Routledge Advances in Regional Economics, Science and Policy

SUSTAINABLE AND SMART CITIES

GOVERNANCE, ECONOMY AND SOCIETY

Edited by
Anshuman Khare and Terry Beckman

ROUTLEDGE

Sustainable and Smart Cities

This book provides a comprehensive overview of the challenges modern cities face in the context of climate change and urban development. By integrating varied viewpoints, it delves into the concept of sustainable and smart cities and sheds light on the opportunities for innovative and effective solutions, underscoring the interconnected nature of urban challenges and the necessity of a holistic approach.

Contributors present diverse perspectives and methodologies, including empirical studies, modelling, simulation, policy analysis, and case studies, to offer insights into innovative and effective solutions for urban sustainability challenges. Chapters are grouped according to themes of governance and management, economy, society, and technology. Topics covered include smart city governance models, the enabling role of managers in sustainability efforts, resilient infrastructure, homelessness, and smart technology implementations. The book also identifies research gaps and areas of uncertainty, which may guide future research.

With contributions from researchers across Asia, Europe, and North America, this book is a valuable resource for researchers in the areas of sustainable development, urban sustainability, and resilience research. It will also interest policymakers, practitioners, and stakeholders working towards addressing climate change in urban areas.

Anshuman Khare is Professor of Operations Management at Athabasca University, Canada. His research focuses on environmental regulation impacts on industry, supply chain management, sustainability, cities and climate change, and digital transformation. This is his second volume on urban studies.

Terry Beckman is Associate Dean of Research and Accreditation at Athabasca University, Canada. His research interests are primarily in corporate social responsibility, corporate branding, international business, and marketing strategy. He has published one edited book and various articles in his areas of research interest.

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Foreword

Mayor Cathy Heron is a lifelong resident of St. Albert, Alberta, Canada. She is serving her second term as Mayor of St. Albert. Before that, she served two terms as St. Albert Councillor (2010 to 2017).

She was elected President of Alberta Municipalities (formerly known as the Alberta Urban Municipalities Association or AUMA) in 2021. She previously served as Vice President in 2017 as Director of Cities up to 500,000 and on the Board of Directors in 2015. She also chaired the organization's Recovery Task Force, Sustainability and Environment Committee, and the Municipal Governance Committee.

Sustainable and smart cities have become essential for enhancing the quality of life for citizens, fostering community engagement, driving economic growth, and promoting environmental sustainability. By integrating advanced technologies and innovative governance practices, smart cities can address the complex challenges urban areas face today. The collaborative efforts of various stakeholders, including government, businesses, and citizens, are crucial for realizing the full potential of smart cities and ensuring that they serve the needs of all community members.

Sustainable and smart cities represent a transformative approach to urban living, integrating advanced technologies and innovative governance to enhance the quality of life for citizens, foster community engagement, and address societal challenges. Their importance can be articulated through several dimensions, including improved public services, enhanced citizen participation, economic growth, and environmental sustainability.

They significantly enhance public services through the integration of information and communication technologies (ICT). By leveraging IoT devices and data analytics, cities can optimize services such as healthcare, transportation, and utilities. For instance, smart healthcare systems enable real-time monitoring of patient health, which can lead to timely interventions and improved health outcomes. Similarly, smart transportation systems can reduce congestion and improve safety by providing real-time traffic updates and optimizing public transit routes. The integration of these technologies not only improves service delivery but also increases operational efficiency, leading to cost savings for municipalities and better resource allocation.

The development of smart cities fosters greater citizen engagement and participation in governance. The concept of "smart governance" emphasizes the importance of involving citizens in decision-making processes, thereby enhancing transparency and accountability. Initiatives such as participatory budgeting and community-driven projects empower citizens to have a say in how resources are allocated and which services are prioritized. This participatory approach not only strengthens democratic practices but also ensures that the needs and preferences of diverse community members are taken into account, leading to more equitable outcomes.

Sustainable and smart cities also contribute to economic growth. Implementing technologies can stimulate local economies by attracting businesses and fostering innovation. For example, cities that invest in smart infrastructure create an environment conducive to tech startups and other businesses that rely on advanced technologies. The enhanced efficiency of urban services can lead to increased productivity, which is essential for economic development. As cities become more attractive to businesses and residents alike, they can experience a positive feedback loop of growth and investment.

Environmental sustainability is another critical aspect. The integration of smart technologies allows for better management of resources, reducing waste and minimizing environmental impact. Smart grids, for instance, enable more efficient energy consumption by allowing for real-time monitoring and management of electricity use. Smart waste management systems can optimize collection routes and schedules, reducing emissions from waste collection vehicles. By prioritizing sustainability, smart cities can contribute to global efforts to combat climate change and promote a healthier urban environment.

The emotional well-being of citizens is positively influenced by the development of sustainable cities. Technology-driven initiatives can enhance residents' quality of life by providing access to high-quality services and fostering a sense of community. The availability of public spaces, recreational facilities, and cultural events can lead to increased social interaction and community cohesion, which are vital for mental health and overall well-being. As citizens feel more connected to their communities and satisfied with the services they receive, their emotional well-being improves, creating a more vibrant urban atmosphere.

This book provides a wide-ranging guide to designing and developing future cities that are not only sustainable but also resilient and smart. It delves into the key principles and strategies that can transform urban areas into thriving communities. The book explores the integration of smart technologies in urban environments. It covers topics such as smart grids, IoT (Internet of Things), and data-driven decision-making that improve efficiency, connectivity, and quality of life for residents.

Mayor Cathy Heron
St. Albert
October 2024

Preface

Cities play a crucial role in addressing climate change. Urban areas are significant contributors to greenhouse gas emissions due to concentrated industrial activities, transportation, and energy consumption. At the same time, cities are vulnerable to the impacts of climate change. By implementing sustainable practices, cities can significantly reduce their carbon footprint; and by developing resilient urban infrastructure and having suitable response strategies, they can help mitigate climate change-related impacts and protect the well-being of citizens, improving their quality of life.

Cities serve as hubs for innovation and policy development. Local governments have the authority to enact policies that promote sustainability, while businesses can help cities achieve sustainable goals. Academic institutions and businesses in urban areas can contribute to research and development of sustainable technologies, as well as raise awareness about climate change issues through educational programs. This, in turn, helps regional and national governments to achieve sustainable development goals.

Climate Change – A Challenge

Climate change is a critical issue for cities to consider in their sustainability efforts because it directly impacts the quality of life of their residents. The effects of climate change, such as rising temperatures, changing precipitation patterns, and more frequent extreme weather events, can significantly impact the health, safety, and well-being of city residents.

Sustainable cities need to take action to reduce their carbon footprint, mitigate climate change, and adapt to its impacts. This can include initiatives such as investing in renewable energy, promoting energy-efficient buildings and transportation, reducing waste, and creating green spaces to help cool urban areas and absorb stormwater.

Cities that take proactive steps to address climate change can also benefit economically by reducing their energy costs, improving public health, and attracting businesses and residents who value sustainability.

Sustainable cities can serve as role models for others, inspiring neighbouring communities and encouraging broader action to address the global challenge of climate change. By prioritizing sustainability, cities can help mitigate the impact of climate change and create a more livable and resilient future for their residents.

The key to studying sustainable cities is to adopt a holistic and integrated approach that considers the social, economic, and environmental dimensions of urban sustainability. There are several emerging methodologies to study sustainable cities, some of which include Urban Metabolism Analysis, Participatory Action Research, Life Cycle Assessment, Systems Thinking, Big Data Analytics, and so on. The Digital Twins approach can also be considered a useful methodology for studying sustainable cities. They can be used to model and analyse urban systems, such as buildings, infrastructure, transportation networks, and energy grids, in a virtual environment.

Cities and United Nations Sustainable Goals

The SDGs provide a roadmap for cities to take integrated and coordinated action on multiple fronts, including energy, infrastructure, and climate action, to promote sustainable development and address the global challenges we face today. Some key SDGs pursued by cities include:

3 GOOD HEALTH AND WELL-BEING	This goal seeks to ensure health and well-being for all, at every stage of life.	7 AFFORDABLE AND CLEAN ENERGY	This goal encourages the use of renewable energy sources and supports the development of clean energy infrastructure.
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	This goal promotes the development of sustainable infrastructure and encourages innovation in technologies that support sustainable development.	11 SUSTAINABLE CITIES AND COMMUNITIES	This goal encourages the development of sustainable, resilient, and inclusive cities that provide access to essential services for all residents.
13 CLIMATE ACTION	This goal promotes urgent action to address climate change and its impacts.		

Figure P.1 Sustainable goals pursued by cities

Credit: United Nations Sustainable Development Goals. https://mdgs.un.org/sdgs/

By aligning their sustainability efforts with the SDGs, cities can leverage a global framework to achieve their sustainability goals and make progress towards a lower carbon footprint.

Resilient, Smart Cities, and Engaged Citizens

Resilient cities are cities that can adapt and recover from shocks and stresses (both natural and manmade disasters) and mitigate the impact on social, economic, and environmental systems. Resilient cities are characterized by strong governance and leadership, community involvement, robust infrastructure, and disaster recovery plans. They also serve as centres for innovation and learning. By investing in resilience, cities can reduce the impact of disasters, improve the well-being of their residents, and build a more sustainable future.

Smart cities aim to improve the quality of life for their residents by providing more efficient and effective urban services, reducing environmental impacts, and promoting economic development.

- Smart transportation using real-time data to optimize traffic flow, reduce congestion, and improve public transportation services.
- Smart energy systems to optimize energy usage, reduce waste, and promote the use of renewable energy sources.
- Smart waste management systems to optimize waste collection and disposal, reduce waste, and increase recycling rates.
- Smart water management systems to optimize water usage, reduce waste, and detect leaks in water distribution systems.
- Smart public safety initiatives to improve emergency response times, prevent crime, and enhance public safety.

By leveraging technology in these and other ways, cities can make significant progress towards achieving their goals for a lower carbon footprint. However, it is important to ensure that these technologies are deployed equitably and inclusively and that they do not exacerbate existing social or economic inequalities.

Engaged citizens and consumers willingly participate in and contribute to formulating resilient and smart city policies and initiatives. For the initiatives to be successful, the citizens must not perceive that they are solely bearing the burden of the implementation costs of creating resilient and smart cities. One would not expect businesses to get involved in implementing sustainable technologies in cities unless they can make a profit. Likewise, city governments may only feel the costs of new initiatives in the long run. However, individual citizens will directly pay for these initiatives through higher taxes and fees. Unless both benefits and costs are seen to be borne by all three stakeholders, the sustainability of the initiatives could be in jeopardy.

The Objective of the Book

The objective of this compilation of research papers related to cities and climate change is to provide a broad overview of the current state of knowledge and understanding of the impacts of climate change on urban areas, as well as the strategies and approaches that cities use to mitigate and adapt to these impacts.

This compilation brings together a diverse range of research perspectives and methodologies, including empirical studies, policy analysis, and case studies, among others. By synthesizing these different perspectives, the collection of research papers provides insights into the complex and multifaceted challenges facing cities in the context of climate change, as well as the opportunities for innovative and effective solutions.

Within the chapters, several different subject areas related to smart, sustainable cities are covered. Significant for all smart cities are governance issues; a review of these issues and their categorization helps to put the following chapters into perspective. As technology is one of the fundamental underpinnings of smart cities, there are chapters focusing on the data and digital side. One chapter examines how a robust data ecosystem can lead to and facilitate efficient data utilization in the development and support of smart and sustainable initiatives. Another chapter highlights the importance of the need for digital tools to manage the variety of systems that are emerging in smart cities – in this chapter, the focus is on the variety of distributed photovoltaic systems, and how they integrate with homes and the power grid.

Additionally, there is a need to look at some of the structural aspects of smart, sustainable cities. One chapter describes a case on how to apply sustainable principles at a city-wide scale, with particular attention to managing water resources through a sponge city approach. Another chapter looks at one of the most fundamental elements of any city: homes. Sustainable housing, designed to use environmentally friendly materials, be efficient in resource usage, and integrate renewable energy sources, is critical to a smart, sustainable city. This chapter provides a review of literature on this subject.

