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

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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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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 (Przebilovicz & 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.

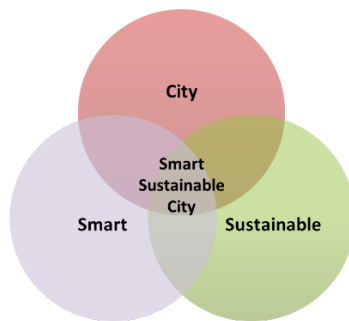


Figure 1. Smart, Sustainable, City (Source: own elaboration based on Höjer & Wangel 2015)

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.

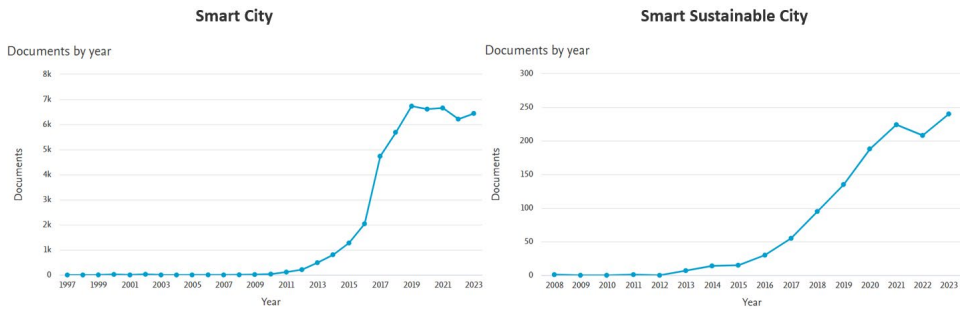


Figure 2. Articles on smart cities and smart sustainable cities by year (Source: Scopus)

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.

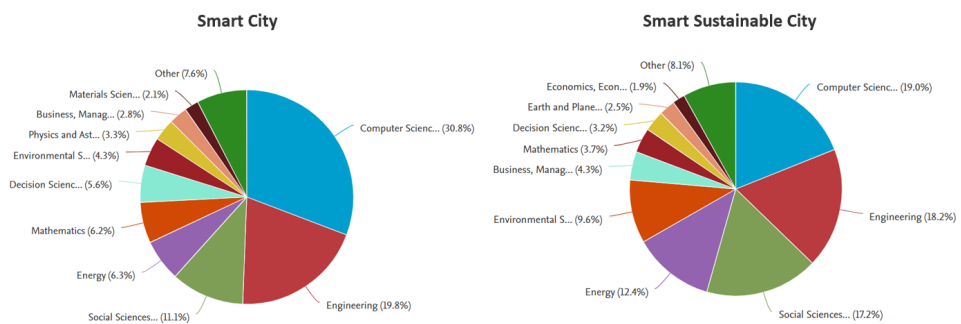


Figure 3. Articles on smart cities and smart sustainable cities by subject area (Source: Scopus)

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; Przybilovicz & 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) | <ul style="list-style-type: none"> • 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) | <ul style="list-style-type: none"> • 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) | <ul style="list-style-type: none"> • 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) | <ul style="list-style-type: none"> • 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) | <ul style="list-style-type: none"> • 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) | <ul style="list-style-type: none"> • 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) | <ul style="list-style-type: none"> • 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) | <ul style="list-style-type: none"> • 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) synthesising 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**).

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 | <ul style="list-style-type: none"> • Living aspects as community needs and public provision of urban services • Innovative healthcare and sanitation facilities • Education facilities to elevate the literacy rate • Accessibility and social inclusion • Social responsibility, informed citizens, knowledge sharing • Community development, collectivism, volunteering networks • Participative and engaged citizens | <ul style="list-style-type: none"> • Lack of citizen participation • Lack of trust • Lack of social awareness • Cultural diversification • Citizen’s inequality • Digital divide • Resistance to change • Social exclusion and gentrification • Unavailability of services for different communities • Lack of connection between technological and social infrastructure |
| Economic | <ul style="list-style-type: none"> • Innovation, urban labs, Research and Development • Crowdsourcing • Knowledge and sharing-based economy, portfolio-thinking • Sustainable management of resources, circular economy • Partnerships, multisector synergies • Promotion of social and human capital • Workforce availability (skilled and non-skilled) • Attract and retain workforce, flexibility of the labour market | <ul style="list-style-type: none"> • High cost of urban infrastructure, imbalance of investments • Lack of funding and investors; short time horizon of investments • Volatility of global economy • Mono-sectoral economy • Competitiveness (local against regional and international markets) • Imbalance between competitiveness and quality of life • Unemployment, lack of equal access to labour market • Lack of qualified human capital • Weak public-private partnership |

