much energy they use |
| Tallinn | Top-down | Government: 1 P<br>Academia: 1 L 1 P | Environmentally friendly and smart automated public transport |
| Helsinki | Top-down | Industry: 2 P<br>Academia: 1 L 1 P | Innovative public transport; research on the applicability or usefulness of self-driving buses for last mile transport |
| Gdansk | Bottom-up | Industry: 1 L 14 P<br>Academia: 7 PNGO: 5 P | Integration and coordination platform for urban systems to build applications across urban systems; methodologies and tools for creating real-time collaborative applications |
| Barcelona | Bottom-up; Top-down | Government: 2 L 10 P<br>Industry: 12 P<br>Academia: 5 P<br>NGO: 1 L 10 P | Strategy definition; new municipal government data model; CityOS; clear definition of roles and responsibilities; Chief Data Officer (CDO) position |
| Buenos Aires | Top-down | Government: 1 L 2 P<br>Industry: 2 P | New ways of thinking about public transport; public bicycle transport system individual and free to local citizens with online registration |
| Curitiba | Top-down | Government: 1 L 3 P<br>Industry: 2 P<br>Academia: 1 P | Urban development oriented to public transportation and resilience; innovation ecosystem |
| Santiago | Bottom-up | Government: 1 L 2 P<br>Industry: 1 P<br>Academia: 1 PNGO: 1 L 2 P | Exhibitions where companies, innovators, municipalities, universities, and small and medium enterprises (SMEs) participate, present their products and SC services; work for the development and massification of technology in Chile |
| Bogotá | Top-down | Government: 1 L 1 P | Connectivity deployment initiatives; digital government consolidation actions; citizen innovation initiatives based on ICT |
| Panama City | Top-down | Government: 1 L 2 P<br>Industry: 1 L 1 P<br>Academia: 1 P | Observatory of performance of the information technology (IT) sector, research and development (R&D) laboratory; instruments capable of transcending governmental changes |
| Montevideo | Bottom-up | Government: 3 L 3 P<br>Industry: 1 P<br>Academia: 1 P<br>NGO: 3 L 2 P | Interventions and applications systems initiated by citizens; availability of public open data inspired the creation of public solutions |

Source: own elaboration based on CAP4CITY project database (internal document)

### *2.4. Step 4: Designing an Actionable Research-Based Roadmap and Practical Recommendations*

Method. The roadmap was created based on the key governance factors identified in Step 2 of the research design and the evidence collected from the initiatives in Step 3, which were combined and described as "conditions" to develop SSC. The first version of the roadmap was validated through two workshops in Bogota and Medellin, Colombia (organised by the CAP4CITY project) and through one online questionnaire following

guidelines of Bradburn, Sudman, and Wansink [49]. The link was sent to the CAP4CITY project members, and 15 participants provided their feedback. Afterwards, a new version of the roadmap was proposed, which was presented and discussed in two workshops at international conferences (DG.O in June 2019 in Dubai and EGOV-CeDEM-ePart in September 2019 in San Benedetto del Tronto), attended by 15 and 10 participants, respectively [1]. Finally, another version of the roadmap was created and reviewed online by 11 experts from 8 countries (Argentina, Brazil, Chile, Colombia, Germany, Greece, Mexico and Spain) in June 2020. The previous versions of the roadmap provided the basis for the proposed SSC governance roadmap, which is described through phases, conditions, and steps in Section 3.

## 3. Constructing and Discussing the Smart Sustainable City Governance Roadmap

The resulting roadmap contains 11 key governance conditions for developing strategies for smart sustainable city initiatives that were classified into three main phases: (1) planning (preliminary activity); (2) implementing (development of initiatives); and (3) adopting, monitoring, and evaluating (follow-up). Each key condition is explained by some steps or recommendations; however, we highlight that the process of developing smart sustainable city initiatives follows a continuous and flexible approach, being comprised of non-specific key conditions that can be adapted according to the city context. Therefore, the linearity of the described conditions is a conceptual simplification. The roadmap is illustrated in Figure 3, and the key conditions are described below.

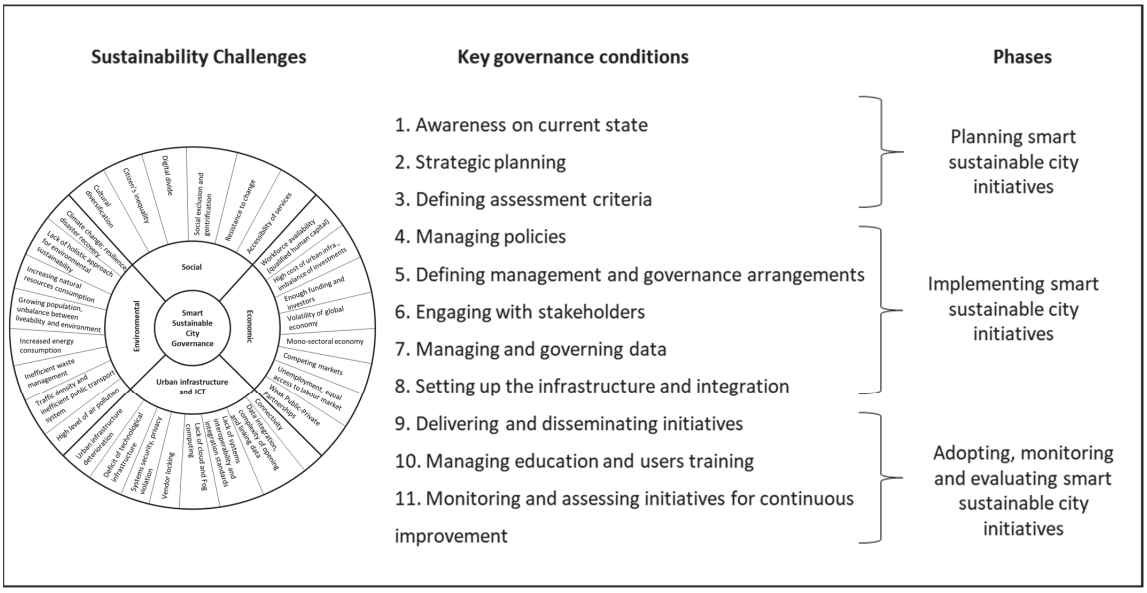


**Figure 3.** Smart Sustainable City Governance Roadmap. Source: own elaboration.

### *3.1. Awareness on Current State*

The roadmapping key conditions vary according to the approach used, but two definitions are strongly recommended: the identification of the current position and the definition of the 'desired situation', resulting in a gap analysis that serves as input for planning actions. Awareness on the current state is achieved by the conditions: 1.1 define stakeholders, 1.2 understand the context, 1.3 needs assessment and 1.4 risk assessment and management. Defining stakeholders refers to the identification of internal and external actors, since involving groups of stakeholders in smart city projects is important for the success of the initiatives [50] and to guarantee a multidisciplinary background. Critically understanding

the context includes the analysis of the political situation, societal problems, and local governance challenges; mapping of solutions and capabilities in place; understanding organizational structure, processes, and interactions; and external environmental scanning with stakeholders. Needs assessment reflects the perception of importance of the local needs, which may set the aims and values of the initiatives. Those are often related to social drivers, which include living aspects such as community needs and public provision of urban services (e.g., safety, culture, and recreation) [8,48,51,52], innovative healthcare and sanitation facilities, education facilities to elevate the literacy rate and to generate workforces [53–59], as well as accessibility and social inclusion initiatives to minimize a digital divide. That aspect is also strongly related to the sustainable concept of smart cities, in which the needs of the present should be addressed without compromising the ability of future generations [60]. Finally, risk assessment and management relate to learning from previous errors and assessing possible risks [61], including technology, organisation and external environment-related risks [62].

### *3.2. Strategic Planning*

One of the findings of this study relates to the importance of developing strategic planning for SSC implementation. Taking the examples of the analysed cases, Barcelona and Vienna have a defined smart city strategy, containing the city vision, plan of actions, assessment criteria, etc. Therefore, planning for the desired situation condition is achieved by the conditions: 2.1 develop a vision for smart sustainable city development, 2.2 plan human resources capacities, 2.3 plan infrastructure, 2.4 define a financial plan, 2.5 plan partnerships, and 2.6 seek for approval and commitment. Developing a vision for smart sustainable city development relates to setting the workplan and defining medium and long-term visions. Since the lack of capacity planning and lack of human capacity have been identified as barriers for SSC development, projects should be analysed thoroughly well before their initiation. Initiatives should have roles and responsibilities defined and documented to set expectations, including a leader responsible for promoting and monitoring the initiative's performance. Those aspects are to be addressed in the planning human resources capacities. Regarding the planning of infrastructure, this will vary depending on the context of application, since cities in more developed economies tend to have the basic infrastructure for implementing SSC in place while cities in developing economies may need to invest more in technology to implement such initiatives. It is also important to plan the strategies to integrate existing technologies [63].

Related to the economic challenges identified in the literature and case studies, defining a financial plan is necessary due to the high costs of urban infrastructure for SSC development (including both operational and maintenance). Therefore, prioritising investments to balance hard infrastructure (physical, hardware, sensors, systems) and soft infrastructure (capabilities) [64] is recommended, as well as seeking funding and investors through partnerships [15,23,48,65–69]. Partnerships between public and private organizations should be planned already in the early stages [4,67,70], as well as promotion of alliances, in particular between emerging industries [71,72]. Finally, seeking stakeholders' approval and commitment (political, societal, business, etc.) is another important recommendation, which includes ensuring the strategic ambition is supported by long-term policies [55,72,73] and that cooperation across organization boundaries is established for the implementation of SSC initiatives [74].

### *3.3. Defining Assessment Criteria*

Still under the planning phase, cities should define the assessment criteria to be used in the monitoring and assessment of SSC initiatives. According to Caird and Hallett, developing effective approaches for city measurement is very challenging, requiring a clear definition of the evaluation process [75]. Therefore, the defining assessment criteria condition is achieved by: 3.1 define key performance indicators (KPIs) (what will be

checked), 3.2 define assessment tools (how the KPIs will be checked), and 3.3 define performance evaluation plan (who will check the KPIs and when).

Regarding the definition of KPIs, the targets must be defined in order to monitor the progress of initiatives [72,74]. Huovila et al. [76] in their study provided a summary of indicators on SSC. According to the recommendations of the ITU-T Focus Group, Focus Group on Smart Sustainable Cities (TR on "Key performance indicators definitions for smart sustainable cities") at least six dimensions should be considered, namely, information and communications technologies, environmental sustainability, productivity, equity and social inclusion, quality of life, and physical infrastructure. That step is followed by the selection and use of compliance and monitoring and assessments tools to achieve the main evaluation goals. The literature presents a huge range of smart sustainable cities assessments [77], but a lack of standards. Some SSC assessment tools and frameworks are focused on sustainability indicators, others in emerging technologies; however, when assessing the SSC, both aspects should be integrated [64,76]. In addition, cities can use the Sustainable Development Goals indicators as a reference to create KPIs to monitor the progress of SSC initiatives. Finally, setting up a plan includes defining responsibilities (who) and the timeframe (when) of the performance evaluation to take place.

### *3.4. Managing Policies*

Establishing supportive government policies and ensuring political will are key aspects of implementing smart sustainable city initiatives due to the current ineffectiveness of policies. The managing policies condition is achieved by conditions: 4.1 identify existing policies and 4.2 review, update, create, integrate, and evaluate policies. Identifying existing policies is the first step, due to the multiplicity of policies and programs in different levels of government (local, regional, national) [59,78–81] and to ensure alignment between them. Addressing sustainability challenges requires a holistic and cross-sector policy approach to ensure the balance between economic, social, and environmental aspects, and being a governance-related issue, requires the right instruments to ensure policy coherence [82]. Therefore, for creating policies, a multidisciplinary team should be involved to understand the context-related challenges [83]. Finally, the process of creating policies should not be centralised; the adoption of participatory governance paradigms (e.g., joint-up governance, network governance) as well as collaboration across government departments and agencies is recommended [84].

### *3.5. Defining Management and Governance Arrangements*

Cities' lack of proper planning, strategy definition, monitoring and assessment practices can be a consequence of the lack of project management practices [8,85]. This condition is defined by conditions: 5.1 establish a governance model and 5.2 manage capacities. The governance model is defined by the clear definition of roles and responsibilities and may include the designation of a leader (also denoted as champion) to promote and supervise the SSC initiative [28,71,74,81,86,87]. One of the findings of the case analysis is the risk of discontinuity of initiatives in the next municipal administration. Therefore, it is important that the assignment of responsibilities is within the civil service to avoid transitions of political leadership resulting in the end of an initiative [88]. Considering that frequently the administrative structure of cities is organised in isolated silos (operational nodes), the governance arrangements should ensure internal coordination and cooperation within the city's agencies [48,74,89,90]. Enabling of information sharing and integration between municipal agencies is crucial for a collaborative governance [91].

Managing capacities is a transversal aspect for initiatives in the different sectors, including human resources management, infrastructure (urban resources) management and financial management. From an economic point of view, an important enabler is related to an effective management of urban resources [92], which aims to avoid waste and to maximise economic benefits. Other authors have called the sustainable management of resources as a Circular Economy [54,93] or Collaborative Consumption [93]. Ramaswami et al. suggested

multisector synergies for resource efficiency [94]; the authors explained that cities must increase their efficient provision of resources, as citizens are increasing their consumption; however, this provision should not come from one single provider, and cities should create opportunities for systemic multisector interventions. Regarding the financial capacity, the high costs of urban infrastructure for SSC development (including both operational and maintenance) was strongly stressed by academics [17,66–68,95–97]. The lack of funding and the challenge of attracting investors are key issues [15,23,48,65–69]. In addition, authors have criticised the imbalance between investments regarding hard infrastructure (physical, hardware, sensors, systems) and soft infrastructure (capabilities) [64].

### *3.6. Engaging with Stakeholders*

SSC is an interdisciplinary concept that connects different disciplines and multiple stakeholders. Engaging with stakeholders is achieved by the recommendations of: 6.1 engaging citizens, 6.2 engaging internal stakeholders and 6.3 engaging external stakeholders. Besides the social implications, engaging with stakeholders may tackle economic challenges by promoting innovative ecosystems and creating living and urban labs to help the development of smart sustainable cities initiatives, as reflected in the cases of Vienna and Curitiba. Urban labs have the potential to co-create value engaging users in research and development (R&D) [98] and provide an infrastructure for knowledge exchange and learning between all these actors [99,100]. The use of crowdsourcing is also an alternative way to foster urban innovation as it helps to generate new ideas serving as an engagement platform [65,71,101–104]. Stakeholder collaboration can be internal (cross-sector) or external, resulting in partnerships and approaches such as the "triple helix model" (public–private–academia partnership) or even the "quadruple helix" (public, private, university and citizens) [6]. A model for stakeholder engagement was suggested by Ibrahim et al. [86].

In particular, the engagement with citizens can be facilitated by online tools but also in traditional offline initiatives, which requires creating mechanisms to allow citizen participation and co-creation besides defining a clear communication plan. Since public participation is a crucial aspect for the sustainable development of a city, it is important to understand the reasons for participation or non-participation of citizens in local initiatives [78]. In addition, authors have stated that smart sustainable city initiatives should be transparent [17,48,94], make use of open government approaches [48,71,105,106] and should empower and engage citizens with the design of (interactive) services [18,71]. These aspects are reflected in the case of Montevideo, in which the availability of open data facilitates interventions and applications systems initiated by citizens in a bottom-up approach. Engaging internal stakeholders can be also understood as cross-sector collaboration and can be facilitated using coordination mechanisms, requiring the establishment of horizontal structures, to foster collaboration. Strategy definition could facilitate the work between multiple stakeholders [72] and help create synergy among different city departments [71]. Engaging with external stakeholders relates to the establishment of partnerships to avoid isolated silos (structures), promoting cooperation and coordination between organizations. This requires a partnership overview, the definition of the legal framework and consideration for the strategic alignment. Furthermore, the use of formal / ad-hoc forums is recommended to map conflicts, and the adoption of techniques to prepare and provide training to city partners [72]. Finally, it is important to consider how to manage stakeholders and how to motivate them to "work collaboratively" in the development of long-term initiatives, as illustrated in the case of Gdansk, by developing methodologies and tools for creating real-time collaborative applications.

### *3.7. Managing and Governing Data*

Another key finding relates to the importance of data for smart sustainable cities development. Therefore, managing and governing data is achieved by conditions: 7.1 ensure appropriate data management, 7.2 establish data governance strategy and 7.3 define security and data privacy policies. The need for data sharing across different systems was

strongly stressed by the literature [9,104,107]. Nevertheless, there are some challenges to overcome to make efficient use of the data. Data management comprises some technical aspects in terms of collecting, normalising (modelling imperfect data), and processing data to transform it into knowledge. In addition, it includes ensuring real-time data analytics, and interoperability of systems that should be capable of aggregating information coming from several systems and devices, which is illustrated by the cases of Gdansk and Copenhagen. The lack of data quality can affect data-based decision making and, consequently, the performance of urban services [108].

Some scholars also stressed the urgency of an "enterprise data management" in the public sector [109], and the importance of observing roles and responsibilities related to data management [110]. In this sense, questions as to who owns the data, which data can be used, and who is responsible for ensuring data quality should be addressed under the data governance strategy. Data governance means defining which data should be used, when and by whom, defining who is the data owner, ensuring compliance with data protection regulations and data privacy policies. In this sense, Barcelona has defined a municipal government data model, in which there is a clear definition of roles and responsibilities, and the establishment of a Chief Data Officer (CDO) position. Moreover, as more and more systems are (or should be) connected, more data is exchanged, consequently increasing the need for ensuring systems' security and protecting sensitive data [55,71,72,79,105,111,112]. In our literature review, several scholars mentioned the risk of threats from hackers, viruses, and privacy violation. Analysing privacy from a different perspective, Bennati and Pournaras [111] stated that big data and IoT are usually "privacy-intrusive" resulting in the feeling of surveillance that could have a negative effect.

### *3.8. Setting up the Infrastructure and Integration*

The implementation phase of smart sustainable city initiatives also involves the configuration of the technological infrastructure and integration with existing solutions and architecture. Thus, this condition is achieved by conditions: 8.1 implement the infrastructure of systems and devices and 8.2 ensure interoperability and systems integration. Concerning ICT, many academics have highlighted the complexity of ensuring connectivity, lack of operational integration, lack of systems interoperability, and data related issues. Disruptive technologies like big data through an IoT, and big data processing through AI bring emerging promises for a city's design and management [113]. Allam and Dhunny [112] mentioned several applications of AI that could benefit from the development of SSC, such as AI for education, environment, health care, policy, mobility and sustainability. Moreover, authors have mentioned the application of advanced ICT and developments in remote sensing, which allows the usage of satellite data for monitoring cities almost in real-time [48,114–118]. However, in order to benefit from the use of those emerging technologies, cities should have a robust infrastructure of systems and devices that are able to capture, process and spread data within different sources [71,97,119], and physical infrastructure integration—optical networks to support the communication of different data centres. Concerned with the importance of "connectivity", Zhang et al. [92] focused their work on the design of optical networks to support the communication of different data centres aiming to enhance network controllability, flexibility, and to reduce the cost of operational management, an aspect also addressed by the Bogotá case with connectivity deployment initiatives. In addition, it is important to use open sources, to facilitate the interoperability within systems and to avoid vendor locker. Some challenges related to this condition include technological obsolescence and the need for upgrading infrastructures [15,23,66,68,93,98,107,120–122]. Another aspect is the risk of vendor "lock-in" due to the use of proprietary software that makes the customer (in this case the city) dependent on the vendor or service provider [8,68,120].

### *3.9. Delivering and Disseminating Initiatives*

After the initiative implementation and integration to the existing environment, this condition aims at delivering and communicating the new or updated solution or initiative to ensure its adoption. This condition is achieved through 9.1 establish good internal and external communication. During the validation process, one of the experts suggested that this phase should be focused on the "appropriation" of the solution, in order to obtain its benefits. Cities should communicate about the initiatives using different channels to ensure social inclusion. Furthermore, to deal with multiple stakeholders (including citizens), establishing good internal and external communication [85] and feedback channels [71] is necessary. Therefore, it is important to investigate the communication methods being used by cities and their effectiveness in the governance process of SSC initiatives [78]. To promote the initiatives in the Santiago case, exhibitions were established where companies, innovators, municipalities, universities, and SMEs participated to present their products and SC services.