One theme that runs through many of the chapters is the role of engaged citizens as key stakeholders in smart cities. Their involvement with both city planners and industry is critical to the effective implementation of smart cities. In particular, one chapter looks at how citizens can be engaged in the co-creation of smart initiatives to enhance the quality of urban life. Another key stakeholder for smart, sustainable cities is industry. Two chapters look at how industry can be involved in smart, sustainable cities. One focuses on the startup ecosystem and the role of support actors in ensuring such an ecosystem functions to nurture small and medium-sized enterprises (SMEs). The other chapter also looks at SMEs and how regional partnerships can build SME competitiveness and have a positive impact on the development of smart, sustainable cities.

Two other chapters look at the humanistic side of smart, sustainable cities. One chapter looks at the issue of homelessness and how smart cities can address the related challenges of this perpetual problem. How can cities leverage technology to enable approaches that address systemic causes of homelessness? The other chapter looks at mental health issues. While sustainability is important to highlight for citizens, the broad and intense communication of increasingly dire predictions about the dangers of climate change and environmental damage can lead to climate anxiety. Caution needs to be applied in communications about these issues such that the smart and sustainable initiatives can proceed without triggering mental health issues.

In addition, the compilation helps identify research gaps and areas of uncertainty, highlighting where further research is needed to better understand the impacts of climate change on cities and to develop more effective responses. This could help guide future research agendas and inform policy and decision-making at the local, regional, and global levels.

Overall, the objective of this compilation of research papers related to cities and climate change is to provide a valuable resource for researchers, policymakers, practitioners, and other stakeholders working to address the urgent challenges of climate change in urban areas.

How This Book Aims to Be Different from Others?

This book aims to present a comprehensive examination of some of the challenges facing modern cities. It discusses a range of topics relevant to urban environments from around the world, emphasizing the interconnected nature of urban challenges and the importance of a holistic approach. The book encourages policymakers, urban planners, and citizens to actively engage in creating sustainable and resilient cities for the future. It provides an in-depth exploration of the multifaceted issues facing modern cities.

Review Process

Proposals submitted were reviewed by the editors, and an initial structure for the book was created. After a shortlisting process, selected authors were invited to submit full papers. These chapters underwent a peer-review process conducted by a team of academics and professionals from around the world. The review process was double-blind and was coordinated by the editors and an editorial board.

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Editorial Board

The editors would like to extend their heartfelt gratitude to all the Editorial Board members and reviewers who dedicated their time and expertise to this edited book. Their timely reviews helped us complete this book on time.

Section 1
Governance

Governance in smart and sustainable cities is crucial for coordinating resources, technology, and human capital to enhance urban living. Effective governance ensures transparency, accountability, and citizen engagement, promoting trust and inclusivity. It facilitates the integration of advanced technologies like Internet of Things and AI, optimizing infrastructure and services. Governance also addresses data privacy and security, ensuring the responsible use of information. By fostering collaboration among various stakeholders, it drives innovation and sustainability, creating resilient cities that adapt to evolving challenges while improving the quality of life for all residents.

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1 Multi-facets of Smart Cities Governance Models

Terry Beckman and Anshuman Khare

1. Introduction

Smart cities represent a paradigm of urban development that leverages advanced technologies to enhance various aspects of urban life. While the specific definitions and implementations may vary, the overarching goal of smart cities is to create more efficient, sustainable, and livable urban environments. This goal is admirable, yet reaching it involves the integration and management of the various components of a smart city, which can include competing priorities of different stakeholders, citizens, and industry groups, matched with limited resources. As such, effective governance becomes a necessary aspect of managing a smart city. Broad governance issues have been well reviewed in the literature (e.g. Babić et al., 2022; Fauzi et al., 2020; Jiang et al., 2020a; Meijer & Bolívar, 2015; Ngo & Le, 2021; Pereira et al., 2018), but these have typically focused on macro issues of city governance. These issues are varied and diverse, and they are critical to the efficient and effective governance of a smart city. However, less covered in the literature are the various meso- and micro-level facets that manifest at a lower level of governance. These facets bring the governance components down to the application and implementation level. It is at this level of application – where governance impacts the regular citizen or business in a city – that this chapter looks at. The purpose is to highlight the facets that need to be considered when governance is implemented.

Globally, urban growth has increased over the past several decades and is expected to continue, with 68% of the world's population expected to live in cities by 2050 (United Nations Population Division, 2019). Smart cities represent a significant trend in urban development due to their ability to leverage advanced technologies, particularly the Internet of Things (IoT), to enhance urban living conditions. These cities focus on improving the quality of life for residents by optimizing resource management, reducing administrative costs, and increasing infrastructure efficiency (Gunawan et al., 2022). The integration of information and communication technologies (ICT) allows for better urban governance and sustainable development, addressing challenges such as traffic congestion, pollution, and energy consumption (Elena, 2024). They

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foster citizen engagement and participatory governance, which are crucial for tailoring services to meet community needs (Casciati et al., 2017). This holistic approach not only enhances the livability of urban environments but also promotes economic growth and innovation, making smart cities a preferable model compared to traditional urban settings (Appio et al., 2019; Pamudji, 2023). As urban populations continue to grow, the smart city framework provides a viable solution to the complexities of modern urban management (Kirimtat et al., 2020). In this context, smart cities have the potential to ensure the well-being and rights of citizens, accommodate evolving innovations, and integrate technological, social, and environmental factors. Traditional cities are typically less focused on using integrated technologies to maximize the efficient and effective use of available information, and consequently, they end up with systems and services that operate relatively independently and function with a shorter-term outlook. Philosophically, smart cities aim to improve urban infrastructure, promote citizen participation, and address challenges such as social inequality and marginalization (Nieto et al., 2021). This more holistic approach ensures that social factors are a key component – in addition to technological factors – in the development of smart cities. Given the importance of governance in smart cities, this chapter sets out to highlight and illustrate the facets that reside under the macro level of smart city governance. First, we will discuss the components of smart cities, the issues and problems that may arise with smart cities, and why the development and management of smart cities are so important. Next, we will provide an overview of smart city governance and some key models and frameworks. Then, we provide a more detailed description of the facets of smart city governance, including some specific areas where these come into play. Finally, we provide a summary of some outcomes of good governance.

2. Smart Cities

Smart cities can be seen as a contemporary urban development concept that integrates ICT to enhance various aspects of urban life, such as transportation, energy, healthcare, and governance (Huang et al., 2021; Kirimtat et al., 2020). These cities utilize IoT, big data, cloud computing, and geospatial information to promote efficient urban planning, management, and services, ultimately improving the quality of life for citizens (Zhang & Goyal, 2022; Lai et al., 2020). The development of smart cities is a dynamic and evolving process, with different countries and cities having varied definitions and connotations of what constitutes a smart city, depending on their development levels and specific objectives (Huang et al., 2021). Thus, the concept of smart cities is multifaceted, including many characteristics such as connectivity, intelligence, and instrumentation, which aim to increase efficiency, transparency, and service quality (Sitna et al., 2021).

Smart cities are not only a means of urban development but also a source of pride for governments, representing a significant step in advancing cities through the use of information and communication technology (Ningrum, 2021). The implementation of smart cities is a sought-after initiative globally, with various cities and regions, such as Dubai, Abu Dhabi, Riyadh, Cairo, and Rabat, aiming to increase their territorial competitiveness through the adoption of smart city concepts (Ahouzi et al., 2020). The emergence of smart cities has been recognized as a significant breakthrough in improving the public sector, leveraging technologies such as artificial intelligence and the Internet of Things (Gurick & Felger, 2022).

The definition of smart cities is not universally agreed upon, with multiple interpretations existing in the literature (Singh & Singla, 2020). However, it is generally understood that smart cities aim to improve urban connectivity and interactions between humans, the environment, and smart devices, ultimately enhancing the overall urban experience (Shirowzhan et al., 2020). The COVID-19 pandemic has highlighted the importance of smart cities in addressing public health crises, with smart technologies being essential for reducing the risk of such outbreaks (Jaiswal et al., 2020).

3. Smart City Governance

According to UN-Habitat (UN-Habitat, 2024), urban governance "refers to structures and processes . . . under which management and administrative systems will operate." Smart city governance adds to this in that it also encompasses the effective coordination of urban technologies, decision-making, administration, and collaboration while addressing the challenges of digital society, information sharing, citizen engagement, and transparency. It involves making the right policy decisions, promoting smart city initiatives, and efficiently managing resources with a focus on environmentally friendly approaches and humanist principles. It is influenced by smart technologies, big data, and citizen engagement, which are essential for the success of smart city initiatives. Key aspects of smart city governance include government, decision-making, administration, collaboration, economy, people, mobility, environment, living, and sustainability.

Smart city governance involves efficiently coordinating urban technologies, models, and methods to utilize urban data, leveraging new communication and dissemination technologies, and developing innovative forms of urban governance and organizations. Several authors have contributed to the literature on smart city governance. They approach the topic from several different angles, each dealing with critical aspects of said governance or addressing different issues and challenges of city operations. Batty et al. (2012) identified four ideal-typical conceptualizations of smart city governance: government of a smart city, smart decision-making, smart administration, and smart urban collaboration. Meijer and Bolívar (2015) and Pereira et al. (2018) contributed to developing a framework for building new, smart governance models addressing the challenges of the digital society, collaborative governance, information sharing, citizen engagement, transparency, and openness. Smart governance involves making the right policy decisions and implementing them effectively (Babić et al., 2022). It also encompasses the promotion of smart city initiatives without necessarily changing the structure or processes of the government apparatus (Ngo & Le, 2021). Smart governance aims to efficiently manage resources by considering environmentally friendly approaches and humanist principles (Mukhlis et al., 2021).

Smart governance is crucial for promoting inclusive development and managing resources in an environmentally friendly manner, aligning with humanist principles (Mukhlis et al., 2021). It is considered a means to enhance the efficiency and democracy of public service delivery from a government perspective (Cranefield, 2020) and is integral to the success of smart city initiatives, as it involves participatory governance, transparency, and citizen engagement, which are essential for the success of smart city initiatives (Gil et al., 2019). Supporting smart city governance versus a non-smart city, though, is a base of information systems. The next section reviews aspects of this critical component.

4. ICT Governance for Effective Smart City Governance

ICT is one of the foundational, underlying components of all smart cities (Pereira et al., 2018). Thus, to effectively govern a smart city, it is crucial to consider various aspects of ICT governance. This involves coordinating urban technologies, utilizing urban data, developing new technologies for communication, and enhancing urban governance and organization (Batty et al., 2012). It encompasses policies related to human capital, education, economic development, and governance, and how they can be enhanced by ICT (Kitchin, 2013). Implementation levels of ICT and smart governance are essential for improved service delivery in smart cities (Ncamphalala & Vyas-Doorgapersad, 2022). Smart city governance involves digital transformation through ICT processes, integrating good governance, improved quality of life, modern ICT urban systems, developed human resources and strengthened urban city resilience in the digital era (Sukmadiansyah & Noviaristanti, 2022).

ICT has the potential to transform urban governance into "smart governance" by enabling city governments to carry out their tasks more effectively and efficiently (Pereira et al., 2017). Further support for the importance of ICT for smart governance comes from the fact that elements like data, information, and communication technologies, along with urban governance, are ubiquitous in deliberations about smart cities (Odefadehan, 2021). It is through the effective use of ICT (e.g. Internet of Things, artificial intelligence, machine learning) that smart cities provide smart services to residents as an integrated part of governance for development (Fatewar & Vaishali, 2021). According to Fauzi et al. (2020), the use of ICT is the most dominant factor in the application of smart city governance.