| SSC dimension | Drivers | Barriers |
|----------------------|--|--|
| Environmental | <ul style="list-style-type: none"> • Urban attractiveness • Tourist attractive projects | <ul style="list-style-type: none"> • Inefficiency of resource management |
| | <ul style="list-style-type: none"> • Energy related: renewable resources, saving initiatives, smart systems • Water related: monitoring quality, efficiency of water usage • Pollution prevention and reduction • Air pollution monitoring, emission control systems • Smart waste management • Recycling • Availability of environmental standards • Environmental projects and green initiatives • Quality of urban space, land use planning • Mobility related: efficient transport systems, cycle paths • Smart building, responsive building envelopes (RBE) | <ul style="list-style-type: none"> • Climate change • Growing population, imbalance between liveability and environment • Increasing resource consumption • Scarcity of resources, loss of biodiversity and natural habitat • Lack of resource sharing • Lack of a holistic approach to environmental sustainability • Lack of knowledge on how ICT can decrease energy consumption • High level of air pollution • Inefficient waste management • Traffic density and inefficient public transport system |
| Governance | <ul style="list-style-type: none"> • Transparency and openness • Citizen empowerment, interactive and participatory services, co-production, co-creation, bottom-up approaches • Information and knowledge sharing, communication channels • Supportive government policies • Urban planning: strategy and vision definition • Context adaptation, analysis of current situation, flexibility • Capacity planning (i.e., infrastructure, cost, and human resources) • Clear definition of roles and responsibilities • Leader / champion: dedicated organisation / person for SSC initiatives • Definition of Key Performance Indicators (KPIs); monitoring / assessment | <ul style="list-style-type: none"> • Lack of planning; lack of vision and strategy • Lack of project management • Lack of capacity (HR) • Lack of IT knowledge among city planners • Lack of operational capability • Lack of capacity building (training) • Structural issues: isolated silos; lack of internal cooperation • Structural issues: complexity of organisational structures • Lack of alignment, conflicts of interests • Lack of knowledge and information sharing • Lack of engagement opportunities • Poor public-private partnership • Centralized decision-making process, top-down approach • Political instability and complexity • Lack of political will and support • Lack of transparency and trust • Lack of regulation and legislation • Inability of policies • Multiplicity of policies and programmes |

| SSC dimension | Drivers | Barriers |
|-----------------------------|---|--|
| | <ul style="list-style-type: none"> • Collaborative decision-making; participatory governance models • Stakeholders' engagement: internal (cross-sector) and external • Managing conflicts of interests • Data-driven decision-making and availability of real-time data • Urban proactiveness for service provision • Data governance: data quality, data sharing and data privacy policies | <ul style="list-style-type: none"> • Lack of standards for measuring performance • Lack of data governance • Lack of open data, issues for opening data |
| Urban Infrastructure | <ul style="list-style-type: none"> • Physical infrastructure integration • Affordable housing facilities, such as water and energy supply • Adoption of innovative construction techniques • Connectivity, broadband, access to internet facilities • Interoperability and integrated ICT • Security verification tools / systems • Advanced ICT, intelligent technologies in urban services • Smart grid; intelligent energy management systems • Use of geographic information systems (GIS) • Data processing: modelling imperfect data; data exchange • Data analytic capacity; business intelligence (BI) • Internet of Things (IoT) • Big Data | <ul style="list-style-type: none"> • Urban infrastructure deterioration • Deficit of technological infrastructure • Lack of infrastructure integration, complexity of networks • Technological obsolescence, system failures, infrastructure fragility • Lack of interoperability of systems and lack of integration standards • Lack of security of systems, privacy violation • Poor quality of ICT-based services • Lack of data integration, complexity of opening and linking data • Lack of data management, huge volume of data • Lack of cloud and fog computing • 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 II³.