### *3.10. Managing Education and Users' Training*

The lack of capacity building, including a lack of investments in skills development, training, and education is one of the main identified barriers for the successful development and adoption of smart sustainable city initiatives. This condition is achieved through 10.1 manage education programs and 10.2 provide training for users. To ensure that capacity building occurs along with public sector innovation, cities should plan resources, including human resources and education programmes to implement sustainable initiatives. In addition, Yarime [104] highlights the need for creating capacity for data management. The lack of information technology (IT) knowledge is considered as a capacity issue, thus, it is a governance-related aspect. Besides the need of an operational IT workforce, scholars have described a lack of IT knowledge among public authorities and policy makers [123] for helping with digital transformation and identifying new ways to deliver urban services, as in the cases of Buenos Aires, Panama City, Tallin and Helsinki. Another benefit of providing users' training activities is to minimise the risk of a digital divide.

### *3.11. Monitoring and Assessing Initiatives for Continuous Improvement*

The development of smart sustainable city initiatives requires continuous improvement by monitoring the progress of all phases, and collecting, and sharing information within their realisation. This condition is achieved by 11.1 performance assessment and 11.2 feedback analysis and knowledge creation. The performance assessment is based on the criteria defined in condition 3 (defining assessment criteria) of the planning phase. Considering the importance of citizens' engagement in SSC, they should be strongly involved also in the evaluation of the initiatives. Cities should have a dedicated team or organization responsible for the "monitoring" of SSC initiatives and they should ensure the use of compliance and assessments tools [124]. Good practice examples can be taken from the Barcelona and Vienna cases, as both cities have an organization responsible for smart sustainable city related initiatives and projects. *Knowledge creation* is also part of this condition, as the idea is to collect user feedback, and to document the lessons learnt from existing initiatives; however, it is worthy of mention that if the city makes use of feedback channels, then public administrations should be able to reply and attend to requests under a predefined service level agreement.

## 4. Conclusions

### *4.1. Practical and Research Implications*

The first three steps of this research allowed for the identification of antecedents that may hinder or facilitate the development of SSC initiatives with a focus on the governance elements to ensure their long-term impact. The analysis of results suggests that a smart sustainable city is indeed a connection between the five dimensions, i.e., social, economic, environmental, governance and urban infrastructure, included in the conceptual framework

proposed by Azambuja et al. [16] and discussed in Section 1.1. Therefore, all the aspects of SSC are connected and all dimensions should be balanced to reach sustainability. The mindset should be towards a "whole city" [74], since isolated initiatives can contribute, but long-term impacts would be maximised by addressing the strategic vision of a city together in order to became smarter and sustainable.

The fourth step of this research elaborated on the SSC governance dimension resulting in a roadmap describing 11 key governance conditions for developing strategies for smart sustainable city initiatives. The roadmap is divided into three main phases, moving from the planning phase, as a preliminary activity, to the implementation of initiatives, and finally to the adoption and evaluation phase. The roadmap can be used to guide initiatives in different levels of development and therefore can be initiated in any phase or condition, in a recurring way. Since the process of developing smart sustainable city initiatives follows a continuous and iterative approach, in each development loop the governance capacities are enlarged. This study also generated several insights for a future research agenda on SSC, which have been translated into actionable research-based practical recommendations that can possibly lead to improvements on smart sustainable city governance capacity as follows:

- Urban/Local planning: define city/initiative strategy, considering a shared vision with stakeholders to promote city attractiveness and competitiveness, accessibility, and social inclusion, as well as environmentally friendly initiatives.
- Adaptive governance: analyse current situation, adapt to the context, allowing for flexibility and responsiveness to local challenges and needs.
- Leadership and proactive behaviour: define a dedicated organization, department, or person for promoting and supervising initiatives, and ensure urban proactiveness for service provision.
- Citizen empowerment: provide interactive and participatory services, promoting co-production, co-creation, and bottom-up approaches.
- Stakeholders' engagement: ensure internal (cross-sector) and external collaboration, including public–private partnerships enabled by information and knowledge sharing and appropriate communication channels.
- Resources: appropriate planning and management of infrastructure, financial and human capacity in a sustainable way.
- Data Governance: ensure appropriate management of data, with focus on the definition of data quality, data sharing and data privacy policies to enable data-driven decision-making and availability of real-time data.
- Governance arrangements: ensure clear definition of roles and responsibilities towards collaborative decision-making and participatory governance models.
- Institutional/organizational framework: establish supportive government policies, ensure political will, synergy among different city departments, policy alignment across government levels, internal coordination and align and manage conflicts of interests.
- Regulatory framework: establish a comprehensive regulatory framework, including norms, laws and directions for integrated solutions and ensure data protection, privacy, and security.
- Open Government and social responsibility: ensure transparency and openness and increase citizen awareness.
- Digital skills: strengthen access to training and education programs to increase IT knowledge among city planners and operational capacity, including IT skills, artificial intelligence, big data, networks, and security.
- Monitoring and evaluation: define KPIs and ensure the use of compliance and monitoring/assessments tools.

Thus, this study has the potential to help different stakeholders, such as decision makers, public administrators, and practitioners in the identification of sustainability challenges and governance aspects to be considered when developing SSC initiatives that can generate long-term impact.

### *4.2. Limitations and Future Research Directions*

Some limitations of this study should be acknowledged. First, the data collection for the development of the roadmap was performed in May 2019, including the systematic literature review and the analysis of the initiatives; however, for the systematic literature review, the authors verified a sample of 20% additional papers published up until October 2021 and no additional drivers or barriers were found, meaning that the study reached data saturation [125]. Thus, we may argue that the timeframe for the data collection does not affect the results of this research, confirming its relevance. Second, the authors used content analysis and followed an existing conceptual framework to guide the identification and classification of the phases and key conditions of the roadmap to guide the development of SSC, covering five main domains; however, a different perspective and the adoption of other conceptual models could indicate a slightly different set of conditions and smart sustainable city governance guidelines. In addition, as sustainable dimensions are often interconnected, some sustainability challenges and conditions identified in the roadmap could also be represented by overlapping categories or phases and they may vary according to different contexts.

We have also identified some aspects that should be further investigated. For example, some authors argue that the ineffectiveness of policies may hinder SSC development and in other contexts the barriers consist of the multiplicity of policies across different public levels, e.g., local, regional, and national. We highlight that the implementation of the roadmap for developing smart sustainable city initiatives should be aligned with existing smart city strategies or subnational strategies to ensure their institutionalisation. Therefore, defining the institutional framework that legitimises the development of smart sustainable cities, ensuring policy alignment across government levels, will improve their sustainability in the long-term. Another important contribution is that investments in emerging technologies should be accompanied by capacity building, since the lack of investments in skills development, training, and education is one of the main identified challenges. Governance capacity is often neglected by public sector innovation, despite being a crucial element to achieve sustainable benefits. Cities should invest in human resources and developing digital skills, for instance by supporting education programmes to implement sustainable initiatives. Furthermore, it is important to investigate if the universities are ready to address the transformation occurring in cities [20]. Thus, a next step of this research consists of using the roadmap as a basis for developing curricula for tackling the required competencies for smart cities and sustainable development. Finally, this research provides the basis for common understanding and action, by revealing the main phases and conditions for developing smart sustainable city initiatives and guidelines for strengthening the governance capacity needed to address the sustainability challenges, and to ensure long-term impact of the solutions. Additionally, as a design-science-based research, the innovation processes (conditions) continue to evolve once the roadmap (artefact) is evaluated in practice as part of the design cycle [43], therefore, multiple case studies are foreseen, in which the roadmap will be used for building and evaluating smart city initiatives, which may generate additional insights about local governance and sustainability challenges.

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

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## 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.



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## 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.

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## 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.

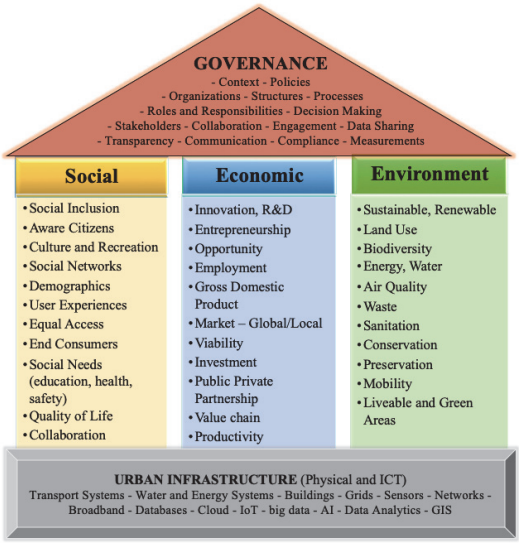


**Figure 1: Smart Sustainable City Conceptual Framework**

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 sustainable 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 concreate 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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**Publication V**

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# Devising an Urban Learning Centre for Municipalities in Eastern Partnership Countries

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**Abstract.** Municipalities worldwide face intricate challenges in promoting inclusive and sustainable development, often hampered by limited internal capacity. Trying to address these issues the Mayors for Economic Growth (M4EG) Facility, a joint initiative of the European Union (EU) and the United Nations Development Programme (UNDP), is devising an Urban Learning Center (ULC) seen as an ecosystem of learning programs, knowledge management, and stakeholder engagement to support municipalities in the Eastern Partnership (EaP) countries (Armenia, Azerbaijan, Georgia, Moldova and Ukraine). This research investigates how to foster capacity development in municipalities and discusses the learning needs of local authorities' members of the M4EG. An online survey was used to identify the learning needs and to define the learning programs to be developed and included in the ULC. The results of the survey reveal considerable interest in diverse learning domains, including project management, IT skills, funding, community engagement, and digital transformation. The ULC, an integral part of the M4EG Facility, seeks to foster collaboration, innovation, and foresight to address complex challenges and develop municipal capacity. By fostering innovation and collaboration, the ULC aims to drive positive transformations for a sustainable future. Future studies can be done to evaluate the ULC's effectiveness in strengthening public sector dynamic capabilities and promoting inclusive growth.

**Keywords:** Capacity Building · Capacity Development · Dynamic Capabilities · Smart Cities · Urban Learning Center · Knowledge Management

## 1 Introduction

Municipalities are constantly looking for ways to foster economic development in an inclusive and sustainable way. However, public authorities are facing complex challenges and are often lacking internal capacity to deal with them. A recent study stressed the need of strengthening the capacity of municipal systems to deal with diverse problems [1]. The


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lack of public sector capacity has been highlighted by the literature as a huge challenge for sustainable development [2–6]. This lack of capacity includes project management practices [7–9], lack of Information and Technology (IT) skills [10–12], among others. Furthermore, the so called "wicked problems" faced by public sector requires innovative approaches and the development of dynamic capabilities [13].

Considering this problem, the Mayors for Economic Growth (M4EG) Facility, a joint initiative of the European Union (EU) and United Nations Development Programme (UNDP) is devising an Urban Learning Center (ULC) seen as an ecosystem of learning programs, knowledge management and stakeholder engagement, supported by an online platform (https://www.sparkblue.org/urbanlearningcenter). The M4EG Facility was founded through a second phase of the M4EG initiative, launched and funded by the European Union in 2016/2017 to support Mayors and municipalities of the Eastern Partnership (EaP) countries (Armenia, Azerbaijan, Georgia, Moldova, and Ukraine), which represent post-soviet states that live in unstable economic, social, and political conditions. The M4EG Facility highlights that municipalities are at the forefront of crisis and opportunity, and these complex challenges require new models and modes of thinking, going beyond sector-specific or technical solutions [14].

In view of the need of developing capacity in the public sector and on the context of the M4EG project, this study aims to start the investigation on the following research questions:

- How to foster capacity development and continuous education in municipalities?
- What are the learning needs of local authorities' members of the M4EG?

The purpose of this article is to introduce the case of the Urban Learning Center as a way of fostering capacity development in municipalities and to discuss the learning needs of local authorities' members of the M4EG. The ULC is being developed as part of the UNDP M4EG Facility in partnership with Arup, EIT Climate-KIC and Tallinn University of Technology.

This paper is organized as follows. The next section contextualizes the research presenting the background of the M4EG Facility and a briefly conceptual overview of capacity development and capabilities in the public sector. Section 3 explains the methodology of this study and the process to devise the ULC, which includes a learning needs assessment survey sent to all local authorities' members of the M4EG Facility (350 members). The findings are presented in two subsections. Section 4.1 summarizes the results of the 166 responses obtained through the survey; and Sect. 4.2 introduces the Urban Learning Center. The last section brings final considerations, limitations of this research and suggestions of future studies.

## 2 Background

### 2.1 The M4EG Facility

The Mayors for Economic Growth Initiative was firstly launched in 2016, through the funds of the European Union (EU), but since 2021 the EU-funded M4EG has been managed by UNDP in close cooperation with the EU, local authorities, and other partners.

The first phase of the project was initially created as a four-year program of the European Neighbourhood Policy and Enlargement Negotiations (DG NEAR) to help local authorities in Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine in their economic growth and job creation [15].

Although the first phase of the M4EG program has increased the knowledge of the local authorities to plan their initiatives for economic growth, they still need guidance and capacity development. Thus, a second phase of the M4EG initiative was created, originating the M4EG Facility, a joint initiative of the EU & UNDP which aims to encourage creative thinking about urban and local areas, with a focus on positive transformation and future readiness.

The focus of the M4EG is on sustainable local economic development (LED) with the ambition to "support Mayors and municipalities at local levels to become active facilitators for economic growth and job creation by developing their capacities and technical skills and working in partnership with their private sector and civil society". The project proposes to be a demonstration project of what new trajectories of growth may look like in the EaP, and how additional financing can be mobilized at the local level. Among the objectives of the M4EG is facilitating the network of the EaP local authorities to learn, test, connect, and mobilize new partnerships and funding opportunities; introducing new ways to help addressing complex challenges faced by municipalities as inequalities, energy transition, conflict and refugee, and test these through a learning and iterative journey of implementing seed-funds at the local level [16].

One of the projects under the Facility is the development of an Urban Learning Center, aiming to be a learning and exchange platform between different stakeholders. The ULC will act as an ecosystem of learning opportunities for municipality staff and their partners, including learning pathways for the new generation local economic development plans (LEDP), green and digital transition, and adaptive leadership, strategy and foresight [16]. The proposal is to have a ULC able to provide training programs, hands-on activities and making use of innovative methods (deep listening, leadership, sensemaking, strategic planning and foresight) [17].

### 2.2 Capacity Development

The concept of capacity development emerged around the 1980s and gained growing attention around the 1990s, but it is still complex to be grasped and operationalized [18]. Starting with basic definitions, what is capacity?

Capacity is the ability of people, organizations and society as a whole to manage their affairs successfully [19]. They can be grouped in *three levels*, namely *Individual* (improving individual skills, knowledge and performance through training, experiences, motivation, and incentives); *Organizational* (i.e., improving organizational performance through strategies, plans, rules and regulations, partnerships, leadership); and *Enabling Environment* (i.e., improving policy framework to address economic, political, environmental and social factors including economic growth, financing, among others) [19].

Those abilities or skills are often grouped into "*hard*" areas (tangible and visible) and "*soft*" (intangible and invisible, social, and relational, including leadership, values,

behaviours, commitment, and accountability) areas. Furthermore, capacities can be classified according to their *types*, being *technical* capacities the ones related to one area as for instance health, education, etc., and *functional* capacities the cross sector ones, which usually refers to essential management skills that allow for planning, implementing and monitoring and evaluating initiatives for growth [19, 20].

Capacity building is "the process of developing and strengthening the skills, instincts, abilities, processes and resources that organizations and communities need to survive, adapt, and thrive in a fast-changing world" [21]. Nowadays, the term capacity development is used in preference to the traditional term capacity building aiming to give the idea of continuous improvement and not as something that is starting or being created from zero.

Another similar term found in the literature is *Capacity for development* defined as the availability of resources (human, financial and technical) and the efficiency and effectiveness with which societies deploy those resources to identify and pursue their development goals on a sustainable basis [22]. In a simple terms, "capacity is the means to plan and achieve and capacity development describes the ways to whose means" [20]. Developing capacity is considered a process of transformation and growth and the process is illustrated in Fig. 1.

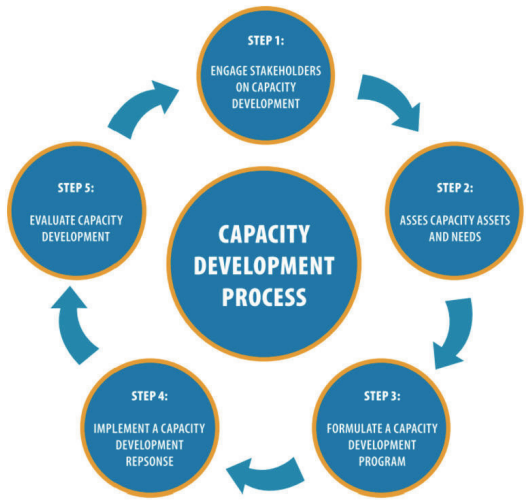


**Fig. 1.** The five steps of the capacity development cycle [20]

Developing capacity is a long-term process whereas outside partners can provide resources and facilitate the process, but it cannot be orchestrated externally, it must be embraced and guided by the individuals and organizations themselves [18, 23].

Another distinction to be made is the difference between capabilities and capacities, explained by Kattel and Mazzucato [13] as "Schumpeterian tradition of dynamic capabilities of the firm, and the Weberian tradition on public sector capacities to make policies". Talking about public sector capacity, it refers to the "set of skills, capabilities and resources necessary to perform policy functions – from the provision of public services to policy design and implementation" [24].

Dynamic capabilities are those which support dynamic actions, or the capabilities to anticipate, adapt and learn within and across organizations [24]. Public sector capacities revolve around the organizational structures within public institutions and dynamic capabilities focus on skills that enable changes [25]. Accordingly, public servants need skills and competencies that are able to face uncertainty as they often need to respond to rapidly changing environments [26, 27].

## 3 Methodology

This empirical research studies the case of the Urban Learning Center for municipalities of the Eastern Partnership under development as part of the UNDP M4EG Facility to foster capacity development among local authorities. The data of this study was collected from primary and secondary sources, including research and project deliverables, project reports, learning needs survey, and organizational websites.

The motivation behind the development of the ULC originated from the results of the first phase of the M4EG initiative and the need of new approaches for capacity development. As part of the project, the partners (UNDP, Arup, EIT Climate-KIC and Tallinn University of Technology) developed a survey to map the learning needs of the local authorities. The data collection instrument chosen was a written questionnaire, as this method is indicated when it is necessary to collect data from a large number of persons [28]. The purpose of the questionnaire was to map the needs and interests of the future users of the ULC; therefore, the results of the survey were used to define and prioritize the content to be included in the ULC and its delivery method. This follows the recommendation of the capacity development process suggested by UNDP [20] (see 2.2).

A first draft of the data collection instrument was developed in June 2022. After many discussions among the project partners, some adjustments were made to better match the profile of the respondents. The final version of the survey was translated in five languages (Armenian, Azerbaijani, Georgian, Romanian, Russian and Ukrainian). The survey was distributed by UNDP among all M4EG members in December 2022, the sample size included 350 local authorities. The list of questions can be found in Appendices, Appendix A1. In a broad way, the content and structure of the survey includes:

- Introductory text: what this survey is, what this will be used for and value in participation.
- General demographic questions.
- Existing learning opportunities and platforms.
- Expectations for new ULC – how to engage (quantitative select from list, plus qualitative final text box for additional comment).
- Learning needs and interests – what content (quantitative select from list, plus qualitative final text box for additional comment).

The survey data was collected between 7$^{th}$ of December 2022 to 13$^{th}$ of January 2023. The responses were translated to English and one of the project partners summarized the results and presented them during a collaborative project meeting. The data was

used to define the expected learning objectives of the ULC courses and the learning methods to be used [22]. The learning programs were defined in a collaborative process online and offline. The project partners realized a two-days' workshop at the UNDP office in Istanbul, Turkey, in March 2023 to discuss and design the first structure of the learning programs. Afterwards, the project partners have had online workshops to refine the learning outcomes and the final structure of the courses. The course structure, modules and content were reviewed by UNDP experts.

# 4 Results

## 4.1 Main Findings of the Learning Needs Assessment Survey

The learning needs survey aimed to identify the learning needs of the local authorities' members of the M4EG. A total of 166 local authorities of the EaP answered the survey. The distribution according to the language of responses can be seen in Table 1.