As the implementation of ICT within a city is so significant, the perspective of local ICT firms is important in planning cooperation with city governments for innovations in smart cities (Głębocki, 2022). Developing and maintaining a collaborative governance model are crucial for success in multi-jurisdictional smart city undertakings (Scholl & AlAwadhi, 2016). Within this, a focus on substantive urban challenges helps define appropriate modes of governance and develop dedicated technologies that contribute to solving specific smart city challenges (Jiang et al., 2020a). Not only does ICT contribute to solving these challenges, but the overall concept of the smart city is usually integrated with the use of ICT infrastructure, especially for monitoring, management, and decision-making tools (Yandri et al., 2020). Smart city initiatives stress the investment in human and social capital, traditional and modern communication infrastructure, and participatory governance (AlAwadhi et al., 2012).

The concept of smart cities observes and incorporates the status of all infrastructure management, governance, people and communities, and the natural environment through ICT (Kumar, 2019). The smart city vision calls for a full integration of the city's physical and digital layers, emphasizing the importance of ICT in governance (Kramers et al., 2016). While ICT is recognized as a significant factor in smart cities, the meaning of a smart city goes beyond that, encompassing various other aspects (Ngo & Le, 2021). The next section looks into these facets in more detail.

5. Facets of Smart City Governance

Understanding the main factors of smart city governance is important at a macro level; it is evident that efficient and effective management of a city is critical. However, it is also necessary to look at the complexities involved in such governance. Cities have the leverage to affect major societal issues such as environmental sustainability, citizen well-being, industry viability, climate change, and future growth opportunities. But this leverage goes both ways: a city can be efficient and effective, or it can be inefficient and ineffective; it can help or hinder; it can create positive effects, or it can create negative effects. Hence, the consideration of meso and micro factors in governance takes on critical importance. From the literature and adapted from Cohen's Smart City Wheel (Cohen, 2014), seven facets that need to be considered in the application and implementation (e.g. Wahyuni et al., 2022) of smart city governance: sustainability, smart economy, smart living, citizen and society participation, resource management, smart government, and humanist approach. In overall smart city governance, these facets integrate with and impact various aspects of city living and health, such as climate anxiety, homelessness, water management, housing, business startup ecosystems, co-creation of city services, regional partnerships, and data ecosystems.

In this section, we delve into the multifaceted dimensions of smart city governance (Figure 1.1), exploring the intricate interplay between technological innovation, public participation, and policy frameworks. Each of the dimensions is important in its own right to smart city governance; but it is through their interconnection and interplay that the benefits of smart cities can be realized. By examining these dimensions, we aim to elucidate the complexities

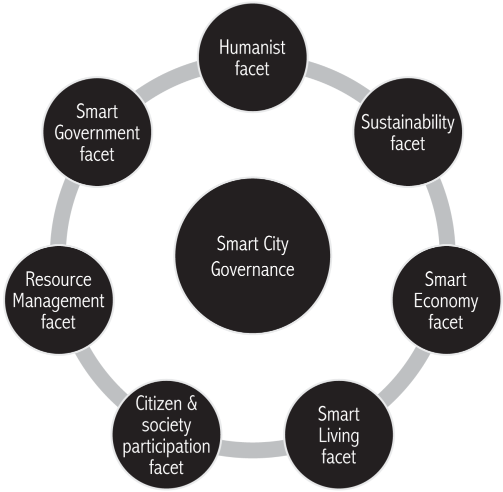

Figure 1.1 Selected dimensions of smart city governance models

Source: adapted from Cohen's Smart City Wheel (Cohen, 2014)

and opportunities inherent in governing modern urban environments poised for digital transformation.

5.1 The Humanist Facet

While the digital and technological components of smart cities are often the focus of smart city development, it is crucial not to overlook the humanist implications and the role of people. The humanist aspects of smart cities emphasize the importance of creating urban environments that enhance the quality of life for citizens. Importantly, this facet also plays a role in identifying and alleviating some negative aspects of modern urban life, such as homelessness and climate anxiety. These aspects encompass philosophical humanism, ecological ethics, and socio-cultural approaches, emphasizing the importance of sustainability, livability, and the well-being of citizens (Xu et al., 2022). Smart city initiatives need to highlight the human-centric nature of the more technologically oriented developments in communications and the use of natural resources (AlAwadhi et al., 2012). The concept of smart cities is based on the utilization of human, collective, and technological capital to enhance urban development and prosperity (Alverti et al., 2020). As much as without the technological part of the equation, a smart city would be difficult to develop, so too, without the human dimension, a smart city would not be possible.

This also means that the humanist facet overlaps with and interacts with other facets. If the humanist facet is addressed, it can have an impact on the citizen and society participation facet; that is, if the quality of life is high, people are more likely to positively participate in societal initiatives.

The quality of life and well-being of citizens are central to the concept of smart cities, and the smart services provided should align with the needs, expectations, and skills of the inhabitants to ensure improved quality of life (Lytras et al., 2020). The connection between smart cities and quality of life is reciprocal, as the quality of life also influences the creation and development of smart cities (Morozova & Yatsechko, 2022).

5.2 *Sustainability Facet*

The transformation of existing cities into smart cities is seen as an urgent need to achieve sustainable development goals and effectively address urban and environmental problems, especially in developing countries (Janik et al., 2019). Smart cities are designed to address environmental sustainability by integrating technologies, monitoring resource consumption, such as water supplies, and transforming existing cities into sustainable urban systems (Angelidou et al., 2017). Sustainability needs to be integrated into smart city governance to mitigate potential ecological threats, such as an incongruence between smart city policies and carbon dioxide emissions (Bibri et al., 2023), the extraction of resources, production process toxicity, and the increasing energy demands of data farms (Kuntsman, 2020). Therefore, the development of smart city governance frameworks should carefully consider and address these challenges to ensure effective contributions to environmental sustainability.

5.3 *Smart Economy Facet*

Smart economy, in the context of smart cities, encompasses the facilitated development of e-business, e-commerce, and new entrepreneurial opportunities. It involves the conscious recognition of the importance of realizing the broadband economy and taking measures to create vigorous economic development. As discussed earlier, smart cities rely on ICT to improve service quality, manage public resources, and focus on comfort, maintenance, and sustainability. Additionally, the smart economy dimension of smart cities focuses on managing economic growth through innovations to increase competitiveness and open new business opportunities. The concept of the smart economy is considered a key dimension in evaluating smart cities, and it plays a crucial role in optimizing the competitiveness of small and medium-sized enterprises (SMEs) within the city (Ali & Nencioni, 2021; Youssef & Hajek, 2021). Thus, ecosystems that support business startups and data management are critical to the economic strength of a smart city.

5.4 *Smart Living Facet*

Smart living is an integral part of the broader smart city concept, focusing on enhancing the quality of life and well-being of individuals within urban areas through the integration of information and communication technologies. It encompasses various dimensions, such as smart homes and housing, sustainable urban environments, and the use of technology to support daily activities and improve overall living conditions. It also includes other dimensions, such as smart mobility, smart environment, smart citizens, smart government, and smart architecture (Ismagilova et al., 2019). Smart living involves integrating daily activities at home and in other settings with the support of integrated ICT (Keijzer-Broers & Reuver, 2016). The concept of smart living extends beyond smart homes to encompass the use of technology to enhance the quality of life and sustainability in urban environments (Lee et al., 2011). This aligns with the idea that smart living technology should advance human needs, increase quality of life, and sustain the environment for future generations (Lee et al., 2011).

A part of smart living, smart mobility involves the integration of various transport systems and technologies to create sustainable and efficient urban mobility. It aims to provide easy, safe, comfortable, and affordable transportation services through the use of information technology, optimizing travel time and reducing road congestion, accidents, and harmful emissions (Paiva et al., 2021). Smart mobility is a driving force for shaping cities from a smart perspective, influencing policies and inhabitants' choices (Marchesani, 2023). It is one of the main elements of a smart city, initiated to create sustainable cities through ICT support (Rachmat & Mangkoesoebroto, 2022). The integration of smart mobility solutions at the municipal level is thought to have environmental, economic, and social benefits, such as reducing air pollution and ensuring universal access to public transportation (Cepeliauskaite et al., 2021).

5.5 Citizen and Society Participation Facet

Citizen involvement is a fundamental aspect of smart city governance, and it is essential for promoting democratic processes, transparency, and citizen-centric development within urban environments (Bartenberger & Grubmüller, 2014). Citizen involvement in smart cities entails participating in the governance and management of the city, promoting e-democracy, and active user involvement (Domingo et al., 2021). This involvement is essential for the success of smart city initiatives, as it fosters a citizen-centred approach to urban innovation, enhances the legitimacy and justice of governance processes (Soomro et al., 2017), and ultimately improves the quality of life for residents (Kusumastuti & Rouli, 2021). Smart city infrastructure aims to engage citizens in collaborative governance, emphasizing the importance of two-way communication between the government and citizens, leveraging new technologies to promote online public consultations, discussions, and petitions (Ngo & Le, 2021; Park & Fujii, 2023). Within the city itself, this occurs as co-creation activities, where citizens are not just passive recipients of city planners' initiatives but actively involved themselves. This engenders pride and ownership of the results of these initiatives.

Citizen participation in smart cities can take various forms, including contributing to decision-making processes, providing data, and engaging with smart city services. The economic interests, social values, and the desire for smart city services motivate citizens to participate in various ways, ultimately enhancing their experience of smart city services (Xu & Zhu, 2020). Additionally, smart cities join in regional partnerships to both gain from and contribute to others in their area.

5.6 Resource Management Facet

Every city faces the challenge of limited resources. A Smart City integrates resource management with its ICT to utilize critical resources more efficiently and effectively and ensure that they are allocated across the broad initiatives undertaken.

For example, in the context of water resources, Smart Cities utilize technologies such as the Internet of Things and machine learning to effectively monitor and manage those resources, emphasizing the importance of building a sensitive city through a well-defined vision (Gușul & Butnariu, 2021; Šulyová & Kubina, 2022). Also, through ICT, a Smart City is capable of monitoring and integrating the functionality of critical infrastructure, controlling maintenance activities, and optimizing resources while ensuring security (Joshi et al., 2016). Sponge cities are good examples of the management of critical water resources.

Smart cities operate under a more resource-efficient management and economy than ordinary cities, utilizing cutting-edge information technology methods to intelligently respond to various needs of public services, social management, and industrial operations (Impedovo & Pirlo, 2020). Efficient and environmentally sound housing initiatives are also resources for a city to manage as they integrate into many aspects of a city's infrastructure. Energy management is a key aspect of smart city development, focusing on the efficient utilization of energy resources to achieve sustainability and self-reliance of energy systems (Rajendiran, 2022).

Overall, it is through the application of ICT to the monitoring, management, and integration of resources that the demands of citizens, industry, and the government of a city are able to be met. As each of these three stakeholder groups has different needs, a balancing of the allocation of resources is essential. Hence, ICT across the city is required to help with the governance of resources.

5.7 Smart Government Facet

Smart government is essential for the success of smart cities as it promotes sustainable urban development, enhances social participation, and involves local communities in decision-making processes. It fosters collaboration and co-creation between various stakeholders and encourages the use of technology for climate change adaptation and sustainable urban development. Smart government plays a major role in a smart city in how it develops and supports data ecosystems that integrate ICT across all of the dimensions of a city. It plays a crucial role in the development and sustenance of smart cities in that it promotes sustainable urban development and involves local communities in decision-making processes (Szarek-Iwaniuk & Senetra, 2020). It is considered a governance capability that combines urban historical context, resource characteristics, facility layout, city sustainability, and service innovation (Lyu et al., 2022). The importance of smart government lies in its ability to improve good governance and promote collaboration between local government organizations, private parties, and community groups, which is essential for the success of smart city programs (Triyanto et al., 2022).

6. Smart City Governance Best Practices

Smart city governance best practices encompass various dimensions and concepts, as identified in the literature. They highlight four ideal-typical conceptualizations of smart city governance, including the government of a smart city, smart decision-making, smart administration, and smart urban collaboration (Meijer & Bolívar, 2015). These practices aim to improve the quality of life, promote sustainability, and enhance public value and benefits through seamless digital connectivity and services. Pereira et al. (2018) emphasize that smart city governance focuses on decisions made by the government to improve the quality of life, integrating facets such as smart living, mobility, people, economy, and environment (Pereira et al., 2018; Dragan, 2023). Dragan (2023) also notes that the concept of a smart city now encompasses governance, environment, housing, and people, in addition to its previous focus on the digital and technological realm.