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.

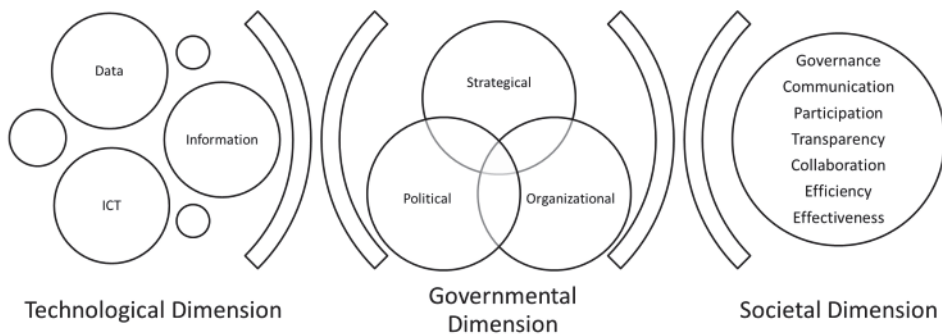


Figure 6. Multidimensional model for municipal operations centres (Source VIII, p. 23)

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.

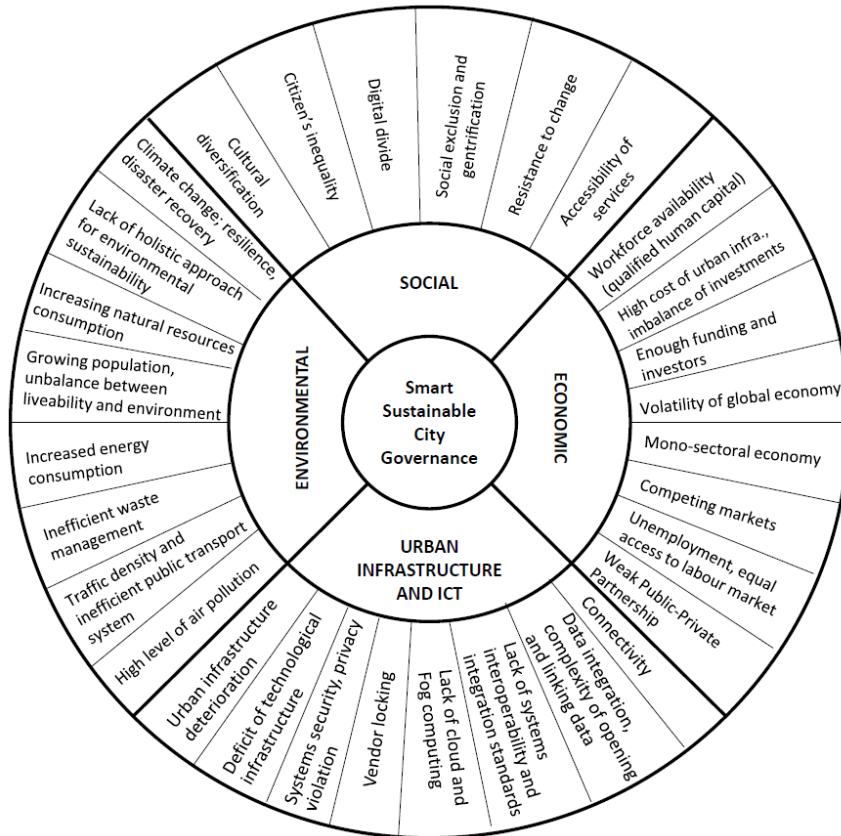


Figure 7. Sustainability challenges for SSC development (Source III, p. 8)

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.