**Table 1.** Survey Respondents according to the language.

| Language | Count | Percentage |
|---|---|---|
| English | 0 | 0% |
| Armenian | 4 | 2% |
| Azerbaijani | 4 | 2% |
| Georgian | 24 | 14% |
| Romanian | 21 | 13% |
| Russian | 9 | 5% |
| Ukrainian | 104 | 63% |

Analysing the profile of the respondents, the majority are from a technical background including planning staff role (52%), followed by leadership or management (27%). The age range with more respondents are from 30–45 years (58.8%) and they can be considered as new in their role, as 50% of the respondents indicated that they are in their role from 1 to 5 years. Sixty percent of the participants are male and 40% female.

The results confirmed that there is a lack of project management knowledge, as highlighted by previous studies [7–9], as 67% of the respondents are interested in learning more about Project Management. Other high topics among the listed technical ones are Funding and Financing (63%), Community and Stakeholder Engagement (50%), Digital Transformation (46.7%) and City Planning (31.5%), as illustrated in Fig. 2 and 3.

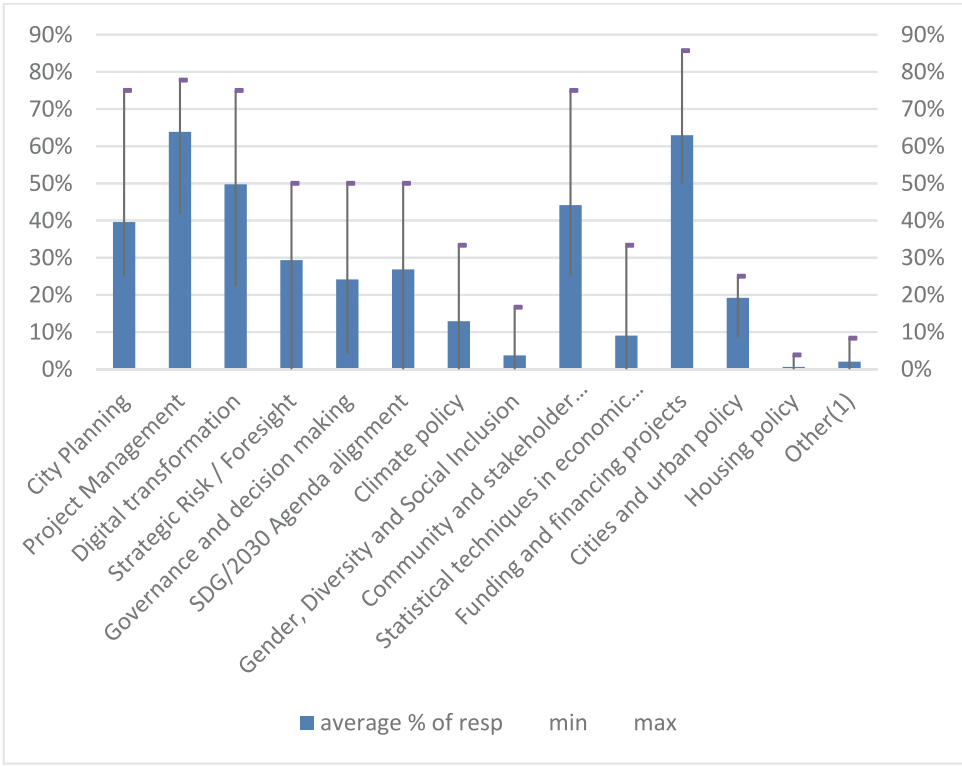


**Fig. 2.** Preferable technical topics.

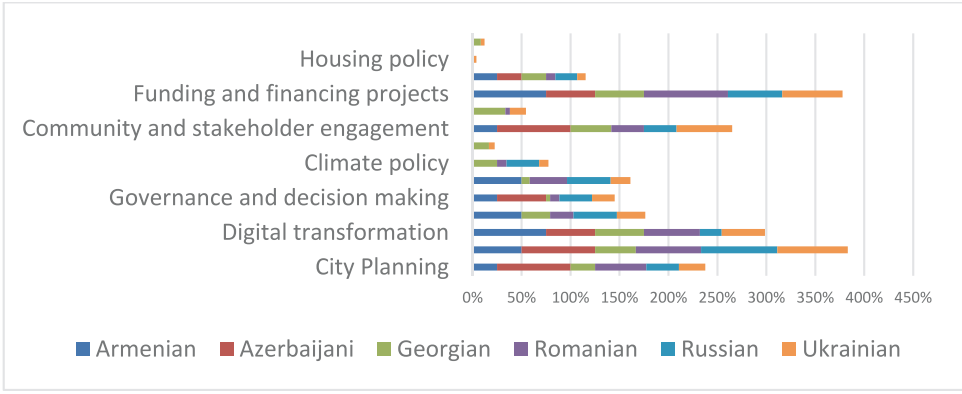


**Fig. 3.** Preferable technical topics (cumulative total of percentage of respondents per country).

In terms of soft and human skills, the topics that the municipalities are more interested in developing are Effective team collaboration (66%), Creativity and Innovation (64%), Strategic Leadership (43%) and Networking and City diplomacy (37%), as illustrated in Fig. 4 and Fig. 5.

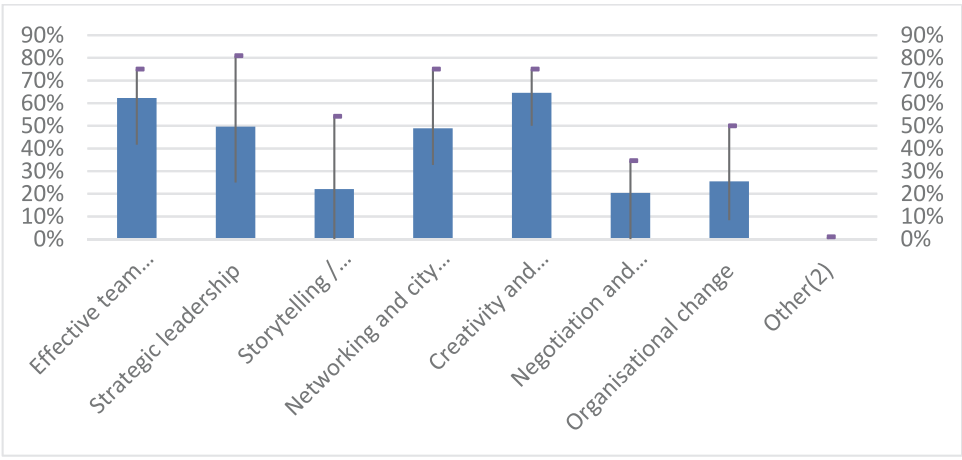


**Fig. 4.** Preferable soft/human skills.

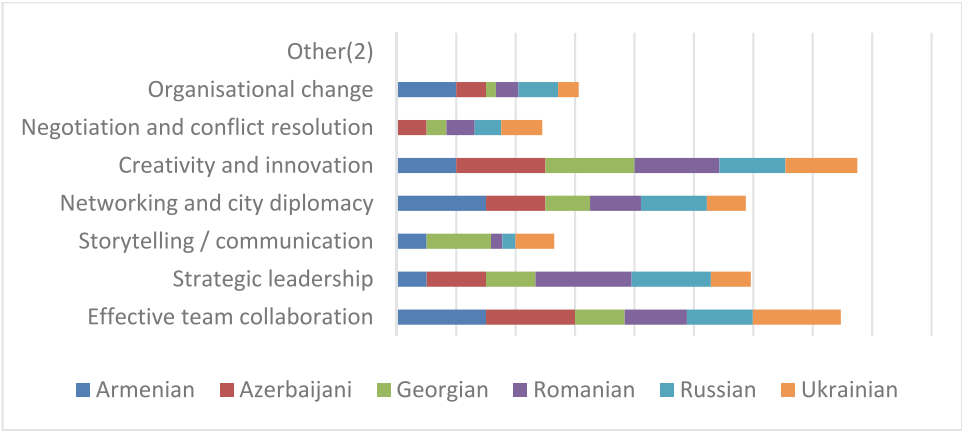


**Fig. 5.** Preferable soft/human skills (cumulative total of percentage of respondents per country).

Regarding the learning modules (question nine of the questionnaire) the respondents needed to score all modules indicating the relevance (1 not relevant, 2 relevant, 3 somewhat relevant and 4 very relevant). The results showed that they are interested in learning about attractive financing, core skills for economic development, alternative finance and crowdfunding, community engagement and inclusion and smarting your city, as illustrated in Fig. 6 and Fig. 7.

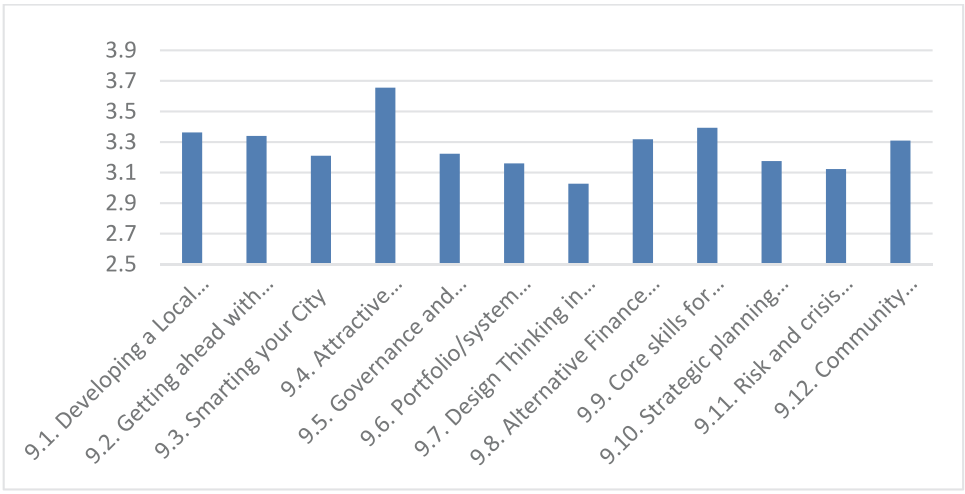


**Fig. 6.** Average score per course (4 very relevant, 3 somewhat relevant, 2 relevant and 1 not relevant).

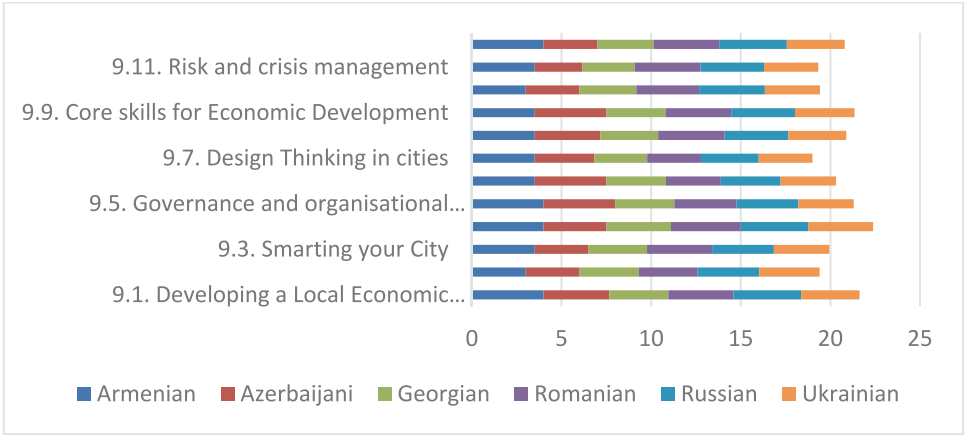


**Fig. 7.** Average score per course per country.

In terms of sources of learning, the respondents showed a majority interest in online courses and in terms of duration, short courses are preferable, of three months (61.8%) or long ones (15.8% prefer courses of 12 months or more).

The results of the survey are being used to define the priorities in terms of content to be developed and added to the ULC. We are also analysing the best method to use in the capacity development, according to the preference of the respondents.

### 4.2 Urban Learning Center

The ULC part of the second phase of the M4EG initiative, is under development based on the lessons learned from the first phase of the M4EG project and on the insights gathered

through the online survey. The ULC is created under the SparkBlue platform (https://www.sparkblue.org/urbanlearningcenter), which is a UNDP's digital platform for online engagement allowing collaboration across the international development landscape. The ULC under development:

- Provides a central point for the programme
- Repository of knowledge & information
- Delivers on-demand training packages (video presentation segments, guidance notes, further learning/reading, quizzes, evaluation feedback)
- Tracks learning activities and enables certification
- Signpost other learning
- Communicates activities and events (on & off-line)
- Enables peer-to-peer activities [29]

Figure 8 illustrate the components planned to be facilitated through the ULC.


**Fig. 8.** ULC ecosystem.

The ULC intends to introduce approaches beyond 'business as usual' with a range of tools and approaches with an 'urban makeover' intention, including foresight, social and community listening, sensemaking, adaptive and agile management, learning and monitoring effects, all with a strong focus on local solutions linked to the global objectives set out in the 2030 Agenda for Sustainable Development and its framework of SDGs [29].

The soft launch of the project happened in December 2022 and the launch of the first ULC course, namely Foundation for Future Readiness, happened on the 26$^{th}$ of July 2023. This course is a building block to a whole range of other courses that will be added under the ULC in the second half of 2023, including Smarter and Inclusive Cities, Green and Just Transition and Pathways for Economic Growth. The course content and videos are in English with translations to the Armenian, Azerbaijani, Georgian, Romanian, Russian and Ukrainian languages.

## 5 Final Considerations and Further Steps

This paper aimed to start the discussion on how to foster capacity development and continuous education in municipalities (research question one) and on the identification of the learning needs of the local authorities' members of the M4EG (research question two). The case study of the Urban Learning Center helped to answer the first question, as it is designed to be a learning ecosystem to foster capacity building and continuous education in cities, aiming to connect community members at different levels (see 4.2). The results of the survey (see 4.1) helped answering the second question of this study and serves as an initial step towards more comprehensive study in the future.

The main contribution of this paper is the provision of an empirical case study on capacity development in municipalities, which follows a different approach and create a network for knowledge sharing, aspects that were pointed by previous studies as a necessity. The ULC approach can be adapted and created in other regions. In addition, the method used for mapping the learning needs of the users can also be of help, as the questionnaire can be applied in other regions.

This research provides some practical insights and potential solutions for improving capacity development and to foster sustainable digitalization in municipalities, but we acknowledge some limitations of this study. First, the results of the survey could be complemented by focus groups or in-depth interviews with local authorities to gain a deeper understanding of their needs. However, this is not that simple considering the different languages spoken in the EaP. Another limitation of the study is that the respondents were in its huge majority from Ukraine (104 out of 166 respondents), but we considered the answers of all countries when analysing the data as the ULC is developed for all EaP countries and not just for Ukraine. Moreover, further investigation is suggested to provide more detailed insights, such as the examination of the learning needs of the local authorities based on different profiles (i.e., mayors and policy decision-makers, municipal leadership, municipal staff). In terms of theory, this study brought an overview of capacity development concepts and theories, but further studies could explore in a deeper way the theoretical basis of capabilities in the public sector and sustainability research, and on how the ULC case could, for instance, facilitate the development of dynamic capabilities.

In sum, considering the lack of capacity and the limited resources of local authorities, it is understood that conventional learning approaches are not enough. That is why the approach adopted by the M4EG ULC is based on continuous learning and co-creation of approaches. As the project is currently in place and the ULC launch just happened in the end of July 2023, it was not possible to analyse the concrete outcomes of the ULC in terms of capacity development. However, following the recommendation of performing a systematic learning on what is working and what need to be improved [23], a first round of feedback on the first ULC course was performed and it is possible to list some lessons learned to consider during the next phase of the project. For instance, online courses should use a simple language without long and complex sentences to avoid problems with the translation; key learning messages should be highlighted at the end of each chapter; it is important to bring examples to illustrate the statements; the course should be as interactive as possible providing spaces for discussions and reflections in each module.

As explained in 2.1 and 4.2, the ULC is part of an ecosystem and future studies could analyse other approaches used as part of the M4EG. In addition, we can suggest the investigation of other cases to understand how municipalities are investing in continuous learning, experimentation, and collaboration. It is important to learn from real cases of knowledge sharing among different municipalities that could benefit from similar solutions.

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# Appendices

## A.1 Survey Questions

0. Survey language
1. Which city, town, or local authority do you work in?
2. Which of these descriptions best describes your role?
   - Options: Political role, policy and decision maker, leadership/management role, technical, including planning, other.

   2.a If you selected Other, please specify: (open question).
3. How many years have you worked in this role?
4. What age range are you in?
5. What gender do you identify with?
6. What are the most pressing learning needs of your municipality? Please briefly specify.
7. Which of the following technical topics would be of interest for you and your colleagues? Please select your top 4.
   - Options: City Planning, Project Management, Digital transformation, Strategic Risk/Foresight, Governance, and decision making, SDG/2030 Agenda alignment, Climate policy, Gender, Diversity and Social Inclusion, Community and stakeholder engagement, Statistical techniques in economic analysis, Funding and financing projects, Cities and urban policy, Housing policy, other.

   7.a. If you selected Other, please specify: (open question).
8. Which of the following soft/human skills are of interest to you? Please select your top 3.
   - Options: Effective team collaboration, Strategic leadership, Storytelling/communicationNetworking and city diplomacy, Creativity and innovation, Negotiation and conflict resolution, Organisational change, Other.

   8.a. If you selected Other, please specify: (open question).

9. Which of the following learning modules would be of most interest for you and your colleagues?
   9.1. Developing a Local Economic Development Plan
   9.2. Getting ahead with Green Transition
   9.3. Smarting your city
   9.4. Attractive financing/resource mobilization for local authorities
   9.5. Governance and organisational innovation for municipalities
   9.6. Portfolio/system thinking in cities.
   9.7. Design Thinking in cities
   9.8. Alternative Finance and Crowdfunding
   9.9. Core skills for Economic Development
   9.10. Strategic planning for climate adaptation and resilience
   9.11. Risk and crisis management
   9.12. Community engagement and inclusion
10. When was your last training or learning opportunity?
11. What learning opportunities currently exist for you?
12. Which online tools, if any, do you use for knowledge exchange and learning purposes?
13. Please briefly comment on what you like and/or what you don't like about the current learning opportunities.
14. What learning functionality do you think you would benefit from the ULC platform?
   14.1. Access to general online courses on various topics relevant to your municipality.
   14.2. Access to skills-oriented masterclasses (e.g., developing business cases).
   14.3. Possibility to find or interact with regional and global experts via discussion forums.
   14.4. Possibility to find or interact with peers in a similar role via discussion forums.
   14.5. Interaction with cities in your country.
   14.6. Interaction with cities in the Eastern Partnerships region.
   14.7. Would you like to be part of a cohort-based learning programme?
   14.8. Co-creation tools and support for involvement of citizens.
   14.9. A knowledge resource bank with downloadable documents and links e.g., policies, studies, strategy documents, guidance notes, etc.
   14.10. Inspiration resources with downloadable documents and links e.g. case studies.
   14.11. Lessons learned via various resources (i.e., a learning repository of train-the-trainers' videos, blogs, and tutorials).
   14.12. Other expectations – please elaborate.
15. How important is it for you to have the content of the learning centre in your local language?
16. What is your preference for in-person vs. online learning?
17. How much time are you able to commit to learning within a month?
18. Is learning best scheduled within normal working times or outside normal working times? e.g., evenings or weekends.

19. Would you be willing to participate in a follow up meeting/workshop for helping the definition of the content to be included in the Urban Learning Centre?
20. I would like to get involved in the definition of the content.
21. I would like to receive updates on the progress of the ULC.
22. Do you have any important final comments to add that you feel has not been covered in the survey?

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# A SMART CITY INITIATIVE:
# A Case study of Porto Alegre 156

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## ABSTRACT
Many cities around the world are investing in "smart" ways to manage the problems associated with urbanization and agglomeration of people. The challenge is how to implement initiatives to attend citizen's necessities aiming a better quality of life. The purpose of this paper is to describe the "156 Speaks Porto Alegre", channel driven to citizen municipal demands, and investigate its integration and relationship with the eight dimensions of the *Smart City Initiatives Framework:* technology, management and organization, policy context, governance, people and communities, economy, built infrastructure, and natural environment. The main findings show that coordination between agencies and departments are needed to achieve citizen better quality of life. They also demonstrate that the use of the right technology is really important and a smart city initiative must have mobility and easy interaction with citizen. Finally, interdepartmental collaboration and cooperation are considered central issues to achieve initiatives' objectives.