Fazil et al. (2022) stress the importance of public participation-based governance for wise resource management in smart cities, emphasizing the role of human resources and social capital. Smart governance is the transformation of local government into a transparent, efficient, and open administration for citizens, utilizing information and communication technologies and formulating appropriate smart city policies (Babić et al., 2022; Ngo & Le, 2021). They also highlight smart governance as the promotion of smart city initiatives without the need to change the structure or processes of the government apparatus (Ngo & Le, 2021).

While these best practices are important, what is seen is that at the implementation aspect of a smart city, it is a focus on the facets listed earlier (see Figure 1.1), that allow the higher-level dimensions of smart city governance to become effective. Understanding and honing in on the seven facets allow for the benefits of smart city governance to be realized.

7. Outcomes of Good Governance

The achievements of good smart city governance in the last five years have been characterized by a holistic approach to urban management, emphasizing collaboration, technology integration, transparency, and responsiveness in governance. These advancements have contributed to the enhancement of various aspects of urban life, promoting economic efficiency, sustainability, and the overall well-being of citizens. Key to the success and the ability to achieve these results has been the focus and involvement of the seven facets that appear at the meso and micro levels of governance, hat is, the facets that come to light in the application and implementation of smart initiatives that make up the overall fabric of smart cities and smart city governance. In smart cities, the underlying integration of ICT has enhanced various aspects of urban life, including the quality of life, local economy, transport, traffic management, environment, and interaction with government (Ismagilova et al., 2019). Successful smart city governance is closely related to the perception and use of technologies across the entire city, highlighting the importance of technology in governance (Jiang et al., 2020b). The development of smart cities has been associated with enhancing economic efficiency, urban development, social inclusion, high-tech industries, sustainability, livability, and good governance (Aggarwal & Solomon, 2019). Lumbanraja (2021) also found that through the implementation of smart city regulations, there was improved governance, better management of city resources, better provision of public services, and a more resilient critical infrastructure.

8. Conclusion

Smart city governance represents a crucial concept and an important alternative method to the current technocratic (top-down) governance of urban areas, offering an alternative understanding of governance and encouraging the use of technologies for climate change adaptation and sustainable development (Thaler et al., 2021). The governance of smart cities should not be viewed solely as a technological issue but as a complex endeavour involving shared responsibilities between government institutions and all other participants in the city's development process (Čolić et al., 2020). While the overarching, macro-level view of smart city governance is important to achieve the benefits of a smart city, there needs to be a more deliberate focus on the application and implementation of smart city initiatives that fall below the broad levels of smart city governance. This chapter has highlighted seven such facets: humanist, sustainability, smart economy, smart living, citizen and societal participation, resource management, and smart government. While these facets have been individually identified out of the literature, it should be noted that there is also a significant amount of overlap and interplay between them. It is our hope that going forward, these facets will be researched in more detail, digging into the more messy aspects of life in a city. Such research is complex, but diving into the meso and micro levels of smart city governance will allow for a honing of that governance, the better implementation of smart initiatives, and ultimately, the more benefits of smart cities.

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2 Advancing Urban Sustainability Through Robust Data Ecosystem Practices

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1. Introduction

Cities are attractive environments as they offer improved living and working conditions for citizens, acting also as centres for education, culture, and entertainment. Cities are also environments where new innovations are engendered, and businesses conducted. It is notable that more than 80% of the global GDP is generated in cities (Worldbank, 2023), making them compelling areas for investments and economic growth. However, despite socio-economic well-being, cities increasingly face challenges that are not trivial to solve. Cities globally account for over 70% of global CO_2 emissions, with sectors such as transportation, construction, and energy production being the largest contributors to emissions in cities. According to IPCC (The Intergovernmental Panel for Climate Change, 2019) global warming is likely to reach a 1.5°C increase between 2030 and 2052 compared to the pre-industrial period. Already, regions with high populations have experienced extreme variations in climate, such as long-lasting and extremely hot periods, heavy precipitation, and drought. Despite cities' significant role in economic and social well-being, they paradoxically are the major sources of greenhouse gases.

1.1 Sustainable and Resilient Smart Cities

Cities globally are searching for solutions to reduce emissions. Cities' efforts to tackle rising CO_2 levels include actions such as replacing non-renewable energy sources like coal and oil with renewable alternatives like wind and solar energy. Further, cities are improving the availability of pedestrian and bicycle roads and increasingly expanding public transportation networks to reduce transportation-related emissions. Highly populated cities are also areas where numerous scarce and non-renewable natural resources such as water, minerals, metals, and concrete are consumed, exchanged, and transformed on a daily basis. Managing urban metabolism, covering the usage and processing of these natural and non-renewable materials, import and export of material flows, recycling, and waste management (Bahers et al., 2019), in more sustainable manners has become salient in cities throughout the world.

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Cities' green transition and emission mitigation efforts require knowledge and funding. In Europe alone, the European Union has allocated numerous funding programmes for European cities to support their efforts to reduce emissions. The two climate missions, "The 100 Climate-Neutral and Smart Cities" and "The Mission on Adaptation to Climate Change," are examples of initiatives through which the EU aims to have best practices for emission mitigation and climate change adaptation in European cities. Indeed, knowledge of best practices and finances for carbon mitigation is needed, as the study by Ulpiani et al. (2023) discloses that the majority of the applicants for "The 100 climate-neutral and smart cities" – programme had little experience in financing some climate projects, and over 70% of the cities had not estimated the total investments needed for carbon neutrality of the city. As cities are the major players in reducing greenhouse gases, they are the trailblazers in initiating the changes that lead to emission mitigation and the achievement of carbon neutrality targets. Together with their partners in the private and public sectors, as well as with the citizens, cities are at the forefront of finding solutions that result in more environmentally, economically, and socially sustainable and equal cities. This requires shared vision, commitment, and broad collaboration.

In parallel with the concept of sustainable city development, city resilience is closely linked to a city's capacity to respond and recover from severe natural or man-made events. Following Godschalk (2003) a resilient city is formed by a sustainable network of physical systems and human communities. In other words, a city's built environment, including buildings, land areas, and energy and road infrastructures, forms the physical environment in which human communities operate. In modern societies, in addition to physical and human systems, information technologies form an integral part of societies and contemporary cities. Telecommunication networks, information systems, and digital services are seamlessly embedded into the structures of physical and human systems in urban environments. Without these technologies, modern urban environments would be unable to operate or even exist. Resilient and sustainable cities should thus consider cyber-physical systems in addition to physical and human systems. A resilient city could, therefore, be defined as a city that has the ability to adapt and adjust its functions in changing conditions and later return its physical, human, and cyber-physical systems to a stable equilibrium after unexpected incidents (Godschalk, 2003; Pickett et al., 2004; Spaans & Waterhout, 2017).

1.2 Smart and Intelligent Cities

As previously mentioned, cities form embedded social-cyber-physical environments in which telecommunication and information technologies play a pivotal role (Anttiroiko & Komninos, 2019; Ekman et al., 2019). Concepts such as smart grids, intelligent transportation systems, and smart buildings have been presented to describe how computing is used and integrated into these physical entities to manage and govern, for example, distributed energy resources or enhance the functional efficiency of public transport and buildings. Information technologies are also harnessed to form seamless interactions with the surrounding environment, including citizens (Baheti & Gill, 2011; Palensky & Kupzog, 2013). Lately, technologies such as digital twins and immersive virtual worlds (metaverse) have emerged as promising tools to support urban designers in land use and urban development projects, enhancing citizen inclusivity and the participation of other stakeholders throughout the urban planning and development processes. Visual digital twins, using (real-time) data collected from cities' social and cyber-physical environments, have been deployed to carry out, for example, alternative city development simulations. The visual simulations, utilizing actual data, have proved to strengthen learning and facilitate knowledge-based discussions with stakeholders in the urban environment, including politicians, citizens, urban designers, and other participants involved in urban development. (Hämäläinen, 2021). Recently, interest in illustrating social dimensions and socio-economic interdependencies within digital twins has emerged in discussions among researchers and city representatives. The aim is to explore and understand the opportunities that digital twins provide for developing more proactive, inclusive, and accessible city services irrespective of time, space, and language limitations (Abdeen et al., 2023; Kopponen et al., 2020).

Interest in these advanced digital technologies, also known as smart city technologies (Dirsehan & van Zoonen, 2022), is rising, specifically from the perspectives of developing more smart, sustainable, and resilient cities. The public sector has recognized the potential of smart city technologies in enhancing green transition and reducing emissions within cities. (Statista, 2024). This has encouraged city organizations, together with players in various industries, to invest in novel technologies and leverage urban data for new innovations and businesses that support the development of more carbon-neutral urban environments. As smart city technologies have the capability to generate and collect data from human and cyber-physical entities in the urban environment, data is seen as a valuable resource that enables, for example, more efficient energy use in public transportation or more inclusive land use planning (Kong et al., 2020). Further, data is harnessed to develop more impactful and inclusive city services. However, despite cities having recognized the value smart city technologies engender, they seem to have difficulties trying to use and benefit from available data on a broader scale. It is noted that cities' knowledge and ability to utilize existing data are relatively limited, and they lack the necessary skills and capabilities to analyse the quality of available data and assess the needs and value of data. (Paiho et al., 2022). In general, cities appear uncertain about how they could benefit from available data and how to govern and share data in safe and secure manners.

Regardless of impediments in collecting, sharing, and using data in the urban context, the concept of a data ecosystem has gained interest among scholars, industry representatives, and city authorities (Capgemini, 2023; Haberkern &

Schäffer, 2023). A data ecosystem is regarded as a complex socio-technical network in which various actors interact and collaborate to find, archive, publish, consume, or reuse data to create value for new businesses and innovations (Oliveira et al., 2019). In the urban context, data ecosystems are considered multi-layered, operating and interacting with diverse entities (public and private sectors) in an environment of varied hierarchies and cultures (Gupta et al., 2020).

This paper aims to address the phenomenon of urban data ecosystems by first exploring the elements that support the formation and governance of robust data ecosystems in the context of smart cities. The paper also aims to identify the bottlenecks that prevent efficient collaboration, data deployment, and sharing in data ecosystems. The research is exploratory in nature and sets its foundation on interviews, workshops, and meeting minutes with actors in smart city projects and research projects related to developing digital platforms for urban developers in built environments in Finland. While urban data ecosystems are also a technological phenomenon, this study will address technologies and their usage at a more general level. As an outcome, the paper presents identified barriers that hinder the formation of robust data ecosystems within the studied city organizations. In addition, the paper provides perspectives on data ecosystem operation models that enhance the establishment and governance of data ecosystems and the utilization of data within cities.

2. Data Ecosystems

Digital platforms paved the way for online businesses, where data forms the foundation for conducting business operations on digital platforms. Data is collected and utilized for various purposes, such as predicting changes in customer behaviour, enhancing customer experiences, addressing market needs, and developing new business models and innovations. Thanks to the development of mobile, sensor, and Internet-of-Things (IoT) technologies, numerous physical and social entities have transformed into new sources of data. Data has become a significant resource and driver for new innovations and businesses (Otto et al., 2022).

As data has become a highly valued resource in modern societies, the concept of the data ecosystem has aroused interest among industrial practitioners and, lately, among representatives in public sectors too. In academia, research on data ecosystems has been fragmented, but research fields such as information systems, computer science, and service sciences are leading the way in data ecosystem research (Heinz et al., 2022). Data ecosystems can be defined as socio-technical systems where a loose set of interacting actors consumes, produces, or provides data or other resources to create value from the data value chain (Oliveira et al., 2019). Since data value creation forms the foundation for digital platform businesses (e.g. two-sided or multi-sided platforms) and is a key element in data ecosystems, the economic dimension should also be considered and emphasized in data ecosystems in addition to the socio-technical dimension.