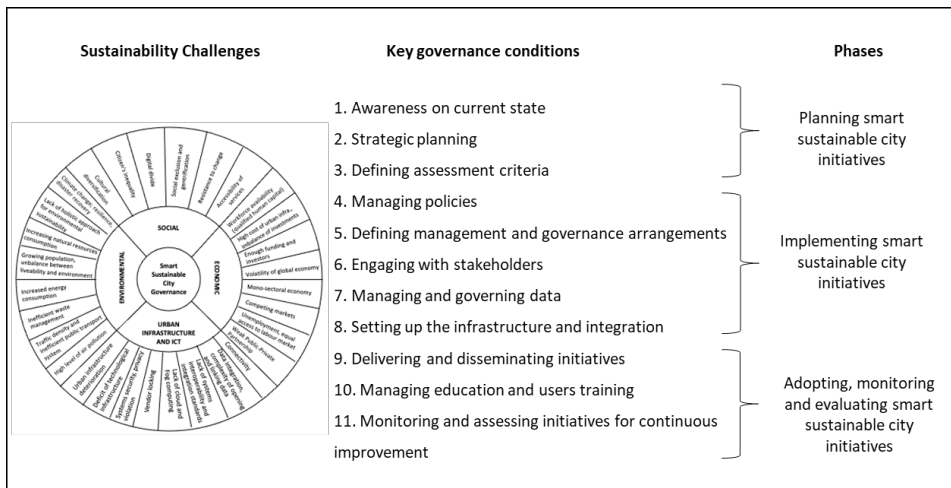


Figure 8. Smart sustainable city governance roadmap (Source: III)

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 (Keshvaridoost 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 (Keshvaridoost 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.

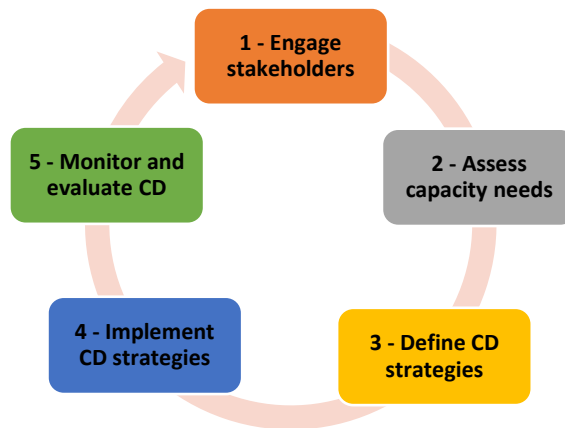


Figure 9. Capacity development process (Source: own elaboration based on UNDG, 2017)

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.

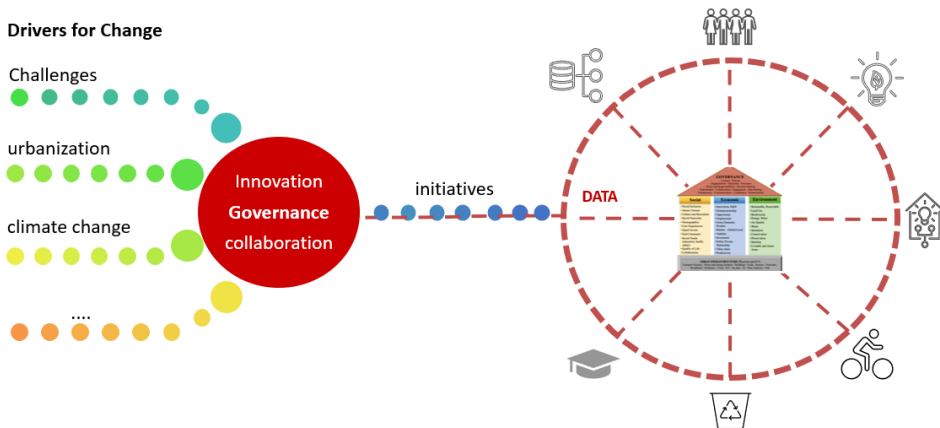


Figure 10. Innovation and smarter sustainable cities

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.

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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 valitsemisuuutlikkust 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 linna käsitlevatest teadustöödest ja innovatsioonist panustada targa jätkusuutliku linna kontseptsiooni?
2. Millised on peamised tõekejõud ja takistused ning peamised juhtimistingimused, mis mõjutavad targemate jätkusuutlike linnade arendamist?
3. Milliseid strateegiaid saab kasutada targemate jätkusuutlike linnade kohaliku valitsemisuuutlikkuse 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 tõekejõude ja takistusi, esitleti tegevuskava nutika jätkusuutliku linna arendamiseks, uuriti ühte juhtumit mittehädaabi teenuste 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.

Publication 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.

Publication 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.

Publication 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.

Publication 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.

Publication 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.

Publication 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.

Publication 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.

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