## Categories and Subject Descriptors
H.4.2 [**Information Systems Applications**]: Type of systems – *e-government applications*

## General Terms
Management, Performance, Human Factors, Standardization

## Keywords
Smart city, Service integration, E-government


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## 1. INTRODUCTION
People around the world are moving to cities in greater and greater numbers, according to the United Nations Population Found (UNPF) the world is undergoing the largest wave of urban growth in history and the number of people living in towns and cities is expected to increase to 5 billion until 2030 [19]. It is not easy to manage this growth and good governance is needed to find a *smart* way to attend the density of urban life. Nam and Pardo, complement [15]:

> "With the rapid increase of the urban population worldwide, cities face a variety of risks, concerns, and problems; for example, physical risks such as deteriorating conditions in air and transportation, and economic risks such as unemployment" (p.282).

Chourabi et al. [5] relate that the urgency around this challenge is triggering many cities around the world to invest in new "smart" ways to manage the problems conceptualizing smart city as a sustainable and livable city. The challenge is how to implement and integrate initiatives aiming to attend citizen's necessities.

Exploring an extensive array of literature from various fields, *a Smart City Initiatives Framework* was proposed by Chourabi *et al.* [5] identifying eight critical factors of smart city initiatives. This framework helps to understand city government-driven initiatives to make a city more efficient, effective, attractive, competitive, sustainable, equitable and livable.

The purpose of this paper is to analyze the initiative "156 Speaks Porto Alegre" in terms of integration and interoperability taking into account the eight dimensions of the *Smart City Initiatives Framework,* suggested by Chourabi *et al.* [5].

The integration and interoperability are fundamental issues to enable a service that seeks to be a contact channel for numerous municipal services from different departments. In the same way, the model proposed by Chourabi et al. [5] makes a deep analysis on smart city initiatives being a great instrument for this study.

Porto Alegre is the capital of the southernmost state in Brazil, Rio Grande do Sul, having 1.409.351 inhabitants [8]. In November 2012, Porto Alegre was recognized by IBM's "Smarter Cities Challenge Program Summit" as one of the 31 winning smart cities

around the world. In this summit, they reviewed innovative solutions to the major challenges faced by cities [7]. Starting by a case study of Porto Alegre's 156 (known by "156: Fala Porto Alegre"), a contact channel between the city and citizen, this paper aims to research its relationship with the Smart City Initiatives Framework [5].

This study is organized as follows: first, a review of the academic literature on smart city and an explanation of the *Smart City Initiative Framework*. The subsequent section explains the method of data collection and the case study. The following section reports the findings of the qualitative analysis of the data from semi-structured interviews in Porto Alegre. The final section presents concluding remarks and suggestions.

## 2. CONTEXTUALIZNG SMART CITY

There are a lot of studies to define and clarify the meaning of Smart City as well as researches proposing systematic understanding of initiatives that make a city smarter. The smart cities concept goes beyond the purely technological aspects of urban development. They are typically referred to as 'digital' or 'intelligent' cities, terms that encompass social and environmental dynamics [18].

### 2.1 Defining Smart City

Smart city reflects a city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive [5], independent and aware citizens [10], (p.11). Taking in account where do the investments are made, Caragliu *et al.* [4] define Smart City:

> […] a city to be 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 (p. 70).

Alwadhi *et al.* [2] provide definitions according to their interviewees: "a smart city is also about proactive service and government action internally as well as interaction with citizens" (p.1697). Their research also detected two elements in all smart city-related discussions: "(a) policy orientation along with the political will aimed at becoming smarter in government actions and interactions and (b) the reliance on modern information technology as a backbone and enabler for doing so" (p.1701). According to Nam and Pardo [15], a smart city is one city with a comprehensive commitment to innovation in technology, management and policy.

Smart City is also used to discuss modern technology and the usage of new channels of communication for the citizens as e-Governance and e-Democracy. This reflects the relation between city government, administration and its citizen allowing good and smart governance. Various aspects referring to life in a *smart* city are also necessary like ICT, modern transport technologies, logistics, new transport systems which improve the urban traffic and the inhabitants' mobility [10].

### 2.2 Smart City Integrative Framework: Components

Chourabi *et al.* [5] identified eight components or critical factors of smart city initiatives, based on the exploration of a wide and extensive array of literature from various research fields such as e-government, local government administration and management, and information systems. The eight clusters of factors include: (1) management and organization, (2) technology, (3) governance, (4) policy, (5) people and communities, (6) the economy, (7) built infrastructure, and (8) the natural environment. The Figure 1 illustrates the framework and the factors interrelations.

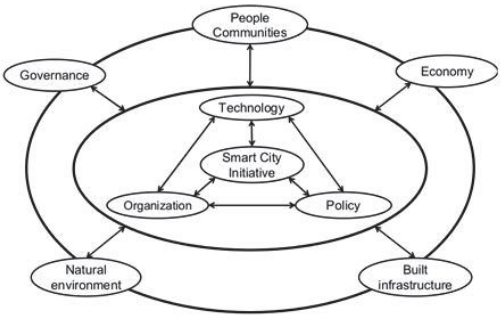


**Fig 1. Smart City Initiatives Fremework (Source: Chourabi et al., 2012).**

According to Chourabi *et al.* [5], all factors should have a two-way impact in smart city initiatives (each likely to be influenced by and is influencing other factors), at different times and in different contexts [5]. Also, there are two different levels of influence, outer (governance, people and communities, economy, infrastructure and natural environment) and inner factors (technology, organization and policy). As the name *says* this is an *integrative* framework in which the attributes have a connection.

#### *2.2.1 Management and organization*

Organization is one factor under the Integrative Framework proposed by Chourabi *et al.* [5] that has a direct connection with *technology* and *policy* factors. Interdepartmental collaboration and cooperation through sharing information and the role of communication and interaction are central to proceeding, managing and organizing smart city initiatives [1].

Gil-Garcia and Pardo [12] listed strategies for initiatives grouped into five categories being *Management and Organization* , whose challenges are: "project size, manager's attitudes and behavior, users or organizational diversity, lack of alignment, multiple or conflicting goals, resistance to change and turf and conflicts" (p. 191) Managerial and organizational strategies for meeting those challenges suggested by Gil-Garcia and Pardo [12] are good communication, adequate training, previous process improvement end-user involvement, planning, project team skills and expertise, well-skilled IT leader (technical and social skills), clear milestones and measurable deliverables, adequate and innovative funding, current or best practices review ( p.194).

#### 2.2.2 Technology

Smart cities should use the technology to better connect seven critical city infrastructure components and services: city administration, education, healthcare, public safety, real estate, transportation, and utilities. Washburn *et al.* [21] (p.2) emphasis technology in this smart city definition: "What makes a city a smart city is its use of Smart Computing to deliver its core services to the public in a remarkably efficient manner...".

Smart city initiatives involve adopting new systems and the government has new opportunities from emerging technologies. Having different contact channels, like social media and smart phones [1] are vital to improve efficiency and effectiveness of service delivery and information provision [18].

Nowadays the usage of *smart* means innovative and transformative changes driven by new technologies [15] but traditional challenges around technologies still exists, like: under-equipped conditions; cost of upgrading back-office technologies; timing of investment of the right technology at the right time; lack of staff and budgetary constraints; lack of interoperability and also technological complexity and incompatibility [1, 12, 17].

Taking in account the importance of technology and all the opportunities it provides, having a good computing infrastructure is a key component of a smart initiative. A plan containing solutions to address all possible challenges is also needed.

### 2.2.3 Governance

Governance [13] (p. 523) involves the "relationships control and accountabilities of shared services organizations is diverse [...]. The term governance structure is used to outline the hierarchy of committees, boards, bodies, or forums that execute the management".

Governance structures, according to Alawadhi *et al.* [1], are embedded in all stages of any project: starting from conception of a smart city initiative, through initiation, through design, construction, and closeout (or maintenance in permanent projects). There is no uniform governance model for smart city initiatives, they could be participatory, hierarchical, and/or hybrid models. In same way, there are diverse organization forms that lead an initiative like committees (having strong authority to command and manage the initiatives) or one particular city agency or departments taking the lead to organize a smart city initiative.

Chourabi *et al*. [5] defined, from literature review, a list of *governance* factors as collaboration, leadership and champion, participation and partnership, communication, data-exchange, service and application integration, accountability and transparency.

### 2.2.4 Policy Context

In reference to the Smart City Initiatives Framework the policy context comprises political components (city council, city government, and city major) and institutional components (law, regulation, code, and intergovernmental agreement) [5]. According to Alawadhi *et al.* [1] the policy context of a smart city initiative is represented by interdepartmental agreements and this context are shaped by executives' directions.

### 2.2.5 People and Communities

A smart city should know citizens' wishes and needs and their opinions as many initiatives request their ideas and feedback on governmental efforts [1]. In this way, People and Communities factors indicated by Chourabi *et al.* [5] are participation and partnership, communication, education, quality of life, accessibility, digital divide(s), information and community gatekeepers.

### 2.2.6 Economy

In the context of urban economy: "smartness indicates overcoming economic challenges, creating new jobs and businesses, and increasing regional attractiveness and competitiveness" [1]. According to Chourabi *et al.* [5] economic outcomes include business creation, workforce development, and retention, and improvement in productivity. Smart city initiatives should find more innovative ways and solutions using limited resources effectively in order to overcome economic challenges such as budget cuts and financial recession across countries.

### 2.2.7 Built Infrastructure

Information and communication infrastructures are fundamental because they create capacity to deliver city services seamlessly to residents and businesses. Chourabi *et al*. [5] ensure that ICT infrastructure is essential but it depends on some factors related to its availability and performance. Challenges associated to this dimension are indicated into three categories: (1) IT Infrastructure; (2) Security and privacy; and (3) Operational cost.

### 2.2.8 Natural Environment

Green infrastructures and green building practices are important and wanted nowadays. Alawadhi *et al*. [1] attest cities' responsibility affirming that they are socially responsible to make various options available in order to be able to remain green and environmentally sustainable. Energy saving and environment protection are a tag for smartness in one city. Became a greener city or go green is included in the cities' strategic goals.

## 2.3 Service Integration

The technology needed to manage transactions and technology infrastructure to support the whole system of an initiative such as "156: Fala Porto Alegre", needs an effective integration to ensure perfect coordination and delivery of services within appropriate levels. This need is due to the multiplicity of actors involved as initiative's user, attendants, employees from agencies that execute the service requested, program managers, etc.

In the technology context, database integration is an important differential that provides the governments' economy of scale, improve repositories of equipment and reduction of transaction costs "that must be the starting point to make business processes more effective and increase citizen satisfaction with the products offered" [3]. Moreover, integrating databases of different formats, which serve different requirements, belonging to various public entities, represent significant obstacle to your success [14].

E-government, the system of government that seeks, through the use of information technology improve processes and services delivered to citizens, the public administration, democratic and social development mechanisms [11], it is closely related to smart cities, may this is considered the first subfield. From the perspective of e-government, integration can occur in two forms: vertical and horizontal. In the vertical plane, integration involves different levels of government such as city and state, for example, while the vertical is within the integration of services and databases, for example, many of the same governmental' s core [14].

In a survey conducted among the employees of the city of Seattle on the concept of smart city, the results obtained showed that the integration of information in terms of technology and services featuring a smart city management [2]. One of the approaches of smart city approximates the electronic government position as it relates to the topic, since it involves the integration of infrastructure and municipal services through information and communication technology [15]. The concept presented by Aldama-Nalda et al. [23] reinforces the arguments:

> A smart city can be understood as the use of smart technologies to build and integrate critical infrastructures and services of a city and it denotes the important cities' efforts to catch the diverse benefits from technology use, such as increases in efficiency, effectiveness, transparency, convenience, and sustainability (p.1).

The model of Elementary Components of Smart City [and] establishes three key factors - human, institutional and technological - which in turn are realized by three principles: learning for human factor, governance of institutional factors and integrations of technology factor. From the view of the latter principle, the smart city concept is linked to an organic network that involves the integration of technology, systems, infrastructure, services and capabilities [15].

The seminal model of smart city initiatives from Chourabi et al. [5], which describes itself as "integrated conceptual, framework to guide future 'smart city' studies", relates the integration in technological areas - hardware, software and network technologies -, governance in terms of services and applications, and economics, in relationship to the local and international markets, demonstrating the relevance of the topic within the smart concept of governing municipals.

The manifestation of the academy regarding the integration leaves no doubt about the importance of the subject in the realms of e-government and smart cities. Important therefore to examine, through the testimonies of the respondents, the "156 Speaks Porto Alegre", which meets the level of integration, an initiative whose characteristics may be presumed that this is one manifestation of smart.

# 3. METHOD

The initiative 156: Speak Porto Alegre, which is analyzed in this paper, was selected due to increasing importance of service integration in Porto Alegre and a whole world. The integration, therefore, is the core of what is intend to be investigated, and the Smart City Integrative Framework is the instrument used to implement the research.

The purpose of qualitative research is to understand social phenomena of multiple realities from respondents' perspectives. This paper uses qualitative case study methodology to understand the city initiative. This type of case study is used to explore those situations in which the intervention being evaluated has no clear, single set of outcomes [22]. Accordingly, should be noted by Dubé and Paré [6] that claim:

> Case research, in its versatility, can be used with any philosophical perspective, be it positivist, interpretivist or critical. It typically combines several qualitative data collection methods such as interviews, documentation, and observations, but can also include quantitative data such as questionnaires and time series (p.598).

## 3.1 Data Collection

The initiative's coordinator, as an initial informant with a comprehensive knowledge of the organization, was asked to recommend others who have sufficient information and knowledge in various aspects of 156's operations. The coordinator provided a list containing suggestions of staff employees to be interviewed. Key informant interviewees are qualitative in-depth interviews with people who know what is going on in the initiative.

The participants were selected in three steps: 1) review of coordinator's list; 2) relationship between profiles and research objectives; 3) selection of suitable profiles. The interviewees were from functions such as initiative coordinator, manager, attendant and technology expert from Data Processing Company of Porto Alegre (PROCEMPA) and are mentioned as: interviewee 1, interviewee 2, interviewee 3, interviewee 4 and interviewee 5 in this paper.

The interview protocol was originally created by the "Smart Cities Service Integration" project team, constituted by several universities worldwide and managed by the Center for Technology in Government (CTG), linked to the University of Albany, USA. The interviews occurred from August to September 2013 and each face-to-face interview lasted between one and a half and three hours. The technique's advantages are that it provides a free-exchange of ideas, and lends itself to getting more detailed responses. Each session was recorded and transcribed and additional information was collected through follow-up email communication.

## 3.2 Case Description

The 156: Speak Porto Alegre initiative sits in the SMGL (Municipal Secretariat of Local Governance). The structure was established by the Law 9.693 dated December 29th, 2004 and also Decree 14.816, dated January 27th 2005. The "156" is a unique channel to attend population demands and non-emergency services, available every day. All requests for transit services, tree pruning, water, sewerage, street lighting, street paving, garbage collection, tourist information, municipal taxes, among others, can be routed via 156.

The 156 started on September 1984, but the population still had to know the number of each call centers specialized like traffic agent, municipal guard, etc. Since 2011 the 156 is the central channel for city services request. The citizen just needs to remember one number and select the option (1-9) according to their needs. The 156 option 9 is called "Speak Porto Alegre" and works from 7 AM to 11 PM. According to interviewee1 the 156: Speak Porto Alegre really wants to give the message "Population: speak through the 156".

In the beginning there were just eight employees and today there are 62 people working in the 156: Speak Porto Alegre (option 9). There are 52 attendees and 10 supervisors (managers, coordination) divided in three shifts (morning, afternoon and night). As this is a public service, all employees were hired through public selective exam.

Any citizen can request a service using the telephone or the Internet. If using telephone, the citizen calls 156 and select the option '9' to talk to one attendee. The attendee asks questions about the service request/information and opens a "request" in the system. According to the service type, it is automatically routed to the specific agency. When this initiative started, there were like 20-30 city services. Currently, there are around 349 types of services and more than 20 organizations involved in this initiative.

Each request by phone or Internet generates a protocol number to track the service resolution. In the last year the 156 received 1,6 M calls and option 9 alone received 440.000. From this amount, 368.000 requests were open and routed.

# 4. DATA ANALYSIS AND DISCUSSION

A smart city, according to interviewee 1, should have mobility, information access, facility and agility: “You should look for something and it might be easy, not complicated. A smart city needs to have a place where you can get anything you need (services) in a simple and easy way”. The interviewee 2 believes that a smart city should have an infrastructure able to interact with the citizen in any contact channel at any time. There is a need of mobility: “the citizen should be able to notice a street hole and instantly open a request to have it fixed, upload pictures at the time”. See below the initiative analysis divided in the eight components of smart city integrative framework.

## 4.1 Management and Organization

Some interviewees believe that there are management issues in 156: Speak Porto Alegre. The service still takes too long to attend the demands. By the other hand, the system has created an approximation between secretaries and agencies, in accordance with interviewee1. Due to organization changes, today it is possible to know where the service delay is. The city administration can access the queue of every agency, as reported by interviewee 5. As each request has a protocol number, this number is used to track requests progress.

According to interviewee1, nowadays about 90, 95% of the agencies and departments are integrated with the 156. The few services that are not integrated yet need to be engaged by email or letter.

One of the biggest challenges faced by 156: Speak Porto Alegre is staffing. According to interviewee1: “People who came here is not familiar with email and we need to improve how we are educating and training staff; Take time to train them and investment in people is a critical factor for succeeding”. The 156 employees (attendees and coordination) are government employees. The attendees have the function of administrative assistance and in order to be able to get the job they took official exams. It is not like a selection process to select people profiles to work with people.

Interviewees believe that a lot of improvements took place since the beginning of the initiative. As described by interviewee1:

> Before the integrated and online system we needed to create labels for each request. [...] It used to take from 5 to 7 days to get to the destination [...] Nowadays, we register the demand and it is directly routed to the responsible agency.

The agencies that execute and receive the requests need to have a good structure and staff as well. As reported by interviewees, they don’t have a great structure and not every agency has access to the system and still needs to go in person to check requests or go to another agency that have the system installed to take the list of services requests to be completed.

According to interviewee1:

> Besides facilitating the lives of citizens, the system allows you to evaluate the service provision, and in particular the reduction of time in service and consequent user satisfaction”. But, as reported by interviewee5 there is no process to check the quality of the service provided, as 156 does not provide any survey to track customer experiences yet.

## 4.2 Techonology

Interviewees identified two programs/systems as the information and communication technology (ICT) being used in this initiative. One is the *Speak Porto Alegre* system used to register, manage and route all demands and the other one is the program used to manage and receive calls, known as *Contact Center.* According to interviewee3 the *Contact Center* program is installed and used for all agencies integrated with the 156 since March 2011.

The calls do not pass through any telephone operator, meaning economy. For security, backups are performed every night so in the event of a fault or problem they can retrieve all the information from the systems until the day before, as remarked by interviewee 2.

The interviewees identified many barriers and challenges to use technology in this initiative. Interviews also revealed various opportunities and challenges of using technologies. According to interviewee 2 the city administration doesn’t have the knowledge of what is possible to do with the use of technology. When a citizen calls to open a request it needs to take note of the protocol number. Nowadays, the only way used by the Municipality to report citizen that their requests were completed is regular letters or email.

All the interviewees mentioned the need of mobility saying that citizen should take pictures and send to the system via smart phones and easily open a service request everywhere and anytime. The current system Speak Porto Alegre does not support pictures upload and even worse, when opening a request by Internet the citizen can see the option “Upload picture” but when trying to upload a picture nothing happens.

The system Speak Porto Alegre used by the Porto Alegre 156 is not supporting the number of demands anymore and does not provide a great service quality. According to interviewee3 "even the technology part is not resolved yet”. Interviewee4 related that: “the system is better than before, but sometimes it gets stuck and a request that could be registered in 2 minutes can take up to 10 minutes due to system performance.

## 4.3 Governance

The initiative governance model, according to 156 interviewees, is more participatory than hierarchical. When the 156 Speak Porto Alegre changed their structure and started using the system Speak Porto Alegre the coordination with other areas did a service redesign.

According to interviewee1, in 2010/2011 the 156 started as an integrated service having the city agencies and departments moved to the number 156. However, five years ago, the demand was not as big as it is today. Now, it is necessary to redesign the service again.

However, it could be observed that there are governance improvements. Since April 2013 the city governance created committees of services. This happens with vice mayor and secretariats to check what demands needed more attention. According to interviewee5 the city administration also started a project known as *city hall in your community* to attend those demands that are for a long time in the queue. This interviewee also mentioned that the 156 has not defined if it is a call center; contact center; attendance central or ombudsman. This is an important issue to be defined as soon as possible, since specific regulations must be followed.