Characteristically, data ecosystems are multi-layered and vary in their hierarchies, cultures, and purposes. They consist of autonomous entities such as enterprises, institutions, or individuals. The actors are motivated by various interests and have some commitment to and shared goals within the ecosystem. (Gupta et al., 2020; Oliveira et al., 2019.) Data ecosystem actors have various fluctuating roles (Oliveira et al., 2019.) and foster value creation by enabling innovation activities and the development of new businesses and services by and between different stakeholders (Oliveira & Lóscio, 2018). In smart cities, multilateral data ecosystems and a new data economy emerge around new digital smart services (Barns, 2018), typically within the mobility and energy sectors. In Finland, a platform called Digitraffic is one example of a mobility data ecosystem offered by a state-owned company. Digitraffic provides information and open datasets for application development from Finnish road, railway, and marine traffic (Digitraffic, 2023).

2.1 Data Ecosystem Elements and Governance in Smart Cities

The ecosystem approach to smart city data and the data economy has proven capable of providing clarity to the complex system of relationships and interactions between the city and other parties, such as local authorities, developers, technology providers, citizens, and other users related to data exchange and value creation (Lnenicka et al., 2022). However, despite the ability of data ecosystems to clarify actor relationships and interactions in cities, and while the significance of socio-technical and economic components is known and established, the complexities of urban systems in general make the orchestration, governance, and organization of city data ecosystems challenging (Curry, 2016; Gelhaar & Otto, 2020). This has prompted cities to develop their skills and capabilities to support data ecosystem development activities (Lnenicka et al., 2022; Oldenburg & Pussinen, 2024).

As mentioned previously, data ecosystems include various socio-technical components and business elements. Data ecosystems utilize technologies (Figure 2.1) such as data platforms, cloud computing, and data analytics solutions to enable and coordinate the ecosystem (Hein et al., 2019). The underlying digital infrastructures, including software and hardware components, should also support data interoperability, portability, security, and safety. Furthermore, data ecosystems should consider organizational strategies and processes and focus on sharing common goals and ensuring data sovereignty, including the authority and rights to collect, store, and manage one's own data. In an urban context, aligning the interests of individuals, such as citizens, with the interests of the data ecosystem is emphasized (Otto, 2022; Hummel et al., 2021). Otto (2022, p. 4) states that the value of data can only unfold when data is used. Value creation within data ecosystems illustrates how effectively data is shared and deployed between the actors to generate benefits, for example, to engender new innovations and businesses. Integrating socio-technical elements with the business dimension, including value creation, funding,

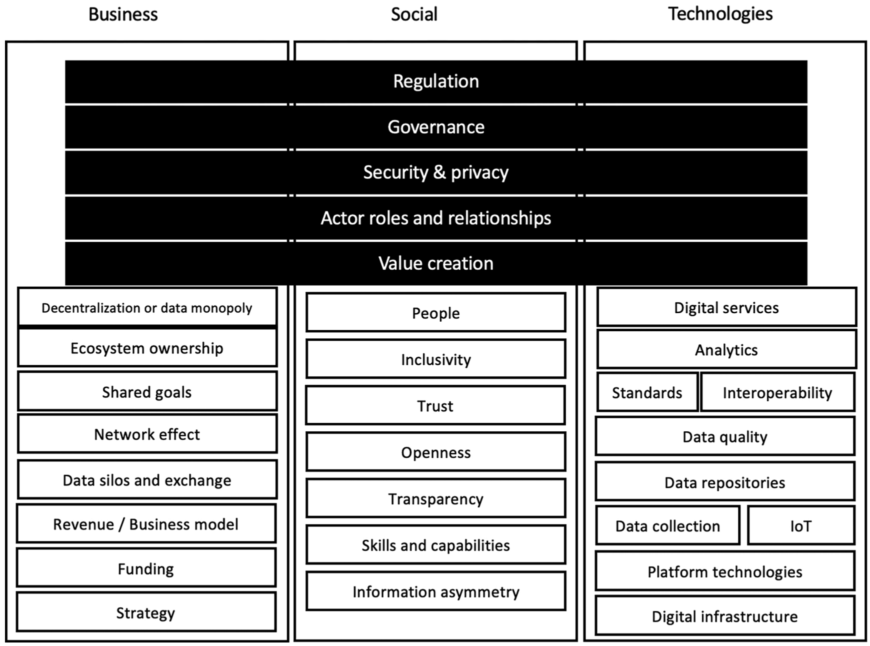

Figure 2.1 Key capabilities and factors in data ecosystem formation

Source: adapted from Shah et al. (2021)

revenue models, strategies, and policies, has proven to reinforce trust and sustainability within data ecosystems, also setting the foundation for a robust data economy (Hummel et al., 2021; Otto, 2022; Shah et al., 2021).

Data ecosystem governance has specifically gained academic interest from the perspectives such as ethical governance (Koskinen et al., 2023) or open data ecosystems (Lnenicka et al., 2022; Runeson et al., 2021), but central concepts and definitions are still under discussion (Koskinen et al., 2023). Data ecosystem governance, including aspects such as ownership, actor roles, and funding, is also of interest to city representatives. Oliveira et al. (2019) have identified four distinct ways that data ecosystems are organized, presented in Figure 2.2. In a keystone-centric ecosystem, the keystone actor provides most of the data used in the ecosystem and has a major role in monitoring, evaluating, and making decisions within the ecosystem. The keystone actor has a level of control over the ecosystem, but, for example, other actors decide freely whether the ecosystem is feasible for them to partake in (Oliveira et al., 2019). In an intermediary-based ecosystem, a central intermediary party or company is responsible for facilitating the data from providers to users. In platform-centric ecosystems, a data platform acts as the infrastructure for data providers and users to interact. The platform provider is also responsible for the supportive services. Marketplace-based ecosystems centre around a data

Organization, decision-making and responsibilities	Keystone actor is responsible of monitoring and evaluating the ecosystem. Keystone actor makes key decisions and governs the ecosystem.	Platform provider provides services, rules and operational models needed for data utilization and creation of new services.	Ownership and key responsibilities are shared amongst the consortium key actors or a steering group.	Intermediary organization can act as a facilitator or broker between various parties in the ecosystem network.	Marketplace provides infrastructure and rules for the marketplace-related operations, transactions and data usage but does not govern the ecosystem.
Data	Keystone organization provides most of the data.	Data platform provides infrastructure to data collection, provision, and consumption for multiple data providers.	Data is collectively formed and accumulated from the ecosystem.	Data is formed and accumulated from the ecosystem through intermediary actors.	Data is sold, distributed and developed into services or applications through marketplace.
Governance	Centralized			De-centralized	
Organizational model	Keystone-centric	Platform-centric	Consortium-based	Intermediary-based	Marketplace-based

Figure 2.2 Governance models and their features

Source: adapted from Gelhaar et al. (2021); Oliveira et al. (2019); Runeson et al. (2021)

marketplace, which encompasses the needed infrastructures as well as business models, rules, and services for selling data, services, and software. Runeson et al. (2021) also propose a consortium-based ecosystem model where governance centres around a consortium owned or formed by the key ecosystem actors.

Keystone- and platform-centric data ecosystems are more centralized in their operations, whereas intermediary-based and marketplace-based ecosystems are decentralized (Gelhaar et al., 2021). The consortium-based ecosystem model can be classified as centralized.

Embedding environmental, social, and economic sustainability perspectives into discussions of data ecosystems brings even more complexity to data ecosystem governance in cities. In the context of implementing sustainability policies and goals within cities, regulatory stewardship and regulation are seen as necessities in urban data governance. Regulatory stewardship can act as a tool for cities to set incentives for actors in data ecosystems to use (urban) data for the benefit of citizens or to innovate new urban solutions that foster the achievement of carbon neutrality and sustainability goals. Regulation, particularly concerning infrastructures such as transportation, telecommunication, and energy, seeks to find a balance between the interests of profit-seeking companies and not-for-profit organizations in public sectors. Regulation is thus presented as a means to create market structures that promote competition and new innovations for producing city services in more efficient, socially, and environmentally sustainable manners. (Franke & Gailhofer, 2021).

3. Methodology and Data Collection

Our research is an empirical study of urban data ecosystem phenomena, combining multiple methods of data collection (see Table 2.1). We used

Table 2.1 Data collection methods and sources

Primary data collection	*Organization*	*Participants*
Interview 1	Smart city research project initiated by City #1	Higher education institution senior manager
Interview 2	City #2	City senior manager, data, and city information systems
Interview 3	City #3	2 city senior managers, open data, and information systems
Interview 4	City #4	City senior manager, strategic development
Secondary data collection	*Description*	*Participants*
DataMust-round table and workshops	Round-table discussion and workshops about initial research results	19 directors, senior managers, and senior specialists from DataMust working group
Open data sources	City of Helsinki Data Strategy City of Tampere Data Strategy City of Espoo Digital Agenda City of Oulu Digital Strategy City of Turku Digital Strategy	

semi-structured interviews, participated in and noted various round-table discussions and workshops, and utilized open data sources to triangulate the qualitative research material.

Empirical data was collected from four semi-structured interviews, three with Finnish city organizations and one with a researcher working in a smart city research and development project. The interviewees represented city functions related either directly to data platforms and data practices or were working with data-intensive city services and solutions development.

The semi-structured interviews focused on understanding four primary topics:

T1: The goals of the organizations' data ecosystem activities
T2: The currently identified benefits of data ecosystems and ways of working
T3: The challenges related to the data ecosystem work
T4: How the interviewees perceive the role of the city in data ecosystems and their take on the argument that by assuming an active role in ecosystem governance, a city can boost local ecosystem activities and help mitigate the risks and challenges

The question for topic 4 was formulated based on the findings of Oldenburg and Pussinen (2024).

The interview data was further enriched with data strategies and similar documents about cities' current and planned data ecosystem activities, as well as smart city initiatives and services. The secondary data collection was based on publicly available documents and emphasizes initiatives, services, and strategic goals especially related to urban sustainability. The data and preliminary findings have also been discussed and processed within an extended group of specialists involved in the NextGeneration EU – funded research project DataMust – Data Markets for Sustainable Cities. The research project and respective specialist group include representatives from Finnish cities, research institutes, and businesses working with built environment, urban development, and energy optimization solutions. The DataMust steering group participated in a round-table discussion and workshop about the preliminary results.

4. Results

The interview findings of each topic can be divided into three main categories: business, social, and technologies (Table 2.2).

4.1 Goals of the Data Ecosystem Activities

> The formation and description of the data ecosystem helps in forming of a comprehensive understanding of the city's service ecosystem.
>
> Interview 3

Business goals aim to increase understanding of the current landscape of services and available data. Cities operate in a complex system of multiple information systems, and understanding the possibilities of data sharing and collaboration is a major effort. Data ecosystem activities, such as building data and service catalogues, as well as understanding the processes of collecting and storing data through the city organization, are seen as possibilities to improve operational efficiency and gain a better situational picture of the city.

Social goals are activities aimed at involving citizens and service provider stakeholders in dialogue and joint efforts around the data ecosystem. Collaboration and dialogue support identifying and understanding potential benefits and use cases for data and bring out the needs of various interest groups.

Technology goals are related to gathering, managing, and enabling the utilization of data in current and new services, improving the quality of the data, and establishing the common technical foundation as well as practices around data sharing. A common goal within the interviewed organizations is to utilize the already existing data and related infrastructure more efficiently, from ICT information systems to city-owned sensors.

The interviewees reminded that, eventually, all city activities are related to the city's public functions and should aim to benefit its citizens. It was also pointed out that data ecosystems are a prerequisite for tackling and addressing systemic issues – the hypothesis being that efficient and broad usage of ecosystem data enables new solutions and innovations that create value and benefits beyond the ecosystem.