## 4.4 People and Communities

According to interviewee1: “we didn’t have a channel with the city administration before this initiative and to request any service was needed to go in person to the agency responsible for that service”. The Speak Porto Alegre contributes for a better quality of life and for people participation

This initiative can help communities and also an individual. According to interviewee4, the 156 receives a lot of calls/requests asking information about courses, where to apply for workshops, documentation needed and vaccination campaigns. Interviewee1 affirms that the 156 receives requests from all social class and asking for simple requests, since urgent and serious ones, as well as calls to complain or give suggestions and improvements.

## 4.5 Policy Context

All interviewees notice that policy interests and mandate changes have an influence to this initiative. When every new government assumes the city administration, they make different actions impacting the initiative as related by interviewee2. According to interviewee5, the current government gives a lot of importance to *services* and the 156: Speak Porto Alegre is getting more visibility because of that.

According to interviewee3 there is a big relation between the initiative and policy context: “the quality of this service can determine the quality of the city administration. This is a way to measure how the city administration is going”.

## 4.6 Economy

The interviewees believe that the initiative could help enhancing the city competitiveness, attract workforce and commerce. According to interviewee 5 the city administration should work in a more proactive way, using the information provided by requests (recurring ones) and work to fix the problem and avoiding recurrence. Interviewee 2 said, “[…] if we have a great service resolution and if we feel that when we need something, it is resolved quickly this could attract new business, commerce and people for the city”.

Economy will also "spend less" and this initiative could reduce expenses. An example was given by interviewee 4: “we receive a lot of requests to remove a falling tree, if those requests were attended on time it could avoid this tree to fall over a house or injure people and consequently it would reduce the chance of having extra expenses with pension or to cover the damage of a destroyed house”.

## 4.7 Built Infrastructure

According to interviewees, if the initiative works as it should be it could function as a CRM (*Customer Relation Management*) or a database of service requests and needs where information recorded could help the government knowing where to invest, what needs to be build, fixed, etc.. Interviewee 3 illustrates this idea: “…the administration should do a better use of the database, like a real CRM to check where we receive more requests and how invest in infrastructure”.

The 156: Speak Porto Alegre initiative already has the infrastructure needed to integrate services. However, it is still needed to invest in the service executers’ agencies to give them the adequate infrastructure to receive and track the 156’ requests. As described before, not all agencies and department have access to the CRM system Speak Porto Alegre and according to interviewee 5 some agencies even doesn’t have a computer and needs to go to other agencies to get the list of requests from the computer.

## 4.8 Natural Environment

This initiative also has a big relation to the city natural environment as it receives requests for garbage collection, falling tree, garbage sitting in unappropriated places are also sent via 156 which helps the environment and the transformation of a cleaner city,. Interviewee5 gives a list of requests types related to the natural environment like native forest and reserves monitoring, cleaning the edge, environmental preservation area and others. Interviewee3 believes that “… if we didn’t have this contact channel where would the citizen claim for this service type of requests? Maybe they would need to go in person to the agencies. Table 1 summarizes the findings discussed up to this point.

| Dimension | Analysis |
|---|---|
| **Management and Organization** | SMGL (Municipal Secretariat of Local Governance)<br>Human resource management is a challenge (recruitment process)<br>Request and referral via system<br>Speak Porto Alegre system created an approximation between secretaries and agencies<br>Now it is possible to know where is the delay<br>Protocol number used to track request's progress<br>City administration can access every agency's queue<br>Difficult to 'manage' other agencies and departments (service executers) as they are not under the same organization<br>The agencies that execute and receive the requests need to have a good structure and staff as well<br>Not all agencies and departments are integrated yet |
| **Technology** | Speak Porto Alegre: system used to register, manage and route demands<br>Contact Center: Call system<br>Intranet: City information<br>Integration between agencies<br>System Limitations and slowness<br>System does not support files upload (pictures)<br>Does not send SMS<br>Number of characters to entry additional notes under the requests is limited<br>Need of mobility (Smart phone app)<br>Requestor cannot access request details - need to call and ask the progress |

| Dimension | Analysis |
|---|---|
| **Governance** | More participatory than hierarchical<br>Service executers (other agencies and departments) are not subordinated by the SMGL<br>Interdepartmental collaboration<br>Need to redefine, redesign and qualify the service, giving internal conditions to meet the demands<br>Committees of services since April 2013<br>156: Call center? Contact center? Attendance central? Ombudsman?<br>Service integration requires cooperation and coordination of multiple authorities from different government levels |
| **People and Communities** | People are getting more involved in smart city initiatives<br>Communication channel between city and citizen<br>The initiative does not collect participants information (to know their profile)<br>There is no satisfaction survey<br>Know people's wants and needs, |
| **Policy Context** | Political mandate has a deep influence<br>Current government showed interest and recognized the importance of service<br>The quality of this service may reflect the quality of the city administration"<br>Interdepartmental agreements shape the policy context of the initiatives.<br>Way to measure how the city administration is going |
| **Economy** | Attractiveness and competitiveness<br>If the city has a great service resolution this could attract new business, commerce and people<br>City administration could be more proactive - using request's information to know what is needed<br>Reduce expenses (remove a falling tree avoiding damage) |
| **Built Infrastructure** | 156 has the infrastructure needed to integrate services, but the executers does not.<br>The service records should be used as a database to collect information and find out where the city needs to invest<br>CRM (Customer Relation Management) |
| **Natural Environment** | This initiative collaborates and help to protect the natural environment - a channel to claim for services<br>Requests for garbage collection, falling tree, garbage sitting in inappropriate places |

# 5. CONCLUDING REMARKS

The initiative 156: Speak Porto Alegre can be used as crucial part of the city administration's strategy to transform the city government into a smarter, faster and better city. The initiative is in the right way as great changes have been made in the last years. According to respondents, the 156 represents a breakthrough in enabling addressing the demands practically on time, a procedure that in the past was a personal communication that took 5 to 7 days to be addressed.

In terms of integration, some positive evidence worth mentioning, such as the number of services provided, which started with 10 different types and in 2013 brought together nearly 300 services; integration of demand for services by users on a single channel, 156, from 2011; and an installed infrastructure that allows, by means of integration, improved integration of services, allowing the recording of requests in two minutes, a procedure that took 10 minutes earlier.

Moreover, the testimonies point to underlying issues regarding integration: in terms of service-citizen relationship, the system does not allow the user to send/upload pictures, in order to demonstrate the object of his demand and assist the government in the problem identification; despite the growing number of services integrated to 156, the design of the service is the same as in 2008; proactivity absence, because the request's information are directed only to the resolution of one particular case, not generating inputs for the city administration; on the same line, but with distinct vision, another interviewee points out that the lack of integration and interoperability between generated by the lack of a unified database, as well as the absence of a system that acts in the manner of a CRM this is an impediment to improve the performance of the municipal management quality. The 156's infrastructure should be extended to the executing agencies of the service, integrating more effectively the registration of demand and it's implementation.

The program Speak Porto Alegre used to register and manage the requests received by the Porto Alegre 156 is not supporting the number of demands anymore and does not provide a great service quality. The city administration is aware of the necessity of having a better system and, according to several respondents, it will probably be replaced next year.

The interviewees point to other problems claiming that there is no user satisfaction survey and also attest that the requestor needs to take note of the protocol number because the system does not send SMS either email informing request information. Furthermore, in a global analysis, the interviewees believe this initiative helps transforming the city in a smart city, but the 156 needs to be better; mainly in technology, system and communication aspects. Moreover, metropolitan authorities demand an important flux of high quality information, which is usually generated among diverse offices. To be effectively managed, these fluxes should be integrated having a real CRM system.

In this paper, it was analyzed the integration and interoperability among "156" and the agency services. It was also suggested a preliminary understanding of the smart city initiative Porto Alegre' 156 based on the *Smart City Initiatives Framework.* This framework helps understanding and analyzing all areas of a city initiative. In the future, would be great to extend this study interviewing representatives from other departments (who execute the services). Further research could also focus on how the integration works on diverse cases of city contact centers and its

relationships with smart cities frameworks to create a comparative analysis.

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# Contact Center in a Smart Cities View: a Comparative Case Study of Curitiba (Brazil), Porto Alegre (Brazil) and Philadelphia (USA)

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## ABSTRACT
The growing number of city inhabitants and continuing rural migration to urban areas demand innovative solutions supported by technology within a new concept of municipal management: smart cities. The initiative "Call Center and Information 156" of the city of Curitiba (Brazil), is examined in this paper with two main purposes: to analyze this smart initiative and carry out a comparative study with related initiative in other Brazilian city (Porto Alegre) and also an American city (Philadelphia). Two smart city models are used here to support the analysis, which concludes that certain manifestations fit into the smart concept while others move away from the concept. The comparative study has found the common, converging and diverging features of each initiative, conducting an evaluation based on smart cities framework.

## CCS Concepts
• **Applied computing~E-government**

## Keywords
Smart Cities; Smart Governance; Non-emergency Contact Center

## 1. INTRODUCTION
Since the twentieth century, there has been an ongoing global trend towards the progressive displacement of rural population to cities, potential centers of better opportunities, better working conditions and quality of life. This phenomenon has generated significant urban growth and the emergence of megacities, whose challenges are to demand intelligent, effective and innovative solutions. Otherwise, living conditions may instead worsen as a result of problems in safety, traffic, energy, air pollution, housing, and etc, deteriorating the environment that population sought through this migration[1].

ICT has enabled interconnectivity as well as instant access to information in a context of a globalized world. This connected citizen has been aware of what happens around him and around the globe. Problems related to urban growth, often cluttered, and social exclusion are widely debated. This context in which the citizen is inserted and his awareness of the social, political, economic, cultural and environmental problems generate pressures for answers and urban policies to deal with the situation [15].

Social demand, however, is not restricted to the pursuit of life improvements for disadvantaged segments of society, since it is the State responsibility to provide quality services for all. In this sense, technology-making information available to citizens has provided the means to analyze, study and promote solutions to problems and offer better services to the population. This idea translates into the smart management concept, expressed at the municipal level as smart cities, i.e. "the city performing well in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens. [10]".

Underlying this concept, the necessary quality of service delivery is a necessary condition for the smart way to govern. This quality is directly related to interoperability and integration of public agencies in order to meet the demands of citizens effectively. Not only must systems but also the means that perform deliveries be integrated, so that the applicant can resolve their disputes in relationship channels covering the whole of municipal services, regardless of the public sector to which the request is made. Integration is a strategic requirement recognized by the public administration as a whole to improve its services for citizens [12].

This study focuses on the Call and Information Center 156 in the city of Curitiba (Curitiba Contact Center) in southern Brazil. It's a non-emergency contact center (Via phone, email or chat) offering



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a wide range of information and services to the population of the municipality and integrating all public city departments and companies.

The purpose of this article is to analyze the Service Center 156, Curitiba, as a smart initiative and compare it with the 156 service in Porto Alegre (Brazil), and with the 311 service in the city of Philadelphia (U.S), known as Philly 311.

After these introductory remarks, this paper presents a smart cities approach. Methodology describing the format of statements, profile of respondents and a description of the process in general is part of the third section. The results of the interviews are then explained in a logical sequence, which starts with the genesis of the process and extends until 2014. The comparative study of Curitiba, Porto Alegre and Philadelphia programs is presented in section 5, which precedes the final conclusions.

## 2. SMART CITIES

Smart Cities is a field that has increasingly received attention from academia due to the richness of its literature and to its importance. However, it demands systematization of a knowledge that is still scattered and fragmented [13].

As a natural result of the development of an evolving field, there are different understandings of Smart Cities in different concepts, emphases and academic approaches. Research carried out by Nam and Pardo [16] lists several meanings of that domain according to the views of academics, highlighting elements such as technology, infrastructure and services; economy, population, governance, mobility, environment and life; efficiency, sustainability, equity and housing; monitoring and integration of critical infrastructure; City instrumented, interconnected and intelligent; culture, knowledge and motivation; ICT as a sponsor of freedom and accessibility to information and services.

Similarly, a large literature review has found that Smart Cities concepts were founded primarily in the following essential areas: smart technologies - focus on technology (23%); smart people - focus on human resources (8%); smart collaboration - focus on governance (12%) and combinations of the focuses mentioned (23%). In the remaining works, 33% of the total did not refer to any kind of definition [13].

Giffinger and Haindlmaier [10] developed an important approach that claims for six key characteristics to a smart city – smart economics, smart people, smart governance, smart mobility, smart environment and smart living – which combined constitute a model that allows us to evaluate, through indicators set by the authors, the performance of cities according to the smart concept [10]. Each of these characteristics encompasses factors showing the systemic understanding of authors, as described below [4, p.12]:

- Smart Economy - competitiveness as innovation, entrepreneurship, trademarks, productivity and flexibility of the labor market;
- Smart People - qualification or education, quality of social interactions regarding integration and public life and the openness;
- Smart Governance - political participation, services for citizens and functioning of the administration;
- Smart Mobility - local and international accessibility, availability of information and communication technologies and modern and sustainable transport systems;
- Smart Environment - attractive natural conditions (climate, green space etc.), pollution, resource management and efforts towards environmental protection and;
- Smart Living - quality of life as culture, health, safety, housing, tourism etc.

In order to build an understanding of the field from a systemic view and based on various approaches, Chourabi et al [6] developed a model with eight dimensions of smart cities critical internal and external factors, which has served as a reference in the matter. The model is composed of the following factors:

a. Internal factors: Organization and Management; Technology (organizational dimensions of ICT skills) and Governance (collaboration, leadership, participation, communication, accountability, transparency etc.)

b. External factors that influence the previous group: political environment, people and communities (digital divide, communication, education, accessibility, quality of life etc.), installed infrastructure (IT infrastructure, security and privacy of information and operational costs), economy and environment.

Consolidation and systematization of smart cities approaches (are necessary and can avoid) the risk of a superficial discussion involving the issue at the political level, as underestimating the potential negative consequences of technology use and infrastructure to make a city smart and the search for strategic solutions rather than any simpler operational solutions [5].

## 3. METHODOLOGY

This study follows a qualitative approach aiming at understanding the social world from the author's point of view [4] and it is based on the case study about the Call and Information Center 156 in the city of Curitiba (Brazil). The choice of this case study was made in an attempt to understand more deeply this social phenomenon by means of an exploratory research [21].

In December 2014, the authors conducted semi-structured interviews with Call and Information Center 156 Curitiba managers responsible for creating and operating the system. Each face-to-face interview lasted about one hour. Data was collected using the protocol developed by the multinational "Smart Cities Smart Government Research Practice Consortium" (SCSGRPC), that aims at exploring the processes of smart city Initiatives and their impact on cities, people, and city governments. The study by Chourabi et al. [6] provided the conceptual background for the interview protocol.

Secondary data taken from two studies by SCSGRPC members were used. Both studies were concerned with integrated service centers for citizens: one was the 156 service in Porto Alegre (156 Speaks Porto Alegre) and the other was the Philly311 service in the city of Philadelphia.

Interviews were semi-structured serving as a guide to the inquiry and dismissing standardized formats that could constrain interviewees [8]. Three professionals with extensive experience in the 156 Contact Center, who have held key positions within the structure, were interviewed. In this study they are called PR1, PR2 and PR3. A member of senior management of the municipal executive, designated as AD, was also interviewed in order to present the view of a professional linked to the information technology area involved in service management. The interviews were recorded, transcribed and later coded by one of the authors using the MAXQDA software, version 11. Thereafter, all the

authors discussed the data and analyzed comparatively the three cases.

# 4. CALL AND INFORMATION CENTER 156 CURITIBA

According to the municipality's website (see http://www.curitiba.pr.gov.br/servicos/cidadao/central-de-atendimento-e-informacoes-156/1086), the Call and Information Center 156 of Curitiba provides information and meets the demands of citizens by phone and the Internet and is focused on effective services delivery. It was developed and managed by the Curitiba Institute of Informatics (ICI), a third-party company.

## 4.1 Context

The city of Curitiba is the capital of the State of Paraná (Brazil), part of the Brazilian southern region, a set of three federal states of the Union. According to the Brazilian Institute of Geography and Statistics (IBGE), the organization responsible for statistics in Brazil (see http://www.cidades.ibge.gov.br/xtras/home.php ), in 2014 its estimated population was 1,864,416 inhabitants, occupying in 2012 the 6th place among the 27 Brazilian cities in the item income per capita. According to IBGE, in 2010 it was the 4th Brazilian capital city with the highest Municipal Human Development Index (0.823).

Recognized as an innovative city, Curitiba was awarded in 2012 the first position in the Digital Cities Index Brazil by the Center for Research and Development in Telecommunications, CPqD. The index primarily considers public access to Internet and network coverage. The classification of 100 cities surveyed was based on three criteria: technological infrastructure, availability of digital services and accessibility features (see http://www.computerworld.com.br).

The Call and Information Center 156 is a service engaged in providing information and meeting the demands of the city population. It started operating in 1984 as a telephone line to receive suggestions and complaints by citizens. In 1999, seeking to improve the work and speed up the response to the citizen, the program underwent structural change in terms of organization and governance through a management agreement between the municipality and the ICI, which became responsible for the control and management of 156 (see http://www.ici.curitiba.org.br/noticias/central-156-completa-30-anos/861).

The ICI, manager of the 156 service, is a Social Organization (SO) focused on Information Technology in the public sector, for example, ERP and BI solutions in the State of Paraná with operations across the country. The organization controls, manages and owns the 156 service infrastructure and the city of Curitiba's ICT and, as reported by the PR1 interviewee, has a 60% share from the private sector and 40% from Curitiba's municipality.

## 4.2 The Origin of the Call and Information Center 156 in Curitiba

According to PR1, the creation of the Call and Information Center 156, in Curitiba, during 1984 resulted from the idea to relieve service counters. Initially the Call Center accepted demands involving public lighting, followed by garbage collection and gradually expanded on services provided, enabling the establishment of a workflow providing various city services. According to PR1, "we were taking each of these services here and qualifying them. At first, the aim was just to classify services, suggestions and complaints..."

Referring to the initial stage of the Call Center, PR1 recalled that the Call Center 156 "was born with this vocation to be a citizen service" and emphasized the concept of integrating city services. He reported that, after some problems, it was decided that citizens served by the Call Center 156 would have their demands met exclusively through that channel, regardless of the agency responsible for complying with such demands. The integration of services showed the city's efforts to increase its effectiveness, transparency, convenience and sustainability towards a concept of Smart City [17].

The ICI, created in 1998, took over the Call Center 156 the following year, which had been managed by the city until then. PR1 notes that the flow and mapping of service management processes were remodeled, so that the new management could be up to the challenge. He adds that "six major government departments were integrated then: transportation, municipal secretary of public works, department of municipal government, education department, the health and environment departments".

Concerning the service transition period, PR2 reports that until 1999 the citizen had to contact the call center to know the result of his demand, i.e. there was no return to the plaintiff. After the ICI took over, changes in flow and processes and the introduction of an information system were a significant improvement in service delivery, as ICT, through its potential to modify governmental structures enabled the delivery of better services to citizens [11]. In this sense, PR2 said emphatically: "Of course technology has helped a lot."

With regard to the refinement in the treatment given to citizens by the Call Center 156, PR3 mentioned the change in treatment levels in 2002 establishing referral levels of demand, due to noncompliance with demands, going up hierarchically by bodies responsible and that may even reach the Civil House. On the subject, PR3 states, "if a bulb had to be replaced in a period of five days, and that did not happen, I had to demand that from the person in charge. Now the demand is made by the system itself by email. If the demand is not met, I inform your immediate boss and warn him that you have these disputes. Every seven days the demand goes up a step till it gets to a hierarchical superior".

The Call Center 156 of Curitiba celebrated its 30th anniversary in 2014, and that may have strongly influenced the population to adhere to the program. PR1 attributed this adherence to the following factors: the credibility of the municipal administration during the launch period, the program stability and its capacity to efficiently meet the demands and the needs of citizens. This position is explained in PR1 statement: "What we observe with respect to demand fluctuations: the citizen uses this service and from the moment he realizes it works, he begins to use it more and disseminate this information in his community, and what delights the citizen at 156 is precisely this concern of the municipal government to give an answer, even if it is a negative one".

## 4.3. The Curitiba Contact Center in 2014

In AD's words, the Call and Information Center 156 "is a service of reception, classification and targeting of contacts." He affirms that he receives various manifestations and requests, including those not belonging to the jurisdiction of municipal government, such as, for instance, information regarding federal income tax, and predicts that "it is a very strong reference in Curitiba... if someone is in doubt about something, he calls 156 ".