Table 2.2 Findings of the goals, benefits, and challenges of the data ecosystem activities

	Business	*Social*	*Technologies*
T1: The goals of the data ecosystem activities	Understanding the current services and available data, its potential and possibilities. Build and offer opportunities to new service providers.	Increasing involvement of citizens and service provider stakeholders. Understanding the needs of various interest groups and enabling dialogue.	Gathering, managing, and enabling the utilization (sharing, reuse) of data. Improving data quality and establishing the technical foundation.
T2: Benefits of the data ecosystems	Increased knowledge improves understanding of city operations, supporting data-driven decision-making. New models of collaboration boost innovation and find new value creation opportunities.	Collaborative efforts to address large topics, such as regulation, together. The ecosystem way of working can bring value to society as a whole and help solve large, systemic issues.	Improving the utilization rate of data and data-related infrastructure. The data ecosystem increases the coverage of data collection beyond the city data.
T3: Challenges of the data ecosystem work	Uncertainty about the data ecosystem as a concept, and how to operate in the ecosystem. Ecosystem business models and how to finance ecosystem operations are still unclear.	Orchestration of the ecosystem, how to maintain the validity and appeal of the ecosystem? Readiness and capability to make organizational changes that enable a new way of working. How to ensure fair operational models?	Responsibilities, maintenance, and financing of the technical infrastructure. Data quality, cyber and information security, data engineering, and other related responsibilities.
T4: The role of the city in data ecosystems	What really is a city data ecosystem, and where is one truly needed? How to lead value creation and identify shared strategic goals? How to make the ecosystem value tangible?	There is a clear need for neutral leadership in ecosystems. The city has a natural role in promoting trust and openness. How to identify and build necessary skills and capabilities?	Roles, responsibilities, and ownership should be clearly defined.

4.2 Benefits of Data Ecosystems

> Increased interaction is clearly a big benefit. New ideas and innovations form through new connections.
>
> Interview 4

Business benefits relate to an increased understanding of the possibilities of the ecosystem and its data. Understanding the complex operating environment enables data-driven decision-making and effective utilization of the ecosystem's possibilities. When data quality and maturity increase, a data ecosystem can also serve as a source of knowledge and information for city decision-makers. A data ecosystem can also act as a platform for conducting fast experiments with new service opportunities.

The social benefits emphasize the new cross-organizational and interorganizational collaborative practices. New models of collaboration reveal new synergies and can also lead to innovative co-creation of services. Data ecosystems are seen as a potential channel for addressing questions that affect the entire ecosystem, such as new data and AI-related EU regulations. Eventually, data ecosystems can give rise to solutions for large systemic issues and benefit the whole society.

Technology benefits relate heavily to utilizing the high-quality data infrastructure many cities already have or are in the process of building. Data accumulated in a data ecosystem is seen as more comprehensive and complementary to data gathered only from city data sources, and cities are interested in improving their own situational picture by enriching it with data from the ecosystem network.

4.3 Challenges of the Data Ecosystem Work

> The city should not compete with feasible market-led –solutions. The public data ecosystem business model is still unclear.
>
> Interview 4

Business challenges include uncertainty about the ecosystem as an operational model – what really is a data ecosystem in the smart city context? Because data ecosystems are still an emerging phenomenon, operating models are not yet established and involve a lot of testing and seeking new ways of working. According to interviewees, it's likely that organizations participating in data ecosystems must make changes to their own operational models. However, it's unclear how ready the organizations are for such changes.

Social challenges of ecosystem activities relate to the overall organization and orchestration of the ecosystem. To establish continuous value extraction, the ecosystem should maintain its appeal and its participants' motivation to partake in common activities. Smart city data ecosystems also differ from private or market-driven ecosystems in the very basis of the ecosystem business models – cities, as public entities, are not engaged in profit-seeking, even though city data ecosystems also contain private businesses of varied sizes and maturities. Balancing varying interests, from supporting city service creation to private business goals, sets its own challenges to equal and fair ecosystem operation.

Technology challenges range from straightforward technical issues to administrative concerns. For one, at least some form of data platform or marketplace was seen as a precondition for a data ecosystem. From the need for a technical data platform, questions of responsibilities related to funding, development, and ownership quickly arise. Data quality was also identified as a technical challenge: turning the data from various sources into an interoperable common resource requires investments.

There are also challenges that span across all categories: data ecosystems need common standards, data models, operating models, as well as practices and technical solutions around privacy and security. In addition, some interviewees identified a need for a governing or overseeing body in the ecosystem: someone who is responsible for the bigger picture.

4.4 The Role of City in Data Ecosystem

> Cities already have a lot of high-quality data as well as the infrastructure to share it.
>
> Interview 1

The interviewees were presented with an argument that cities, by assuming the role of a data ecosystem lead, can have a significant impact on the local data ecosystem and its performance.

Reflecting on the notion that data ecosystems are still an emerging phenomenon, the interviewees raised several questions about the nature of the ecosystem and even about the need for an ecosystem in smart city collaboration, as well as the ecosystem's benefits compared to a collaborative network of various actors. At the same time, the city is seen as a natural and neutral partner, and even as a local ecosystem leader or enabler, given that the rest of the ecosystem accepts the city's role and the requirements that follow. Digitalization in cities will require new types of collaboration, and it might require public entities to work and act in ways and areas that they are not accustomed to. This also applies to cities' own internal organization and emphasizes the need to dismantle organizational silos.

The interviewees agreed largely that there is a need for leadership and active creation of operational models, rules, and responsibilities. Leadership is needed to ensure that concerns like cybersecurity, privacy, and the safety of critical information are considered in ecosystem activities. As trust in public authorities in Finland is at a high level, the active participation of the city might increase ecosystem trust and appeal.

One key question about the city's role revolves around the need for a data platform and data collection infrastructure, and the responsibilities – both fiscal and administrative – that follow. On one hand, cities already maintain vast information systems, data storage, and, in many cases, technical infrastructure built and maintained using public funding. Utilizing that infrastructure to enable more value extraction is a logical step. To some extent, providing a basic infrastructure to be used publicly can be claimed to be even the city's responsibility. Again, it's hard to draw a clear line regarding how much public funding should be used to boost for-profit businesses and whether infrastructure and data that are built and collected for public usage can even serve businesses at a sufficient level.

For cities as well as businesses to feel comfortable with the proposed new roles and responsibilities, they should take steps towards maturing the operative models and clarifying the goals of the ecosystem activities. Interviewees pointed out that it's still somewhat unclear how value is extracted from ecosystems or how value is even defined. Cities already act as facilitators, supporters, and active, central participants in nascent local data ecosystems, but to take a step further and lead them, the benefits of leadership should be clear and welcomed by the ecosystem.

5. Discussion

> Digitalization will force cities to look beyond their traditional responsibilities.
>
> Interview 2

Interest in the data usage of cities, data-intensive city services, and the networks of data consumers and providers is growing (Mora et al., 2023; Oldenburg & Pussinen, 2024; Oliveira et al., 2019). To realize the potential of new data-based smart city services and the increasing demand for sustainability through the city value chain, cities need operative models, guidelines, and rules to govern the new networks of actors in data ecosystems as well as to develop city capabilities.

Cities in Finland already engage in a variety of activities that can be seen as data ecosystem activities, even though local data ecosystems are in their early stages. The hypothesis is that the efficient and broad usage of ecosystem data in cities enables the emergence of new solutions and innovations that may benefit the whole society. In this study, we identified that the organization and governance of data ecosystems are central themes that preoccupy city organizations.

The interviewees emphasized that through data ecosystem activities, cities have the possibility to improve their operational efficiency and, overall, gain a better situational picture of the city. However, cities face uncertainties about a data ecosystem operational model. Because data ecosystems are still an emerging phenomenon in cities, operating models are not yet established and involve a lot of testing and seeking new ways of working. According to the interviewees, it is likely that organizations participating in data ecosystems must make changes to their own operational models. The readiness of organizations to partake in such change is not yet certain.

Following Oliveira et al. (2019), we identified that a keystone-centric approach enables the city to organize and orchestrate the ecosystem activities, rules, and processes. With a keystone-centric approach, a city can drive the ecosystem formation, facilitate the discussion around the rules and operational models, and link the data ecosystem goals to city or regional strategies. In this approach, the city can also naturally advocate for citizens and groups that experience vulnerabilities and promote social sustainability. On the other hand, the platform-based approach emphasizes the city data platform as the centre of data exchange. In this approach, cities with already existing large data sources and infrastructure can open parts of their existing infrastructure or purposefully build more open data platforms to invite other ecosystem actors to participate. Aligned with the findings of Lnenicka et al. (2024), we identify that the platform-based operational model can have various formats, the common denominator being a technical platform solution.

Literature emphasizes trust as a vital element in creating and maintaining a functional data ecosystem (Lnenicka et al., 2024; Oliveira et al., 2019). Cities, as public entities operating with a level of openness and having an impartial responsibility to serve their citizens, can promote trust, fairness, and equal premises for data collaboration (Koskinen et al., 2023). Since a city data ecosystem is largely dependent on the city data resources, more centralized organizational and operative modes, such as keystone-centric or platform-based ecosystems, can more effectively support the strategic goals of cities while still bringing benefits to other ecosystem actors. Keystone-centric and platform-based approaches do not exclude one another, and the emphasis of the operational model can also evolve through the ecosystem lifecycle (Gelhaar et al., 2021). Based on the research data, our hypothesis is that a city data ecosystem operational model is most likely a combination of the two: the city can lead the whole ecosystem as a keystone organization and take responsibility for some parts of the ecosystem data infrastructure. One additional model could be the consortium-based ecosystem model as proposed by Runeson et al. (2021), where the ecosystem governance is co-owned by the ecosystem's actors.

We propose that by engaging data ecosystems from a leading position and taking action in setting the ecosystem vision, strategy, and operative goals, a city can drive the ecosystem towards sustainable smart city service creation. This leading role can be a keystone organization, platform provider, or a hybrid, depending on the city's own strategic goals. We suggest that by assuming a leading role in a centrally governed data ecosystem, a city can also promote strategy and value creation from sustainable city goals and ensure that environmental, social and economic sustainability, citizen inclusivity, and resilience are considered.

Our study supports previous findings and knowledge about the challenges cities face with data ecosystems. One previously observed challenge relates to balancing the responsibilities and roles between public and private participants in the ecosystem. This has also been observed by Franke and Gailhofer (2021), who state that contradictions with market-oriented goals can even hinder achieving sustainability-related goals. The issue is multi-faceted: the city is a natural and neutral key actor of the ecosystem, but funding the data ecosystem facilitation, especially if the ecosystem is technology-driven and based on a data platform, is a major fiscal burden for a public entity. Cities could balance the funding with EU (in European cities) or national-level public funding instruments and encourage business entities to also invest in the data ecosystem.

Maintaining trust and the appeal of the data ecosystem is also crucial for its longevity. Interested actors should be able to find the city data ecosystem and understand its offerings, as well as its potential to expand their own value proposition and offerings. This requires comprehensive data catalogues; accessible, interoperable, and reusable data; and active collaboration through the ecosystem. For cities, this also means investment in their own data and information management practices and similar capabilities to provide high-quality data for the ecosystem.

When the city's operational models evolve and digital infrastructure creates new services, it will also give rise to new risks and responsibilities. Issues like data quality, cyber and information security, and the need for new skills and capabilities will challenge cities in data ecosystem formation. On the other hand, by taking an active leading role in defining robust security and trust practices, cities could further increase trust in the data ecosystem. Cities can set and enforce regulatory boundaries for the ecosystem and ensure that legislative responsibilities are fulfilled – this is especially important when the data of the ecosystem is related to citizens' personal information or critical national infrastructure.

6. Conclusion

Cities have the possibility to lead, promote, and enhance their local data ecosystem activities and help the data ecosystem mature. In this study, we have identified three key bottlenecks for city data ecosystems. First, there is the challenge of establishing the roles, responsibilities, organizational models, and financing of the data ecosystem. Second, maintaining the ecosystem's attraction, trust, and relevance is a significant hurdle. Third, providing the appropriate technological infrastructure, comprehensive risk management, and a proper level of regulatory framework is essential yet difficult to achieve.

We propose that cities should investigate and compare benefits when it comes to different operating models to identify and assume the necessary roles for the data ecosystem. Cities that have already invested in data platform infrastructure could explore the possibilities of opening their infrastructure to the ecosystem and leading it as a platform organization. On the other hand, cities that have broad regional networks with local businesses should explore the possibilities of forming consortiums and seek operational models to share the ecosystem costs. In cities where the data ecosystem is emerging and data platforms and collaborative networks are still nascent, the city, as a keystone organization, can accelerate the ecosystem formation by offering guidelines and facilitating collaboration for the ecosystem.

Considering trust and attractiveness, active ecosystem collaboration and communication about the ecosystem increase transparency and visibility, adding both trust and appeal to the network (Mora et al., 2023). Ecosystem trust and relevance could also be increased by investigating new financing policies and capabilities in the collaborative use of financing instruments, especially in areas that are risky for businesses (Ulpiani et al., 2023). Especially in countries where trust in public organizations is high, cities can utilize their position as neutral operators and justify the data ecosystem by its extensive and equal benefits, such as promoting environmental, social, and economic sustainability. Clear and comprehensive governance models, rules, and regulatory guidelines support building trustworthy and robust data ecosystems. These elements also support the development of appropriate technical infrastructure. Cities should also focus on identifying and developing the needed key capabilities that support technical ecosystem activities, such as transparent, trusted, and secure technical solutions, as well as building partnerships with relevant technology providers (Jussen et al., 2023).

We acknowledge that our research data has limitations; however, it provides guidelines for further exploration of the operative models of urban data ecosystems and for seeking alternative operating models, for example, with industrial data ecosystems. This would be relevant for both smart city practitioners and researchers in academia. In addition, our research framing leaves space for further study of ecosystem capabilities related to various technologies in smart city services and urban data platforms.

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3 Co-creating the Smart City

Integrating Market Orientation for Sustainable Urban Planning

Terry Beckman and Marta Massi

1. Introduction

Smart cities are defined as cities that "use information and communication technology (ICT) to improve operational efficiency, share information with the public, and provide better government services and citizen welfare" (Twi-Global, 2024). According to most definitions, a city is considered "smart" when it leverages technology to enhance sustainability, economic development, and overall quality of life (Maček et al., 2019; Ojo et al., 2014). This tech-centric view of smart cities is heavily influenced by the role of information technology (IT), which was originally the primary focus (Singh et al., 2022).

Now that the focus has expanded to incorporate diverse communication systems in conjunction with the Internet of Things (IoT) (Jebaraj et al., 2023; Mehmood et al., 2017; Nassereddine & Khang, 2024) and artificial intelligence (AI) (Singh et al., 2023), the concept of smart cities has evolved to recognize that technology alone is not sufficient for the success and acceptance of smart city initiatives. The emphasis is now on "how this technology is used rather than simply how much technology is available" (Twi-Global, 2024).

Especially, the emergence of the second generation of smart cities, known as "smart city 2.0" (Trencher, 2019), has emphasized a decentralized, human-centred approach that prioritizes collaboration and community involvement (Maček et al., 2019; Zhao et al., 2021). This novel paradigm necessitates a bottom-up approach where community needs and feedback become integral to planning and implementation processes. The next desirable level, smart cities 3.0, envisions smart communities characterized by a shift in mindset towards people's needs, a citizen-centred approach, and co-creation (Starc-Peceny et al., 2017). In this third generation, control shifts from technology providers and city leaders to the public, promoting social inclusion and community engagement (Twi-Global, 2024). In this context, participatory methods (Afzalan et al., 2017) and the democratization of decision-making (Angelidou, 2015) become essential, as does learning about citizens' interests and ideas (Kitchin, 2021).

Despite this shift towards a more inclusive and co-creative approach, smart city planning often fails to integrate an element crucial to the success of these

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projects: the perspective of citizens. As a result, there is a lack of market orientation, which is surprising because market orientation – not only in understanding and satisfying the needs within the community but also as a priority in adjusting offerings based on the market needs (Avlonitis & Gounaris, 1999; Kohli & Jaworski, 1990) – can play a significant role in empowering citizens, encouraging environmentally friendly behaviour, and attracting investments. This orientation also fits with the tripartite model for sustainable partnerships (Khare et al., 2011) that emphasizes the need to have equivalent input from government, industry, and citizens. Additionally, this is supported by the concepts from Mitchell et al.'s (1997) work on stakeholder salience, which helps organizations understand who their critical stakeholders actually are and how to integrate their needs into planning and operations.

Market orientation aligns technological advancements with the needs and preferences of residents and stakeholders, ensuring that these innovations are embraced and effectively utilized by the community (Maček et al., 2019). It promotes citizen-centric planning by favouring co-creation and directly involving citizens in the planning and development of smart city projects to ensure their needs and preferences are met (Starc-Peceny et al., 2017). Through the engagement of citizens in the planning process, market orientation can promote the development of projects based on community desires, leading to higher satisfaction and better resource utilization (Guo & Gu, 2022).

Integrating market orientation into the planning process could, therefore, recover the often-neglected human-centric dimension in the context of smart cities (Zhao et al., 2021). Indeed, market orientation can complement technology by bridging the gap between technological solutions and their practical, user-centric application, thereby enhancing the sustainability of smart city initiatives.

In contrast, the lack of market orientation in smart city projects can lead to public opposition and failure, as seen in the 2017 Quayside project by Sidewalk Labs in Toronto. Despite its innovative urban solutions, the project faced intense scrutiny over data privacy concerns and inadequate public consultation (Jacobs, 2022). This failure to understand and incorporate the community's needs resulted in significant distrust and resistance, ultimately contributing to the project's abandonment. In essence, this smart city project failed to respond to human needs (Jacobs, 2022). The Toronto example illustrates well a common mistake made by city planners: the failure to understand what citizens truly want (Zhao et al., 2021).

The Toronto example is just one of many debacles in smart city planning that highlight how market orientation can effectively bridge the gap between sustainable initiatives and the community, thereby amplifying the impact of smart city programs (Starc-Peceny et al., 2017). However, several obstacles persist. A common challenge is the tendency to undervalue the roles of marketers, often prioritizing the role of engineers and city planners in the planning process (Sadoway & Shekhar, 2014). This approach can result in technically sound solutions that may lack appeal or relevance to citizens, akin to marketing myopia (Levitt, 2004). Such an imbalance can overlook key factors related to community engagement, behaviour change, and the marketability of sustainability initiatives, which are essential for the holistic development and success of these projects. In addition, if city planners focus too narrowly on the technical aspects of sustainability without considering the broader consumer context, they might miss important market trends and societal shifts.

This chapter explores the importance of market orientation in smart cities, highlights challenges, and presents strategies and case studies for effective market orientation in urban planning. The goal of the chapter is to review initiatives in smart cities, provide a taxonomy of smart cities, and demonstrate how market orientation ensures that smart cities are not only well-designed but also well-received and seamlessly integrated into citizens' daily lives, increasing their likelihood of success.

2. Role of Market Orientation in Smart Cities

Market orientation has been defined as an organizational philosophy that gives precedence to customers when assessing the company and its products to ensure both meet specific customer needs (Avlonitis & Gounaris, 1999). In addition, it involves elevating marketing to be the dominant culture within the company, thereby mobilizing the entire organization to satisfy customer needs rather than relying on the company's perceptions and beliefs to ensure customer satisfaction (Avlonitis & Gounaris, 1999). In the context of smart cities, market orientation refers to an approach where city planners and developers give precedence to understanding and meeting the needs and preferences of residents and other stakeholders (Starc-Peceny et al., 2017).

In fact, a common challenge in city planning is the tendency to undervalue the role of marketers while prioritizing that of engineers and city planners (Starc-Peceny et al., 2017). Adopting a market orientation for a smart city implies a shift in roles, where city planners actively involve citizens and other crucial stakeholders from the beginning of the planning process. This approach includes actively seeking their feedback, engaging with the community, and tailoring city initiatives to align with their desires.

Incorporating market insights and customer feedback can lead to projects that resonate with community needs, resulting in more effective sustainable initiatives (Alt et al., 2019).

Afzalan et al. (2017) also claimed that this participatory style enables more effective, inclusive, and sustainable solutions in urban intervention. As Calzada and Cobo (2015) point out, citizen engagement in the planning process can make smart city initiatives more meaningful, enabling residents to be owners of them. In addition, because citizens and stakeholders are actively participating, more practical new ideas can be found that tackle real-world challenges to increase the chances of achieving sustainable city projects. This will also contribute to developing trust, transparency, and various qualities in community social cohesion, which are all key for the smart city's sustainability and resilience (Calzada & Cobo, 2015).

Market-oriented smart cities can create a more inclusive, responsive, and sustainable urban environment that not only leverages technology but also ensures that the human element remains central in urban development (Maček et al., 2019; Zhao et al., 2021). In addition to intercepting citizens' needs, marketers can play a critical role in mitigating resistance to change by developing communication campaigns that resonate with the community, thus facilitating the adoption of new sustainable initiatives (Huertas et al., 2021).

Market orientation can be regarded as having two sides. When embraced, it leads to value co-creation, fostering stronger community engagement and satisfaction. This guarantees that city planners engage with their residents and other stakeholders throughout the planning process, asking for feedback from them in a meaningful way. This leads to solutions designed around what the community actually needs and wants, making them far more effective in the long term. In doing so, it improves people's quality of life and fosters a feeling of ownership towards developers.

On the contrary, when market orientation is neglected, it results in a form of myopia (Levitt, 2004). This narrow focus can lead to a disconnect between city initiatives and the actual needs of residents. Projects not genuinely designed with input from the ground may never really address issues in a way that is germane to their local context and, therefore, will be less effective.

2.1 Value Co-creation in Smart City Planning

Before being associated with cities, the "smart" buzzword originated in the service industry to indicate those services that leverage advanced technologies to enhance efficiency, customer satisfaction, and operational effectiveness (Schleeter, 2015). In addition to their unprecedented characteristics, such as real-time data analytics, automation, and personalized customer experiences, smart services also revolutionize the way firms interact with their customers, turning these relationships into continuous and open-ended engagements (Porter & Heppelmann, 2015).

A typical feature of smart services is that "value is co-created via interactions between the service provider and the customer" (Dreyer et al., 2019, p. 66). This means that customers actively participate in the service delivery process, providing feedback and contributing to the development of new features and improvements (Lee & Lee, 2014). Such a collaborative model not only results in improved consumer experiences but also provides a foundation for service innovation and improvement cycles (Castelnovo, 2016). Co-creating value in the sense of smart services has been described as a collaboration between customers and service providers (Gavrilova & Kokoulina, 2015). Value co-creation puts increasing pressure on service providers to constantly meet the changing needs of customers (Kitchin, 2021), interacting in a way that leads to new business models.

Despite the potential of co-creation in the context of smart services, the role of the customer has not been sufficiently addressed in both practice and literature. Research has often focused on how to involve customers in the initial innovation process, but customer involvement in the operational phases remains relatively unexplored (Dreyer et al., 2019). This oversight is significant because continuous engagement with customers can lead to more effective and sustainable service improvements.

In smart city planning, for instance, the concept of co-creation could significantly enhance the development and implementation of urban initiatives. Key to the success of smart city initiatives is turning users into active participants (Starc-Peceny et al., 2017). By involving citizens not just at the inception but throughout the lifecycle of smart city projects, planners can ensure that the evolving needs and preferences of the community are consistently met. This ongoing interaction can take the form of regular feedback loops, participatory workshops, and real-time data sharing, which would allow for adaptive and responsive city management.

Adopting a co-creation model also allows city planners and service providers to address the dynamic characteristics of urban scenarios. This approach enables them to be more agile, making tweaks on the fly using real-time information fed by residents, which results in increased citizen satisfaction and engagement. This integrated development model of co-creation allows smart services to be novel at inception and then grow into a mature solution that adapts with the people who actually use them over time (Polese et al., 2018).