This indiscriminate demand could be explained by the range of services offered, because, according to PR1, about 3,200 services

could be requested at 156. The services are diverse, as shown in the website: accessibility, animals, street layout, tree, collection, drainage, buildings, schools, inspection, street lighting, information, property taxes (municipal tax on urban property), ITBI (tax on real estate transaction), cleaning, municipal parks, final paving, squares, Citizenship Street, traffic lights, traffic signals, health unit and others (see http://www.central156.org.br/).

According to PR1, in operational terms there is a workflow that maps all procedures. As a request is submitted, there is an immediate coding and shipment to the Head of Customer Service in charge, an employee trained for the job that will handle the request. All departments are integrated with the Central and represented by an employee in charge, so that for a service to be completed there is an employee in charge of providing a solution to your request. PR1 says that in 2002 there were 2000 requests a day, but figures have tripled in 12 years, presently reaching the figure of 6,000 daily requests.

A positive point noted by PR1, which was just incipient in 1999, refers to reports that the system generates monthly containing statistics of various types, such as requests for information and demands, distribution by districts and regional (geographical areas bounded by the municipality) etc., which have been delivered to the City Hall. As PR2 points out, the volume of information that the call center receives daily highlighted its importance as a tool at the disposal of municipal management, representing a set of inputs available to the municipality management for immediately use by the BI (Business Intelligence) tool. Concerning the use of 156 information, it is worth mentioning that "this information is used for budget planning and review and followed by the mayor and secretaries in reports that explicit the priorities of society by district and region periodically. Projects are prioritized according to criteria such as relevance and urgency, impact on quality of services, population demand, degree of innovation, political feasibility and impact on the government plan [20]. "

According to AD, despite the technology invested in it, the Call and Information Center 156 is characterized as "monocall", i.e. 90% of citizens' contact with the center takes place by phone and calls are charged by operators and paid by the user. There are two million monthly visits to the site, and the remaining 10% are divided between an available chat line and recording messages on the site. One possible explanation for that is the difficulty to change people's habit of accessing the Call and Information Center by phone, a practice that has been part of their routine for thirty years, and make them use new ways of relating.

As far as responses to citizens' demands are concerned, the Call and Information Center 156 service receives, monitors and returns them as mentioned before. In this respect, the interviewee AD clarifies that because the ICI and the City Hall are separate entities, the Call and Information Center 156 does not address demands inside the town hall, which he considers a vulnerability in the process. He adds that sometimes due to weaknesses in the internal processes of the city hall, responses by the 156 service take time. Utility is one of the principles in an information model based on transparency; information is only useful when it is accessible, intelligible, easy to get and use. Following this criterion, late information would not be useful [7].

As to the type of demands received by the 156 service, PR1 reports that most are requests for information, which would represent about 65% of the total, leaving little more than a third for services. This emphasis on information demand greater training of attendants since the request must, as a rule, be dealt with in a first contact.

In order to provide service quality, the initiative followed two fundamental assumptions: employee training and service delivery control. Regarding the first item, PR2 highlights the problem of turnover due to strenuous working conditions since professionals deal with complaints during a considerable part of their daily journey. He also points out that there are volunteer dismissal programs due to economic and political crises. This constant turnover demanded training of new employees and professional development of old ones. PR2 refers to the subject by saying: "Imagine what it is like to have information about various topics from 31 departments. So it's a great challenge to requalify the team [...] So you do a mapping, take all the information on a subject, you qualify and train operators and then you're ready. It's there inside the organizational structure in the 156 system. "

PR3 informs that the process of service quality control occurs between employee and service flow, since there is a constant monitoring of the situation online. In order to make it effective, there is a verification of logged employees, an analysis of their professional conduct, monitoring of conversations and the possibility to pass on information to the attendant without the citizen noticing it. Another aspect of control turns to the analysis of service flow demand, which can determine the rescheduling of breaks in some circumstances.

Taking into account that the service level agreement refers to "an agreement between the provider of the service and its customers, which quantifies the minimum quality of service that meets the business need" [19], Curitiba Contact Center has another control mode called "work hidden citizen". This monitoring is done by a professional who makes certain types of questions, previously defined, and evaluates, through a specific template, the service provided. Each month at least two subjects are checked. All monitors ask the same questions and attendants' evaluation is performed based on the correctness and clarity of information, whether it was complete, on the politeness and security of the attendant in addressing the issue and on time elapsed in attendance, which are all later compared to set standards.

Yet another feature of the service is the constant search for information about what is taking place in the city in order to be prepared for certain events, as states PR3. Therefore, the 156 Center has a professional in charge of seeking for new events in the city and passing information on to be included in the initiative database. According to an interviewee, "…the 156 service is a thermometer of what happens in the city. This has an immediate impact. If there is heavy rain, a street demonstration... it is here in 156". This search for information, and a further focus on staff training and central structure following an excess in demand meets the assertion that emergency information serves as alerts that can be targeted to the right people and that proactive services represent a feature smart cities [2].

Concerning results transparency, interviewee PR1 reported that the data are passed on to the relevant department and to the municipal government. When asked about the transmission of information to the population, he said that communications department advisors usually act as a data broadcast channel, so this is not the 156 service's responsibility. In addition, data gathered are posted in the city's website.

AD, the interviewee linked to the technological area and member of the senior management of the municipal executive, has some objections to the Call and Information Center 156 that disagree with subliminally positive approach of respondents who held prominent positions in the initiative. His greatest restriction on the Call Center, and also on ICI itself, concerns the governance issue. In fact, his

questioning goes even further to discuss the informatics technology policy of the city, the context in which the initiative operates. Initially he explains the origin of the relationship between Curitiba and the ICI; then he adds, "Curitiba, 15 years ago, decided to organize the informatics department into a computer Social Organization, which is a private entity outside the administration to perform all ICT activities in the City Hall through a management contract. So there is a contract that sets out the conditions that the city should fulfill for the ICI to run all ICT activities".

AD believes that it is positive that a private organization, not subjected to typical bureaucratic obstacles in public administration, has greater agility and flexibility in finding solutions. On the other hand, the performance in this area, especially in services such as the 156, should demand the presence of two fundamental requirements: transparency and control. As a top executive of city municipality, he affirms: "So today, I do not have this sorted out". He adds that the fact that the entire infrastructure and technical expertise and the Call Center 156 are in the hands of an external organization makes the city a hostage of the entity.

With regard to the infrastructure installed by ICI at the disposal of the city hall, AD considers it "reasonable" although insufficient for a city with the intention of becoming smart. In addition, he adds that due to lack of material resources he cannot implement policies, such as the creation of a single database of citizens, which would allow the 156 service to identify all the background of the citizen being served. He states that some of the databases are outdated and that the prioritization and targeting of Curitiba Institute of Informatics (ICI) turned to financial interests: "the ICI has maximized profitability of some systems". On this authority gap of municipality, the interviewee states "it is the ability to set policy, to set action plans, a process of priority setting, identification of needs and opportunities of using technology, to be able to hire and manage contracts. That the city has not created, on the contrary. When the ICI was created, more and more stuff was delegated to it".

In order to correct this distortion, AD defends the creation of a new governance system in which the city manages infrastructure, not in terms of data center installation or operation within the physical structure of the city hall, for example, but by giving the local authority the effective management of its ICT area, so that it can create policies, establish guidelines and determine the implementation of actions following certain lines. As a solution to what the interviewee considers a distortion, the project "Curitiba, a smart city" seeks primarily to change the form of ICT governance in the city.

## 5. COMPARATIVE ANALYSIS

This study presents a comparative case study between three non-emergency contact centers in two Brazilian cities (Curitiba and Porto Alegre) and in an American city (Philadelphia). We also have interviews data from the contact centers in Brazil, some of which already presented in this paper and, from Porto Alegre, presented by Azambuja et al.[3]. Concerning the American city, we have used Nam et al. studies[18][14], which used the Chourabi et al [6] dimensions to analyze Philly 311.

The eight components of a smart city developed by this group are: technology, management and organization, governance, policy, people and communities, economy, built infrastructure, and natural environment [6]. In the present study we used these critical success factors as the basis of the analysis of our findings.

The tables below are not exhaustive, listing common attributes to the initiatives, interesting remarks and certain strengths or weaknesses of these services to citizens. CTB is used here to refer to the Call and Information Center 156 (Curitiba), POA to refer 156 of Porto Alegre, and PHI to 311, Philadelphia (US). The eight smart cities factors, worked by Chourabi et al [6], are listed below and a comparison between the three cities studied is drawn here.

I - Management and Organization

| | |
|---|---|
| **Human Resources Development** | |
| a. | Initial training of 30 days and constant recycling (CTB); |
| b. | The new employees must be able to use e-mail, requiring heavy investment in training (POA); |
| c. | Program for internal customer service training of all city employees (PHI) |
| **Integration** | |
| a. | All municipal systems are integrated (CTB) |
| b. | System created an approximation between secretaries and agencies (POA) |
| c. | The information Philly311 provides to other departments is driving internal business process changes (PHI) |
| **Weaknesses** | |
| a. | Turnover and delay in deliveries of certain requests (CTB) |
| b. | Not all agencies are integrated yet; difficulty to 'manage' other agencies (service executers), because the demand is directly routed to the responsible agency and human resources (POA) |
| c. | Limited funding, under-staffing, and the change in organizational culture (PHI). |

As for training, the information provided shows relative similarity between the center of Curitiba and Philadelphia, with structured training policies. However, in Porto Alegre there are problems in the qualification of employees, although human resources apparently represent a common problem in all analyzed initiatives.

II - Technology

| | |
|---|---|
| **Strengths** | |
| a. | Public management system of 26 applications that integrate (CTB) |
| b. | Integration between agencies (POA) |
| c. | We are the only agency-level centralized database (PHI) |
| **Weaknesses** | |
| a. | Difficult to keep up with all the demands of technology and upgrade; main system is technologically outdated (CTB); |
| b. | System Limitations and slowness and requestor can not access request details - need to call and ask about the progress (POA); |
| c. | Under-equipped conditions and the lack of interoperability (PHI). |

As shown in the table above, Philly presents a serious problem in the operation of a call center, which is interoperability, an important requirement for effective service. In Porto Alegre, besides a

deficient system, it is up to citizens to investigate the progress of their demands. The 156 service of Curitiba, in turn, needs to update the core system.

III - Governance

| Strengths |
|---|
| a. Autonomy of decision (to ICI) to be a strategic project (CTB) |
| b. Interdepartmental collaboration (POA) |
| c. Leadership of the top management, executive support, organizational learning, and staffing (PHI) |
| **Weaknesses** |
| a. In governance (the necessary structure to achieve a desired future) the city has nothing; (CTB) |
| b. Service executers (other agencies and departments) are not subordinated by the 156 service (POA) |
| c. Philly311 does not have a formal governance body for organizing new interdepartmental collaboration and cooperation (PHI) |

Governance is the greatest fragility factor regarding the 156 service of Curitiba. In fact, the problem lies in the relationship between this initiative with the municipality. The underlying discussion involves outsourcing of a strategic service for the population and for the city management to be run by private companies. The discussion in Porto Alegre turns to the relationship of the initiative 156 Speaks Porto Alegre and service providers, and Philly311 service is concerned with the lack of a formal cooperative relationship between central and county.

IV - Economy

| |
|---|
| a. Use of information to perform strategic management (CTB) |
| b. Reduce expenses (remove a falling tree avoiding damage) (POA) |
| c. Philly311 also enables the City Council (the city's legislative body) to use their resources more effectively, by saving their budget and staff time spent on providing constituent services |

Considering primarily the benefits, the factor economy manifests itself in two ways: (a) in an indirect way, based on the information for managing the city strategically, enabling better resource allocation and, as a consequence, saving money, and (b) directly by mitigating damage and potential risks.

V – People and Community

| |
|---|
| a. CTB - 65% information to 35% of demand for services; conducting a survey with good results and tariffed telephone service to the user; |
| b. POA - You do not know the user's profile; no satisfaction survey and tariffed telephone service to the user; |
| c. PHI - Through integration of channels for municipal services and information, Philly311 is seen as a main gate to residents, businesses, and visitors of the city; toll-free phone line |

While the Call and Information Center 156 in Curitiba stands out in the assessment by its users and Philly311 is seen as the citizen's portal and it was a toll-free phone line. In Porto Alegre weaknesses were pointed out with regard to the relationship with citizens.

VI – Political context

| |
|---|
| a. The ICI practically defines and organizes the 156 service strategy (CTB). |
| b. Political mandate has a deep influence; current government showed interest and recognized the importance of the service (POA) |
| c. Mayor's strong political and administrative leadership was found to be critical to build city-level service integration capabilities (PHI) |

Unlike other centers where the strength of political context and in particular of mayors appears clearly, in Curitiba the decision-making process has been for more than 15 years in the hands of the outsourced entity responsible for the service. However, since 2013 the current administration has been working to change this situation, having created the Municipal Secretariat of Information and Technology, which has worked in the city's IT Governance.

VII - Infrastructure

| |
|---|
| a. ICT infrastructure is outsourced (CTB) |
| b. 156 has the infrastructure needed to integrate services, but the executers do not (POA) |
| c. Integration of technologies such as CRM and GIS software is essential to 311 service report and tracking as well as service delivery (PHI) |

Again the issue of the Call and Information Center 156 service being outsourced in Curitiba and also covering the city's IT infrastructure reappears. In Porto Alegre, the weakness of integration is evident in administration, which fail to meet the demand.

VIII - Environment

| |
|---|
| a. The population in Curitiba is very concerned about the environment. The graph helps to identify the location of the problem (CTB) |
| b. This initiative helps to protect the natural environment - a channel to claim for services (POA) |

Both concerns involve an aspect of great importance in public management: social control. In Curitiba, The 156 service is used as a channel to monitor a major concern of the population. In Porto Alegre, the contact center was used as a response to citizen complaints by the public city management.

## 6. FINAL REMARKS

This study focused on the Call and Information Center 156 in Curitiba, carried out based on semi-structured interviews, and later compared it with similar initiatives in the cities of Porto Alegre (Brazil) and of Philadelphia in the USA. Some final considerations can be listed specifically regarding the Curitiba's Contact Center, as a manifestation of smart city in the dimensions of the framework Chourabi et al (2011):

Management and organization – the focus is stakeholders' identification strategies; for dealing with all social segments of the population; the effective communication and; the training provided to the workforce, whose performance seems to meet citizen needs.

Technology – the big gap refers to the organizational level of collaboration between the two organizations (ICI and Curitiba City Hall), once knowledge has been restricted to the services provider and the contractor is slowly increasing IT management in the city.

Governance - reflects more acutely the problem of technology, since the city of Curitiba, which is responsible for setting the city guidelines, until recently did not have powers to directly support such policies and depended 100% on a external entity ICI) for this purpose. On the other hand, the analysis of the reports provided by the third party organization to manage the Call and Information Center 156 in Curitiba can be considered of great importance to the management and planning of the city.

Political context - a public initiative which has been in practice for so long and has gone through several administrations even of different parties is seen as having reached its institutionalization and legitimacy within the political context.

People and Communities – its emphasis is on the relationship with citizens, availability of information, ease of access and on quality of life since it seeks to facilitate people's daily life.

Infrastructure - according to city officials, the infrastructure in the field of ICI, although reasonable, is not at the level to have a smart initiative.

Economy - the analysis of activities performed by the Call and Information Center 156 in Curitiba can be of great use for handling the needs of the population, which can have a positive impact in terms of making the city's economy more attractive city for investment, allowing the adoption of preventive policies, etc.

Environment - environmental issues and their consequences for the population are also part of the 156 service portfolio.

In reviewing this case from Giffinger and Haindlmaier's perspective [10], two important factors, not explicitly addressed in the previous model, arise. The first one refers to smart mobility, which is strongly supported by information provided by the 156 service and seen as one of the most wanted by the population. The second factor regards smart living, where again the central service stands out for its utility and public value delivered to the citizen.

The comparison between the cities has shown that Porto Alegre is apparently weaker in service delivery and, furthermore, the service user profile is not known due to lack of integration with service executors, slow systems and low-skilled workers. Philly311 has shown to be on a relatively high stage; however, it has interoperability problems, lack of personnel and of IT infrastructure.

In the case of the Call and Information Center 156 in Curitiba, the service provided has been evaluated positively by users and apparently has met the demands of the population. On the other hand, outsourcing management is one of the main weaknesses of the initiative. The city has had a low level of management in the 156 service of Curitiba and has not had the control of the technological infrastructure of the city for over 15 years. In other words, it slightly dominates a very important initiative for the population, for management and planning of the city, becoming hostage to a private entity, created to collaborate, but which has gained independent legal personality and administrative autonomy.

Besides comparing various service centers for citizens, it was the purpose of this paper to understand in depth the Call and Information Center 156 in Curitiba service as a smart city initiative. One limitation of this study was the fact that the interviews remained restricted to professionals directly linked to the initiative and to the municipal executive, but other relevant sectors and directly related parts (e.g. citizens) were not investigated. Another limitation was the use of secondary data to carry out the comparative study of the initiatives. Further research on the topic should involve other stakeholders, such as users, press, political situation and opposition, as well as use of primary data through interviews or on-site research, and the study of related initiatives in other municipalities.

Finally, it is worth mentioning that the initiative of the Contact Center of Curitiba, which is being used for over thirty years and is now part of the city's routine, despite being supported by a "reasonable" technology, has apparently met the needs of the citizen. Its features strongly resemble a smart initiative and, once the sensitive issue of governance of the initiative is addressed, it will be consolidated in its full smartness.

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# Building Understanding of Municipal Operations Centers as Smart City' Initiatives: Insights from a Cross-Case Analysis


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## ABSTRACT

Cities around the world have been facing complex challenges from the growing urbanization. The increase of urban problems is a consequence of this phenomenon, added to the lack of policies focusing in citizens' well-being and safety. Municipal operations centers have played an important role in response of social events and natural disasters as a way to address the urgency and dynamism of urban problems. This research aims at analyzing the main dimensions and factors for implementing municipal operations centers as smart city initiatives. In order to explore this phenomenon it was conducted an exploratory study, based on multiple case studies. The empirical setting of this research is determined by municipal operations centers in Rio de Janeiro, Porto Alegre and Belo Horizonte. The research findings evidenced that the implementation of the centers comprises technological, organizational and managerial factors, in addition to political and institutional factors. Increasing smart cities governance is the main result from the initiatives.



## CCS Concepts

• **Applied computing~E-government.**





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## Keywords

Smart Cities; Municipal Operations Center; Multiple cases study; Smart Cities Governance.


## 1. INTRODUCTION

Cities around the world have been facing complex challenges of increasing urbanization and should manage their operations in an innovative way to avoid social, political and organizational problems [14, 26]. Data from the 2015 edition of the study Demographia's World Urban Areas [9] shows that 53% of world population (2.06 billion of people) lives in urban areas. From these 2.06 billion of people, 82.6 million are in Brazil (characterizing nearly 50% of Brazilian population). As a consequence of the rapid urbanization in Brazil, without the correct consideration of policies focusing in the well-being of individuals living in the cities, perceives the aggravation of urban problems such as the increase in deaths associated with violence or external causes, including homicides, suicides, traffic accidents, and drownings, among others [3].

When dealing with the phenomenon of rapid urbanization, Michael Bloomberg [6] states that the best way to improve the lives of billions of people around the world is enhancing the way that cities work. In this regard, cities are now linked to human and social development by stimulating the proliferation of smart cities initiatives as a strategic response of governments to this scenario [30]. According to Goldsmith e Crawford [17], governments are closer to an ideal setting of responsiveness, in which, through ICT, can empower, engage and enable the involvement of government agents working to ensure a better life for citizens and citizens to work with local governments in shared solutions for the challenges and urban problems. Supported by ICT, cities can change the way citizens perceive the local government and their civic engagement [17].

Smart cities are characterized as ICT-based urban innovations. One of the major goals of smart cities is the improvement of

citizen's quality of life, as well as the enhancement of municipal operations efficiency and local economic growth [15]. Although crucial to its achievement, the technology must be equalized with human factors to advance the concept of smart cities [22].

Since decades ago, Closed Circuit Television (CCTV) cameras became a very common feature of public life [7] and an important crime prevention and security measure [16]. In an attempt to manage a range of activities such as criminal and anti-social behavior (but not only) many local authorities have been installing CCTV cameras to their town center streets [7]. Gill and Spriggs [16] emphasize that CCTV systems have different capacities for addressing a variety of objectives. According to Brown [7], the CCTV system can be used for gathering information and patrolling city areas, in order to monitoring the occurrence of incidents. "CCTV is a situational measure that enables a locale to be kept under surveillance remotely" [16, p.1]. This system allows the observer to respond to the incidents faster and have information about the whole situation before reaching the site. By applying the concept of smart cities in CCTV systems, it can be seen as a smart initiative since it is applied to an urban environment, is ICT-based and has the focus on improving citizens' quality of life. According to Gill and Spriggs [16] technology is one part of the systems, combined to a control room and the related decision-making processes.

CCTV systems have been applied to municipal operations centers, which begins to be implemented as a way to address the urgency and dynamism of urban problems. The municipal operations centers, in the exercise of command and control of integrated operations, have played an important role in the response of social events and natural disasters through communication and coordination [22]. Currently, several municipalities are managing their operations based on real time analysis, which are manipulated mainly by isolated systems and are controlled by a single agency [21]. However, the municipal operations centers are an attempt to unify the management of several city' aspects, through the monitoring and analysis of public data from different agencies in a single location, as the operation center of Rio de Janeiro [22].

Considering the diverse aspects of city management, the centers of municipal operations support functions such as: monitoring of vehicles and public transportation, controlling of traffic flow and adjustment of semaphores to avoid traffic jams, monitoring and tracking accidents in real time, enabling correct resource allocation to attend a situation, collecting data on environmental conditions, allowing the measurement of air pollution, water levels and seismic activity, as well as aspects such as public participation and accountability through the monitoring of employees [21].

The responsiveness of governments is related to the extent of they meet the citizens' needs [1]. Considering the focus of this research in urban problems as a result of rapid urbanization, the combination of organizational processes and technologies applied in local government has been a breakthrough in the delivery of public information and services to society, as well as prompt response to the city's problems. Thus, in view of the research contextualization, this paper aims at answering the following question: What are the dimensions and factors for implementing municipal operations centers as smart city initiatives?

This research is situated in the smart cities' context. This paper aims at identifying the dimensions and factors for implementing municipal operations centers in the smart city domain. In order to explore how this phenomenon occurs it was conducted an exploratory study, based on multiple case studies. We have chosen this particular research method due to its key-characteristic of holistic investigation that allows the understanding of the complex and ubiquitous interactions between organizations, technologies and people [10]. Municipal operations centers have emerged in Brazil as a way to mitigate the consequences of the rapid urbanization and the absence of specific treatment on quality of life issues and citizens' well-being, which leads to the growth of urban problems. In this sense, the empirical setting of this research is determined by the municipal operations centers in Rio de Janeiro, Porto Alegre and Belo Horizonte.

The city of Rio de Janeiro is the capital of Rio de Janeiro State, located in the Southeast of Brazil. With a land area of 1,199.828 square kilometers, the city has around 6,476,000 inhabitants (2015). In 2013, the GDP per capita of the city was 43,941.25BRL. The city has a Municipal Human Development Index (MHDI) of 0.799 [20]. The Center of Municipal Operations Rio de Janeiro (COR) started operating in December 31st, 2010 and is formed by 30 agencies that monitor the everyday situations of the city twenty-four by seven. In the center all stages of a crisis management are integrated from the anticipation, reduction and preparedness, to the immediate response to events such as heavy rains, landslides and traffic accidents. The processes of monitoring and data analysis allow acting in real-time for decision-making to solve the problems of the city.

Porto Alegre is the state capital of Rio Grande do Sul, located in southern Brazil. The city has a territorial extension of 496.682km² and 1,476,000 inhabitants (2015). In 2013, the GDP per capita of the city was 39,091.64BRL. The city has a MHDI of 0.805 [20]. The Center of Integrated Command (CEIC) was opened in 2012 and is the central intelligence of the city. The center's mission is monitoring the city of Porto Alegre and integrating public services for the protection of the citizens, seeking a new security level and use of technology to better serve the society. The center centralizes operations such as the management of public services, video surveillance of the city, the operational planning of major events, climate monitoring and emergency response.

State capital of Minas Gerais, the city of Belo Horizonte has a territorial extension of 331.401 km². The city has an estimated population of 2,502,000 inhabitants. The GDP per capita in 2013 was 32,844.41BRL. The city has a MHDI of 0.810 [20]. The Center of Operations - Belo Horizonte (COP-BH) was launched in 2014 and is a strategic center of decision-making, with high technology, safety and accessibility, ensuring improvements in urban mobility and promoting environmental sustainability, as well as contributing to the increase in the population's quality of life.

The remainder of this paper is organized as follows: the next section provides a literature review in topics such as smart governance and smart city, followed by the proposed research questions. The subsequent section describes the research method. Then, the following sections report the preliminary findings from data analysis, including the cases descriptions. The final section presents concluding remarks.

## 2. LITERATURE REVIEW

This section aims at understanding and discussing initiatives undertaken by the government to become more intelligent. Governments are making a city smarter not only adopting innovation in technology, but also worrying about aspects such as governance, policies, and management. Thereby, the smart

government term is used to describe activities that invest in emerging technologies along with innovative strategies to achieve more agile and resilient government structures and governance infrastructures [13]. According to Awoleye, Ojuloge and Ilori [5], e-government is characterized by the progress in improving the delivery of public information and services through organizational processes and technologies that allow information to be achieved and disseminated across all government agencies, expanding the promotion of opportunities for citizens in several ways. Such opportunities, which result from the integration of government services with smart technologies, include public services, participation and communication at anytime, anywhere, and especially, accessible from any device [5].

A key point when dealing with a smart government scenario is that organizations, in addition to increasing efficiency, effectiveness and transparency in the management and provision of public services [28], create a collaborative environment with the public and other organizations [23, 28]. Interoperability defines the necessary condition for cooperation by exchanging information and communication between organizations. Moreover, measurement processes, performance evaluation and improvement are expected [23], thereby facilitating public participation in decision-making and services monitoring [28].

Smart cities are characterized by a new way of governing with the use of technology and the consequent increase in the public administration capacity in focus on improving the quality of life of citizens. According to Anthopoulos and Reddick [4], smart cities initiatives are a manner for governments changing urban spaces, by increasing the provision of public services and democracy.

Meijer e Bolívar [24, p.7] presents the following definition of the smartness of a city: “the smartness of a city refers to its ability to attract human capital and to mobilize this human capital in collaborations between the various (organized and individual) actors through the use of information and communication technologies”. In this definition, the authors emphasize the three main aspects of a smart city, the technological focus, the focus on human resources and the focus on governance (collaboration). In the same approach, Osella, Ferro and Pautasso [31] relate the concept of smart cities with the notion of governance, in which it perceives a greater intention on value creation through society considering aspects such as leadership, citizen participation, partnerships, public-private partnerships, accountability, responsiveness, transparency, collaboration, data sharing, and information integration services and communication.

The improvement in the provision of information and services tends to be one of the smart city initiatives results. These outcomes are the result of the organizational changes in smart city initiatives, which aim at increasing the efficiency and efficacy of public administration, as well as promoting smart governance to encourage greater collaboration between stakeholders [8]. The integrative framework of smart cities proposed by Chourabi et al. [8] and validated by Alawadhi et al. [2] covers practically all the proposed components in smart cities’ definitions [27]. The framework expresses the relationship between smart cities initiatives with factors that are important to assess the extent of them in contextual, organizational, and technical terms. It is noticed that the impact of factors in smart cities initiatives is bidirectional and factors are represented by two levels of influence. External factors are governance, people and communities, environment, infrastructure, and economy. The internal factors are technology, management and policies. However, since many initiatives are strongly based in technology, it can be seen as a factor that in some way influences every other factors of the model [8].

Whereas the internal factors suggested by the framework [8], the technological factor includes aspects such as interoperability, information and data quality, and technical skills. The organizational factor addresses issues such as funding, goals’ alignment, resources, and inter-governmental relations. The political context includes interrelationships between different levels of government (federal, state and municipal), the removal of legal and regulatory barriers, the political integration between different government agencies, as well as the reformulation of the relationship between government and other stakeholders [8, 26].

Within the external factors there is the governance factor, which includes collaboration, participation, communication, accountability, and transparency [8, 12]. The economic situation is seen as one of the biggest drivers of smart cities initiatives, especially in areas such as competitiveness, economic growth, productivity and agility, as well as integration with national and global market [8]. The infrastructure factor is related to the use of the built infrastructure. Finally, the aspects related to the environment, such as the protection of natural resources, the impact on sustainability, and livability of the city, should be considered in the analysis of smart cities initiatives [8].

An extended version of the integrative framework of smart cities was proposed by Gil-Garcia, Pardo and Nam [14] in order to identify core components and proposing an integrative and comprehensive conceptualization. The proposed framework has four dimensions (1) technology and data, (2) government, (3) society, and (4) physical environment, in which the technology is seen as a component that extends across the others and helps to enhancing and interconnecting them. The authors [14] claim that smart city is a multidimensional and multifaceted concept and the evaluation of the smartness of a city should consider the following components: (1) public services, (2) city administration and management, (3) policies and other institutional arrangements, (4) governance, engagement and collaboration, (5) human capital and creativity, (6) knowledge economy and pro-business environment, (7) built environment and city infrastructure, (8) natural environment and ecological sustainability, (9) ICT and other technologies, and (10) data and information.

# 3. RESEARCH QUESTIONS

The authors concern in this paper is with the main dimensions for implementing municipal operations centers in the smart city domain. Based on the literature review, this research addresses specifically eleven research questions that will guide the further discussion.

## 3.1 Technological dimension

Research Question #1: What is the main application of technology and information in the cases?

Research Question #2: What are the main barriers regarding technological aspects in the cases?

Research Question #3: What are the benefits of data-based initiatives in the cases?

## 3.2 Governmental dimension

Research Question #4: What are the main organizational factors in which the cases are built on?

Research Question #5: What are the main challenges and barriers regarding governmental (managerial, political and institutional) aspects in the cases?

Research Question #6: The achieved results are aligned with the initiatives strategy and objectives in implementing the centers?

### 3.3 Societal dimension

Research Question #7: What is the governance model in the cases?

Research Question #8: What are the main aspects regarding collaboration in the cases?

Research Question #9: What are the main aspects regarding communication and participation in the cases?

Research Question #10: How do the cases act to improve accountability?

Research Question #11: What are the main benefits regarding the increase of efficiency and effectiveness in providing and delivering public services and information?

## 4. METHODOLOGY

### 4.1 Research design

This paper focuses in three cities in Brazil that have municipal operations centers as an effort to become smarter: The Center of Operations Rio (COR) in Rio de Janeiro city, the Integrated Center of Command (CEIC) in Porto Alegre city and the Center of Operations at Belo Horizonte (COP-BH) in Belo Horizonte city. These cities have been recognized as smart cities[1] and represent the totality of municipal operation centers in Brazil, by the time the data collection was done. The cities range widely in terms of population, demographics, economy and location, addressing interesting differences in context.

Considering that most studies require the analysis of multiple cases, for the selection of multiple case studies method it was adopted the logic of literal replication, where the conditions of the cases leads to a prediction of similar results [32]. We chose the cross-case analyze of multiple cases, in which they are not shown separately, seeking more general results [33]. This research is characterized as a holistic study of multiple cases in which each case have a different context (three different cities) and a single unit of analysis, in this study the implementation of municipal operations centers.

### 4.2 Data collection

The data collection model in this research aimed to cover a variety of techniques and sources of qualitative evidences [32], in order to guarantee data triangulation. In total thirty four semi-structured interviews were conducted with thirty seven respondents across the cases from mid-2014 to mid-2015. The interviews have been done in loco at the three municipal operation centers. Each interview lasted between 40 to 60 minutes and was recorded for further analysis. The sample selection was done following the snowball technique, starting with a first point of contact in each center. The selected individuals are included in different functional teams at different levels and with different professional backgrounds, in order to get a wider range of perspectives on the case. Thus, due to the specificities of the cases the sample includes representatives of senior management, as directors and coordinators of the centers; administrative managers and administrative staff, as advisors and managers of the centers, technology analysts and technicians; as well as operating managers and service operators, specially composed by agents from other agencies but allocated in the center. In Rio de Janeiro seven representatives were part of the sample, in Porto Alegre 10 and in Belo Horizonte 20.

### 4.3 Data analysis

The interview protocol included questions for the selected dimensions identified in the literature review, as follows: (1) technology and data, (2) government, and (3) society. The conduction of semi-structured interviews was supported by an interview protocol, but the interviewers were free to build an appropriate interaction with each interviewee. The protocol was based on the literature review, featuring open questions as well as topic-related questions. The Table 1 presents the questions that have been asked during the interviews.

**Table 1. Interviews Questions**

| Dimension | Questions |
|---|---|
| Technology and data | • What is the role of ICT in this initiative?<br>• What are the main barriers and challenges in adopting ICT in this initiative? |
| Government | • How does this initiative make the city smarter?<br>• What were the motivation and the objectives implementing this initiative?<br>• How is this initiative governed and managed?<br>• What are the challenges this initiative is facing to achieve its objectives?<br>• What is the strategy to overcome these challenges? |
| Society | • What is the governance model of this initiative?<br>• In which way are other stakeholders, such as citizens and non-governmental organizations involved in this initiative?<br>• What is the relationship between this initiative and the political environment?<br>• How the interorganizational relationships are guided? |

The set of primary data is very abundant, considering that the content of the interviews transcribed has 558 pages (231,422 words). Also, it was analyzed documental sources that have proved highly relevant and complementary to the interviews, ensuring greater data triangulation capability [33]. The analyzed documents consist of the action plan of the centers for the subsequent year, the regulations (when available), website and news, and reports. This research followed the strategy of evaluating the data collected from a theoretical perspective [11, 33]. According to Miles and Huberman [25], data analysis from a qualitative perspective consists of reduction and display of data, activities that were performed with QSR NVivo software support.

[1] http://www.smartcityexpo.com/awards

## 5. DATA ANALYSIS: CASES DESCRIPTIONS

This section presents the case studies description based on the concept of smart cities as ICT-based urban innovations [26]. In general, the perception of respondents on the objectives of the center as public administration are supported by the prospect of Chourabi et al. [8], where most of the smart cities initiatives are characterized by the use of ICT oriented for the government to better serve the citizens. Besides focusing on citizens, the aspects proposed by Nam and Pardo [26] on the conceptualization of smart cities initiatives were confirmed by the respondents, being the municipal operations centers implemented in urban environments and applying ICT-based innovations in the public sector, specifically in the local government.

During the data analysis the respondents were identified by codes to ensure the confidentiality of the participants. Representatives of Rio de Janeiro are identified by the letter "R" followed by an identification number (e.g. R1, R2, R3…). Similarly, representatives of Porto Alegre have been identified by the letter "P" and from Belo Horizonte by the letter "B", followed by the respective identification number.

Among the smart cities' characteristics, it is clear that the scope of application of the operation centers is limited to the urban environment. In the cases of the analyzed centers, the focus is on urban services and citizens. According to the respondents B1 and B7, the COP is defined as an operational center for the provision of urban services. According to P9, despite being a center for control, due to its constitution, the center is related to the services, being a service center. Comparing the State's command and control centers, the P11 respondent states that "actually our focus is broader, the concept of our center [CEIC], the Belo Horizonte and the Rio de Janeiro center, is on citizens' protection, so in addition to security, there is the involvement of all the services that somehow affect people's lives". In addition, the focus is on cities' management, as the center centralizes the operation of municipal agencies regarding the urban space (R3) and the work of several municipal forces (P11).

When asking the interviewees about the differences of the operation centers comparing to other initiatives, "innovation" and "integration" appeared to be relevant concepts to this context.. The integration (ICT-based) is seen as an innovation in the public sector, supporting the characterization of the centers as smart city initiatives. According to the respondent P3, the initiative "deals with the concept of innovation and systems integration". In the same view, the respondent B1 believes that it is "an innovation this integrative work, working together, this partnership". For the interviewee B13, a smart city consists of actions, such as the center, which allow the integration of systems, services, databases and information crossing. He said that the center is "a very strong innovation to the City Hall" (B13). According to B14 and B15, the key aspect of the initiatives, considering the concept of smart cities, is the integration between the institutions. As reflected by the interviewee B15, this integration allows "optimizing the use of public resources, providing better service with greater readiness, which leads to greater well-being for the population".

As well as aspects of integration, the focus on citizens appears to be as one of the objectives of the analyzed centers (B1, B13, P6, R1, R2, R6). According to the respondent P6 "the purpose of the center is to integrate these utilities for the citizens". The P7 respondent complements saying that "the center [CEIC] sees the city 'as one', if the problem of a specific agency is not being solved, it is also a problem of the population, we are part of the same institution, not different City Halls" (P7). The idea brought by some interviewees is that all municipal agencies have a common goal, which is providing to the citizens (P1, P6, P7, P10). This can be seen in the speech of P1: "everybody has their assignment, their competence and their mission, but our goal is one, the citizen is the same, all [agencies] are engage to attend the same citizen". Moreover, the function of the citizen as the beneficiary appears in the speech of many respondents (B1, P3, P6, P8, R6), as can be seen in P3's statement: "I think the citizens have an involvement within the initiative, as it is the major beneficiary of the center".

In addition, R6 brings the perspective of "return on investment" for public administration in the sense that it in some way returns to society. Thus, this interviewee states that "the interpretation that I make about this initiative is that a large part of our projects should be developed for the citizens, [...] because we are spending citizen's money" (R6). One way to evaluate the return on investment is through the delivery of public value, as can be seen in the speech of the interviewee B1 which emphasizes that the focus of the center is the citizen and the increase of the quality of life by improving the city, "this initiative exist thinking on the citizen [...]. This is an operational center for the provision of urban services [...]. Our focus is to improve the quality of life of the citizen who is our ultimate goal; the big end of operation is improving more and more the city for the citizens".

Considering the definition of CCTV systems, the municipal operations centers differ from each other in their structure, but are mainly configured with the combination of static and fixed cameras or mobile ones. All centers have a control room, which varies in the way they operate [16]. The centers are mainly monitored in a full-time base for operators from different agencies (depending on the agency by a dedicated operator but usually for someone who has other duties besides the monitoring of the CCTV).

## 6. PRELIMINARY FINDINGS AND DISCUSSION

This section presents findings from the analysis of documents and interviews, considering the three dimensions in which municipal operations centers can be understood and implemented: technology, government and society [14]. The analyzed data provide insights into each of those dimensions. As a result of this research we propose a multidimensional understanding of municipal operations centers that was framed from empirical evidences of the centers in Porto Alegre, Rio de Janeiro and Belo Horizonte and is graphically presented on Figure 1.

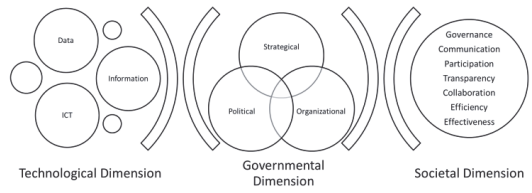


**Figure 1. Multidimensional Model for Municipal Operations Centers.**

In the technology dimension were included the technological factors and the use of government' data and information. The society dimension is represented by governance factors that emerged from the empirical analysis. The government dimension is defined by strategic, organizational and managerial, political, and institutional factors and by the provision and delivery of public services. The description of the dimensions will be presented in the following sections.

## 6.1 Technology

For this study, the technological dimension and its categories were analyzed across the three smart city initiatives. The technological dimension has three main categories that were derived from the literature: (1) ICT; (2) Barriers and challenges; (3) Data and information. These categories have in total 36 codes that were derived from the data through 178 codified parts. The main codes are showed in Table 2.

**Table 2. Technological Dimension Factors**

| Codes (Factors) | Number of codified parts |
|---|---|
| **ICT and other technologies** | |
| Adoption of new technologies | 17 |
| Data sharing and integration | 14 |
| Monitoring system | 12 |
| Integrator system | 6 |
| **Barriers and challenges** | |
| Lack of interoperability | 14 |
| Privacy and consistency of information | 14 |
| Budget constrains | 11 |
| Technological Upgrade | 3 |
| **Data and information** | |
| Geo-located based data | 9 |
| Data-based decision making and planning | 9 |
| Real-time Data | 7 |
| Big Data analysis | 7 |
| Data Crossing | 6 |
| Integration and opening data | 3 |

***Research Question #1: What is the main application of technology and information in the cases?***

The use of ICT to promote interdepartmental communication, information sharing and data management is a key aspect to achieve integrated local governance [29]. In this sense, considering the technological factors, among the most important aspects identified is the use of ICT to enable integration of information and information sharing between the several agencies integrated into the municipal operations centers. However, the results of the analysis show that the initiatives are characterized especially by the integration of services and government' agencies, but there are still possibilities for improvement regarding the integration of systems and information. Thus, it can be stated that:

- The main objective for the use of ICT in the initiatives is enabling the sharing and integration of information between different agencies integrated into the municipal operations centers.
- There are possibilities for improving the integration of systems and information (especially with the implantation of the integrator system in some initiatives).
- The use of mobile devices facilitates the communication between government agents.

***Research Question #2: What are the main barriers regarding technological aspects in the cases?***

In reference to Maheshwari and Janssen [23], the interoperability defines the necessary condition for cooperation by the information exchange and communication between organizations. Although it is still not a reality, it was noticed that the interoperability of systems is on the agenda of the operations centers, being one of the main barriers identified in terms of technology. Even in a more advanced technological maturity level, interoperability of systems is also a barrier in the case of Rio de Janeiro. The lack of interoperability between the centers' systems and the legacy systems of integrated agencies makes the center management more complex and more susceptible to error, resulting in loss of efficiency and effectiveness. An integrator system tends to optimize the municipal operations centers' processes. The main barriers identified are the interoperability of systems and financial resources, and the need of a technological upgrade is one of the main challenges in this regard. In summary, it can be stated that:

- The lack of interoperability and limited financial resources are the main barriers in the technological dimension.
- The need of technological upgrade is a big challenge for the initiatives.

***Research Question #3: What are the benefits of data-based initiatives in the cases?***

A key aspect to make smarter cities is the use of government data and information [14]. By analyzing the influences of data-based initiatives in the context of smart cities, it was found that they can be considered potential mechanisms in the creation of public value. The identified mechanisms involve all dimensions proposed by Harrison et al. [19]. In terms of intrinsic improvements, there is a relation between the use of data to meet the needs of citizens and the creation of new products and private services. Regarding government effectiveness, the data is used for supporting decision-making and for the improvement of the everyday situations. In terms of transparency, it is clear that the initiatives are promoting public access to data and information generated by the city centers. Aspects such as participation and collaboration are also identified by the use of citizens as a source for decision-making processes and stimulating mutual cooperation between government and services application users. Considering these aspects, it can be noticed that data-based initiatives in a smart city context contribute for the improvement of access to public information by the population and in the provision of public services. Thereby, it can be stated that:

- The use of data to support decision-making is one of the key benefits of data-based initiatives to promote smart governance of a city.
- The collaboration can be increased through the adoption of tools and applications already used by the population.

• Data-based initiatives allow the partner institutions to analyze the amount of data generated and government resources through open data platforms, as well as social media.

• Data crossing contributes to increase efficiency in the provision of public services through the optimization of resources.

• The provision of government open data encourages innovation through the creation of new products and services.

• There are still many possibilities of improvement for the use of government data in smart cities initiatives.

## 6.2 Government

For this study, the governmental dimension and its categories was analyzed across the three smart city initiatives. The governmental dimension has four main categories that were derived from the literature: (1) strategic factors; (2) organizational factors; (3) political and institutional; (4) barriers and challenges. These categories have in total 46 codes that were derived from the data through 249 codified parts, as synthetized in Table 3.

**Table 3. Governmental Dimension Factors**

| Codes (Factors) | Number of codified parts |
|---|---|
| **Strategical factors** | |
| Integration between government agencies | 20 |
| Municipal services integration | 19 |
| Optimizing the response time | 10 |
| Focus on citizens | 4 |
| **Organizational factors** | |
| Integration and transversality | 14 |
| Leadership | 12 |
| Resources optimization | 5 |
| Strategic actions for training | 4 |
| **Political and Institutional factors** | |
| Interinstitutional relationship | 13 |
| Intergovernmental relationship | 7 |
| Management of agreements for new partnerships | 4 |
| **Barriers and challenges** | |
| Limited human and financial resources | 25 |
| Legal and regulatory requirements | 10 |
| Resistance to change | 7 |
| Cultural change | 7 |
| Institutionalization | 7 |
| Need for qualified resources | 4 |
| Municipal dynamicity | 3 |

***Research Question #4: What are the main organizational factors in which the cases are built on?***

The operations centers perform the function of leading organization, making the link between organizations and internal and external stakeholders. As well as e-government initiatives, the analyzed smart cities initiatives are guided by the existing need to meet mainstreaming demands. The direct interaction of the Mayor with the agencies integrated with the center is a way to ensure, even coercively, the transversality. Therefore, it can be stated that:

• The municipal operations centers are directly linked to the Mayor's office, which plays the role of leader in the analyzed cases.

• The role of the lead organization is a key aspect to performing integration.

• Transversality can be a way toward governance and transparency in internal actions of government.

Considering the interaction between institutions that occurs in the centers, it has become easier to manage resources, ensuring better utilization of them in service delivery and, which leads to a greater optimization of resources. Moreover, the need for training added to the lack of their own resources at the centers is a challenge in terms of waste of resources in capacity building and, eventually, the absence of skilled resources because of its volatility. Thus, it can be stated that:

• Resource optimization is one of the major benefits in terms of management and organization.

• There is a need for training and relocation of professionals to work in the analyzed initiatives.

• There is a demand for new roles in the organizational structure to deal with emerging technologies and the dynamics of smart cities.

• It was identified the existence of conflicting structures between traditional management and the dynamics of the structure of a smart city.

• To deal with the challenges in terms of human resources, it is suggested the definition of strategic actions in the management model including capacity building and training of government agents to work in the centers.

***Research Question #5: What are the main challenges and barriers regarding governmental (managerial, political and institutional) factors in the cases?***

Financial resources are essential to ensure at least two key aspects to the initiatives, human resources and technology for integration. Despite the differences in terms of budget, all cases had at least one situation where the budget constraint causes a lack of human resources. In the case where the funds are disbursed by the agencies and their secretariats, it may have a lack of funds, for example, for paying over hours in an emergency situation. In this sense, it is clear that the lack of human and financial resources makes it difficult to attend some demands. Considering this context, it is possible emphasize that:

• Budget Constraints and financing needs are substantial challenges for smart cities initiatives.

• Limited funding results in the lack of human resources to meet some demands effectively.

• Lack of human resources may result in public services efficiency drop.

• Alternative funding, such as the search for public-private partnerships, is a way to overcome budget constraints challenges.

Cultural barriers and the resistance to change are recurrent factors when integrating with the municipal operations center, both at

individual and organizational levels. At the individual level, resistance in migrating from a hierarchical structure to a collaborative structure is noticed, for example when the representative of an agency allocated in the center is in a lower level comparing with his leader, but at some point this allocated person may need to coordinate an action (including its superior). In this case, pride can be a barrier for collaborative governance. At the organizational level, the representatives tend to individualism and they understand that their functions should be managed and controlled by the agency in which they operate. In addition, each agency has its culture and its way of operationalizing processes, which makes it difficult to integrate in the same environment. It is suggested that:

- There is a need of cultural change, which embraces a vision of integration culture.
- Defining guidelines that leads to a cultural change is a technique to overcome the cultural challenge.

Considering the inter-organizational relationships were identified different contexts of integration: vertical and horizontal. One of the clearest relationships that occur in the initiatives is the inter-organizational between different agencies of the municipality. In addition, the centers have been setting strong partnerships that go beyond the agencies allocated in the operation centers. As suggested by Halchin [18], it was noticed an improvement in the internal collaboration increasing the relationship between the federal, state and local governments, facilitating information sharing (intergovernmental relations). In this regard, it was identified that the operations centers have also established partnerships with organizations in different spheres of public administration.

The regulatory barriers appear as a problem for the initiatives, considering the dynamism of a smart city and the limitations of the city's management structure. Considering the high level of inter-sectoral link in smart cities initiatives, there is a need for a strong legal framework for new partnerships.

In terms of the management of agreements and new partnerships, it was noticed the existence of resistance in becoming part of the center, especially by public agencies, and the need for mutual benefits management for organizations that want to have a partnership, especially the ones from outside the government sphere. As the centers have been institutionalized and are gaining recognition, more organizations want to be part of the initiatives in order to get benefits or advantages of it. Depending on the case, the centers present different stages of institutionalization. In the case of Belo Horizonte, the initiative is still in the regulatory process. It was identified that the institutionalization depends on contextual factors such as the economic situation of the country, and political issues such as mandate termination. Therefore, it can be stated that:

- The lack of knowledge about the role of the centers generates resistance from some government agencies to share and integrate their activities.
- A greater understanding of the technical aspects of integration offered by the center can facilitate the acceptance and adherence to the center by representatives of government agencies.
- The operations centers are in different stages of institutionalization.
- With the institutionalization of the center, it tends to become more visible and recognized.
- The institutionalization process of smart cities initiatives goes through many trials, especially in its identity search.
- The institutionalization of smart cities initiatives is influenced by contextual factors.

***Research Question #6: The achieved results are aligned with the initiatives strategy and objectives in implementing the centers?***

Considering the strategic factors in the definition of smart cities initiatives and the accountability mechanism proposed by Agrawal, Kettinger and Zhang [1] in the definition of e-governance, we have identified that local governments are concerned if their actions meet the population' expectations and demands.. Moreover, it was noticed an increased responsiveness of public administration regarding both, government actions focusing on the citizens and in the emphasis on results control [8]. When analyzing the goals of the municipal operations centers and the organizational factors, it has been identified several mechanisms that correspond to the metrics for the evaluation of government initiatives. Among the metrics identified, draw our attention: the mechanisms to ensure accountability as organizational integration, coordination and government' information sharing; and governance, as the focus on the citizen, seeking to improve the quality of life and the search for transversality. In addition, tools for demands request, as well as communication channels and social networks are highly available at the initiatives and are constantly verified to ensure that the main demands are met. In this sense, the objectives of the analyzed initiatives corroborate one of the main objectives of smart cities, which, according to Gil-Garcia, Pardo and Nam [15], consist of the citizens' quality of life improvement.

## 6.3 Society

For this study, the societal dimension and its categories was analyzed across the three smart city initiatives. The societal dimension has five main categories that were derived from the literature: (1) governance; (2) communication and participation; (3) transparency; (4) collaboration; (5) efficiency and effectiveness. These categories have in total 33 codes that were derived from the data through 176 codified parts, as synthetized in Table 4.

**Table 4. Societal Dimension Factors**

| Codes (Factors) | Number of quotes |
|---|---|
| **Governance** | |
| Collaborative governance | 8 |
| Hierarchical structure | 6 |
| Participatory decision making | 6 |
| Crisis management for decision making | 6 |
| **Communication and participation** | |
| Interaction through media | 19 |
| Interaction through social media | 15 |
| Lack of channels for engaging with citizens | 9 |
| **Transparency** | |
| Real time information | 3 |

| Codes (Factors) | Number of quotes |
|---|---|
| Supervision of public services | 3 |
| **Collaboration** | |
| Intersectoral partnerships | 10 |
| Civic engagement | 5 |
| **Efficiency and effectiveness** | |
| Agility and increased quality responding a call | 22 |
| Increased quality of service provision | 9 |
| Process agility | 6 |

***Research Question #7: What is the governance model in the cases?***

The governance is considered collaborative when there is a shared responsibility for decisions on operations and actions of government through internal collaboration, characterized by inter-departmental or inter-institutional relationships (among government agencies). The centers have a hierarchical governance structure, represented by the Mayor in the role of decision maker, along with representatives of senior positions in each center.

The convergence of the agencies in a shared environment contributes to the decision-making in demanded situations in a participatory and coordinated way, which is one of the main advantages of the center. A mechanism integrated with the crisis room, where the decision making processes occur, is the operational briefing that serves to ensure the leveling of information, both external, such as the city situations, and internal, as related to the resources available to meet a particular situation.

Among the identified governance mechanisms, the operating protocols are set to provide autonomy to those responsible for the center in the absence of the Mayor or in situations that do not present any risk or unfavorable political consequences. The protocols define the processes and responsibilities in operational terms for each situation. It can be stated that:

- The centers have a hierarchical governance structure.
- The decision-making process in the initiatives is founded on collaboration and participation.
- The decision-making is sometimes authoritarian and others combined, depending on the situation.
- The leader's role in decision-making is critical.
- The situation room [or crisis] and the operational briefings are a way to operationalize the collaborative decision-making, coordination, democratization of information and the creation of combined strategies of action.
- The operating protocols provide autonomy in decision-making, promoting processes flexibility and agility.

***Research Question #8: What are the main aspects regarding collaboration in the cases?***

In addition to the inter-institutional collaboration, the governance also includes the interaction with stakeholders. In the analyzed cases, these groups are represented by public-private partnerships (cross-sector partnership) and by individuals or civic groups, as suggested by Alawadhi et al. [2], which are important actors in the governance of smart cities initiatives.

One of the challenges for governments in adopting new technologies and smart management is that the agents should be able to follow this progress, which requires training and new skills. However, among the barriers identified in the organizational context of operations centers are budget constraints and the lack of qualified human resources, making the progress difficult in some areas. Public-private-university partnerships are identified as a way to overcome these challenges.

In terms of collaboration, we have identified two ways for citizens to get involved and participate in public affairs: directly through citizen service channels or tools available for online communication, and through representatives in the communities and neighborhoods. In sum, it can be indicated that:

- Public-private partnerships are based on mutual cooperation.
- Inter-sectorial partnerships are especially represented by technology companies and social networking services.
- One way to overcome barriers related to the scarcity of financial resources and the need for qualified human resources is through the interaction between universities, industry and government.
- The partnership with universities can assist in training people to work in smart cities initiatives and operations centers.
- Local governments are attentive to citizen participation regarding demands request.
- Local governments promote citizen participation through communication channels.
- Local governments are concerned to provide feedback to the population, through the communication channels.
- Public participation occurs through intermediary actors who interact and actively participate in the decision-making process in local governments.
- Local governments allow citizens monitoring of city services.

***Research Question #9: What are the main aspects regarding communication and participation in the cases?***

In communication and participation, it was found that the interaction between the center and the society is mainly through the media and social networks. To facilitate this interaction, the centers have a press room or a space allocated for television and radio stations in order to provide greater transparency and participation. In addition, tools have been identified, such as social media, websites and applications serving as channels to inform citizens about the situations of the city. Twitter, specifically, has an alert feature that allows the user to be informed about an event and take the protective measures.

Related to communication, the main challenge is the lack of communication channels with citizens to enable a better understanding of the actions and the existence of the centers. It was found that the perception of the centers actions by the population is very low; despite they are recognizing improvements in the city. The creation of communication channels, the dissemination of the center and the establishment of a closer relationship with citizens are part of the agenda of the cases. Considering this context, it is possible emphasize that:

- The communication with citizens is a key issue for managers of the city.

• The creation of information channels in real time is a resource for citizens.

• The characterization of citizens involved in projects varies depending on the project and the secretariat that it is involved.

• Social networks are tools to assist in citizen communication and participation.

• Social networks are widely used tools for the population to monitor government data.

• The press room aims to provide aspects such as transparency and participation.

• The lack of communication channels with citizens, to enable a better understanding of the actions and the existence of the centers, is one of the barriers.

• The agents realize that the initiatives benefit the citizens even without their knowledge.

• creating communication channels is part of the agenda of the centers.

• The press room installed inside the centers allows citizens to access government information (transparency) faster.

***Research Question #10: How do the cases act to improve accountability?***

Among the results of the analyzed initiatives is the increase of government's ability to supervise the institutions linked to the center providing public services, reinforcing the commitment with quality and increasing public satisfaction (accountability). Through the integrated environment provided by the center, is the increased efficiency of public services, because it allows agencies to better target their resources, as well as extending the inspection of services. Considering governance as increased responsiveness of public administration with emphasis on results control, follow up agencies' results is a mechanism of control used by the government to create better action plans in order to improve the provision of public services. This mechanism can result in some level of stewardship as a public value generated by improving administration efficiency [19]. Therefore, it can be stated that:

• The integrated environment allows better control and monitoring of the results of public services agencies, impacting the effectiveness of the services.

• Through the monitoring and control of results it has been also an increase in the efficiency of public services.

• Increased efficiency and effectiveness in providing and delivering public services tends to increase the satisfaction of citizen services user.

***Research Question #11: What are the main benefits regarding the increase of efficiency and effectiveness in providing and delivering public services and information?***

As suggested by Odendaal [29], the organizational integration is essential for ICT to contribute effectively in the local governance improvement. The integration aspect not only helps in terms of organizational communication, avoiding that scarce resources are wasted on duplicate calls, but also can help reducing possible inequalities of information between agencies [29]. Both factors were perceived in the cases analyzed, with increased efficiency and effectiveness in public administration. Being the internal management efficiency related to the proportion of generated results to the applied resources, were identified at least two aspects in terms of public management efficiency which effectively occurred after the implementation of the centers: the optimization of resources and greater efficiency in public spending. Considering the democratization of access to public information by the agencies, were identified at least two benefits in terms of effectiveness in public administration: the use of data for decision making and service optimization through data crossing. Thus, it can be stated that:

• The fastest and most effective are the government interventions; greater is the impact on the city's dynamism.

• To the extent that government can more easily identify problems and integrate more than one agency to solve them, this brings economic benefits to all involved.

• The organizational integration reduces the waste of resources, lack of communication between agencies, and rework.

• By centralizing the coordination of agencies, it helps to respond quicker and solve problems more effectively.

• Improved quality of public services provision is among the main results of the centers regarding effectiveness.

• The use of technology in operations centers allows more accurate data-based decision-making.

When analyzing the results obtained with the implementation of municipal operations centers, through governance factors were identified several mechanisms that correspond to the metrics for government initiatives evaluation. Among the identified metrics, draw attention the mechanisms to improve: efficiency, such as the optimization of resources and agility in providing services; effectiveness, such as improving the quality of services provided; collaboration, as the increase in inter-organizational relationships; and transparency, as the generation and availability of information for citizens. In this sense, it was noticed that the analyzed initiatives are aligned with the definition of smart government where organizations increase efficiency, effectiveness and transparency in internal management and in the provision of public services, and create a collaborative environment with other organizations and society [23, 28].

## 7. CONCLUDING REMARKS

The change in how local governments respond to emergencies and daily situations of a city makes the municipal operations centers an important strategy of resilience and smart governance. The improvement in the provision and delivery of information and public services through government agencies integration and collaborative governance structures is a way to increase the quality of life and citizens' well-being. This research aimed at identifying the dimensions and factors for implementing municipal operations centers as smart city initiatives. To achieve the main objective of the research, multiple cases of municipal operations centers were analyzed, allowing comparisons and maximizing the research results.

It was found that the implementation of municipal operations centers involves technological, organizational and managerial factors, in addition to political and institutional factors. Considering the research objective, the main results of the initiatives in terms of improving the delivery of information and urban services were mapped, considering aspects related to smart cities governance, such as: communication, participation, partnership and collaboration, transparency and accountability, in addition to efficiency and effectiveness in public administration. It was identified that the implementation of municipal operations

centers results in an improvement in the provision and delivery of information and public services.

This study provides both practical implications for professionals in government who works in municipal operations centers and theoretical implications for academics and professionals in the smart cities field. The main theoretical contribution of this study is the proposed factors for implementing municipal operations centers that can be used by researchers and by professionals in the area of public management. Based on the Gil-Garcia, Pardo and Nam [14] framework, we affirm that municipal operations centers can be understood for its implementation, considering technology, government and society dimensions. In the technology dimension is included the technological factors and government data. The society dimension is represented by the governance factors that emerged from the empirical analysis. The government dimension is defined by strategic factors, organizational and managerial, political, and institutional. Despite being a representation of municipal operations centers, considering that the context of the study was focused on smart cities, the model may be applied to other initiatives in future studies.

Although its results permit a solid reflection on the studied phenomenon, this research is not exhaustive in their suggestions and proposals. The research also has some limitations, which are discussed and explained throughout this lines, as well as proposals for future studies. Both the composition and the number of participants of the interviews are different between the three cases. The sample selection following the snowball technique has generated different compositions, probably by the differences in size, age and organizational structure between the cases. One way to minimize this situation in future studies can be by prior analysis of possible respondents. The difference in age of the centers may have some limitations, as well, especially in the case of Belo Horizonte that was with one year of operation when the data collection was performed. Over time the operations centers exhibit more accurate performance indicators that can provide data for analysis of the impact of the center's actions in future research. In addition, due to the constant technological changes, new technologies can emerge and a longitudinal study may bring new contributions. One of the aspects to be analyzed in future studies is the implementation of the integrated system in Porto Alegre and Belo Horizonte. Moreover, the government term period is an aspect that can be included in a longitudinal study, considering that one of the dimensions of the initiatives is the management, especially with factors such as change in the way of governing the city.

## 8. ACKNOWLEDGMENTS

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