2.2 Marketing Myopia in Sustainable City Planning

The underlying premise of the "marketing myopia" concept, an expression coined by Theodore Levitt in a seminal 1960 *Harvard Business Review* article, is that companies too focused on their products (or services) lose sight of customers' needs and wants. This shortsightedness can cause companies to overlook opportunities and not adjust for market changes, resulting in inevitable decline. Marketing myopia in the context of smart cities refers to city planning that is overly focused on the technological aspects as opposed to the broader city environment. This can result in smart city projects that do not connect to local needs, and the promotion of sustainability principles becomes less effective or even collapses. The consequences of ignoring market insights and customer feedback include missing important market trends and societal shifts, reducing the effectiveness and appeal of sustainability projects (Becker et al., 2023).

Examples of marketing myopia abound. The Sidewalk Labs example mentioned earlier is just one of many instances of marketing myopia in smart city planning. Another example is the Songdo International Business District in South Korea. Frequently referred to as an exemplar of a smart city, Songdo was built from scratch with many forms of advanced technology (Huh et al., 2024). However, it has failed to satisfy residents and businesses. City planners largely emphasized technology and infrastructure as opposed to considering future residents' goals, desires, and lifestyles (Huh et al., 2024).

Marketing myopia can also manifest as an excessive focus on digital transformation without considering critical factors such as the digital divide (Lam & Ma, 2019). Companies and city planners may become overly fixated on integrating the latest technologies and digital solutions, believing that these alone will drive success. However, this narrow perspective overlooks the varying levels of access to and familiarity with digital tools among different segments of the population. This scenario reflects what happened in Barcelona. Despite being at the forefront of implementing smart city technologies, Barcelona initially failed to understand the needs of its citizens, facing challenges related to the digital divide, such as access disparities. The city is now actively involved in reducing the digital divide by investing in pilot projects like Connectem Barcelona, which focuses on increasing access to digital technology and skills acquisition (Citiesfordigitalrights, 2024).

Examples like Songdo and Barcelona indicate that without integrating citizen input through effective market orientation, these investments might not yield the expected benefits. On the contrary, smart cities that integrate market insights into their planning processes can develop initiatives that are more likely to succeed and gain widespread acceptance.

A myopic approach to city planning can cause frustration and disengagement among citizens, leading to resistance and opposition to city initiatives. In the long run, ignoring market orientation can undermine the success of smart city initiatives, highlighting the critical importance of integrating this philosophy into urban planning.

3. Classification of Smart Cities

Several smart city initiatives worldwide have successfully integrated market orientation into their planning and implementation processes. These case studies provide valuable lessons and frameworks for other cities to follow.

Based on our analysis, smart cities can be classified according to two key dimensions: governance paradigm and orientation. Based on the first dimension, cities can be categorized as top-down or bottom-up smart cities. Top-down smart cities are characterized by centralized planning and execution, mainly driven by the government and large corporations. These cities implement smart city initiatives through strategic direction and large-scale projects, often with significant investments in infrastructure and technology. Examples include Singapore and Dubai, where government-led initiatives drive urban development and technological integration.

In contrast, bottom-up smart cities incentivize citizen participation, local innovation, and community-driven projects. This is possible because of a citizen-centric approach, which creates ample opportunity for co-creation and collaboration with residents to participate actively in smart city projects. Models such as those in Barcelona and Amsterdam, where participatory platforms allow the public to not only propose projects but also have a say in how local transportation funds are spent – all while ensuring that work aligns with community needs through robust and broad public engagement, including in-depth feasibility studies.

The second dimension is orientation, which distinguishes between technology-driven and market-centred smart cities. Technology-driven smart cities focus on technological infrastructure such as the IoT, AI, and Big Data for better management and services to their citizens. Examples of tech-based cities are Tokyo and Seoul. In contrast, market-driven smart cities focus on social inclusivity and community engagement to help citizens achieve a better quality of life. The result is consumer-oriented cities that utilize market orientation to shape technological solutions that will appeal to and be adopted by the community. Cities such as Helsinki and Melbourne prioritize citizen involvement in the conception, planning, and delivery of smart city initiatives so that innovations are responsive to what citizens truly want.

By intersecting the two dimensions, a matrix can be formed (Figure 3.1) where four categories of smart cities are identified:

1. High-Tech Hubs (Tech-Centric & Top-Down Governance)
2. Innovation-Driven Cities (Tech-Centric & Bottom-Up Governance)
3. Citizen-Focused Smart Cities (Market-Centric & Top-Down Governance)
4. Co-Creative Smart Cities (Market-Centric & Bottom-Up Governance)

3.1 High-Tech Hubs

We define "high-tech hubs" as smart cities characterized by top-down governance and a technology-driven orientation.

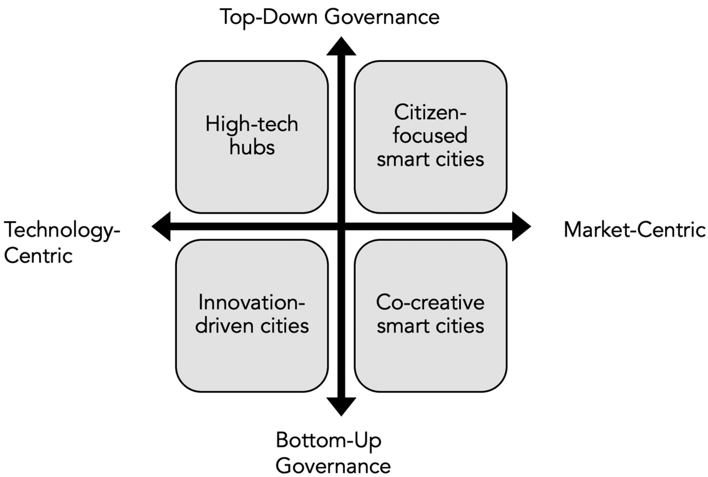

Figure 3.1 Four categories of smart cities

An example mentioned earlier, Songdo, South Korea, is a tech-centric and top-down governance city. Developed from scratch, Songdo was designed with integrated technology to create a highly efficient and sustainable urban environment (Huh et al., 2024). The city's infrastructure includes extensive use of sensors and IoT to manage energy, transportation, and waste. For instance, Songdo's waste management system is based on a network of underground pipes moving trash directly from homes to processing facilities, reducing waste collection costs by 30% and improving recycling rates (Benedikt, 2016). The centralized planning and implementation ensure cohesive and effective use of technology across the city.

Another notable instance of a tech-centric, top-down governance model is Masdar City, UAE (Ismael, 2023). This city was named the most sustainable city in the world in that it applies technologies aimed at reducing energy consumption, as well as cutting carbon emissions (Masdar.ae, 2021). The city's centralized method is based on tight construction standards alongside renewable resources such as solar power to meet its sustainable development goals. By 2021, the total energy balance of Masdar City had been reduced by 40%, compared to conventional buildings in the UAE (Masdar.ae, 2022).

3.2 Innovation-Driven Cities

Innovation-driven cities are technology-driven smart cities with a bottom-up approach that encourages extensive citizen participation in both planning and execution. An example is Tokyo, which has launched the Tokyo Smart City Project, aiming to develop smart energy management systems, improve urban mobility, and enhance disaster preparedness using IoT (Policy Asia Pacific Energy, 2012).

Citizen engagement is a key element of Tokyo's approach. The city engages its residents through platforms that allow them to report issues, participate in decision-making processes, and contribute ideas for urban improvement. The governance structure enables the city to engage with its citizens across online platforms, allowing them to report issues, be included in the decision-making process, and suggest ideas for urban improvement. The city employs a mix of digital and physical channels for its online portals, ensuring that solutions are fit-for-purpose among those who lie at both ends of the tech-savvy spectrum. Moreover, the introduction of smart transport systems, including real-time data on public transport, has increased the efficiency of Tokyo's transportation network, leading to a 20% reduction in average commute times (Wolniak & Grebski, 2023).

Seoul can also be considered the epitome of a bottom-up, technology-led smart city that uses ubiquitous technologies to enhance urban living and increase citizen engagement. Smart Seoul 2030 is a key initiative, putting ICT at the core of city governance, creating a smart infrastructure that maximizes efficiency and seamless connectivity while maintaining sustainability and developing public services close to citizens' needs. Some projects include intelligent traffic management, public safety systems using IoT, and digital government services (Seoul Metropolitan Government, 2019). Another interesting project is Seoul's mVoting app that enables citizens to vote on local topics and policies, encouraging direct citizen participation in governance to ensure new urban planning proposals are closely aligned with their needs (Seoul Metropolitan Government, 2019).

In Canada, Montreal is among the winners of the country's first-ever Smart Cities Challenge, "a pan-Canadian competition that encourages communities of all sizes to harness the potential of connected technology and data to improve the lives of Canadians" (Government of Canada, 2019). Montreal has promoted initiatives that integrate technology into its urban development while encouraging public participation. For instance, Montreal has developed open data platforms to allow citizens to participate in city planning and provide feedback on different city projects (Government of Canada, 2023).

3.3 Citizen-Focused Smart Cities

Citizen-focused smart cities tend to give precedence to residents' quality of life through centralized decision-making, ensuring that technological advancements and sustainable practices meet the community's needs. Examples of such cities include Singapore and Dubai, UAE.

Singapore is a leading example of a market-centric and top-down governance smart city. The government has committed SGD 2.4 billion to finance the building of digital infrastructure and services (Smart Nation Singapore, 2018). The Smart Nation project, for example, incorporates technologies like sensors and data analytics to improve quality of life in areas such as public housing, transportation, and healthcare infrastructure among others (Smart Nation Singapore, 2018). In addition, the government has launched the Smart Health TeleRehab, which enables patients to conduct rehabilitation at their homes while they are monitored from afar by therapists in lieu of frequent hospital visits and healthcare accruement (Tan, 2017). The programme achieved a 15% reduction in hospital readmission rates and saved more than $5 million in healthcare costs by the time of publication. Moreover, Virtual Singapore is another initiative consisting of a 3D city model and collaborative data platform that supports decision-making in various sectors, including urban planning and disaster management (GovTech Singapore, 2020).

Dubai, UAE, also exemplifies a market-centric and top-down governance model through its Smart Dubai initiative. In 2016, the city government launched the so-called Happiness Agenda that is aimed at enhancing the well-being of its citizens through various smart initiatives. Happiness Meter works as a real-time feedback tool that measures citizens' satisfaction with public services. By 2021, over eight million feedback responses has been collected, with a satisfaction rate of 89% (Digital Dubai, 2024). The centralized decision-making process ensures that technological advancements are aligned with the needs of the community, enhancing the overall quality of life.

These cities highlight how a market-centric and top-down governance approach can effectively improve urban living conditions. By focusing on the needs and preferences of residents and utilizing centralized decision-making, these cities can implement large-scale projects that address specific community issues while ensuring that technological innovations are practical and beneficial to citizens.

3.4 Co-Creative Smart Cities

Co-creative smart cities actively involve residents in the planning and development processes, ensuring that technological advancements and sustainable practices align with the community's needs and preferences.

A typical example would be Barcelona in Spain that, for its emphasis on community engagement and participatory governance in its smart city initiatives, has been defined as "the capital of technological humanism" because of its inclusive approach to digital transformation "that leaves no one behind" (Citiesfordigitalrights, 2024)

The city has developed several platforms that involve citizens in decision-making processes, such as the "Decidim Barcelona" platform, where residents can propose and express their vote on various city projects and policies. This platform has significantly increased civic participation, with over 40,000 registered users and more than 10,000 proposals submitted as of 2021 (Decidim Barcelona, 2024). The city has also launched Superblocks, a project that creates areas that belong to local people and limits motorized vehicle traffic to reduce pollution. Based on a study by the Barcelona Institute for Global Health (2019), the implementation of Superblocks could prevent 667 premature deaths annually by reducing air pollution and increasing physical activity among residents.

Another interesting example of a co-creative smart city and participatory innovation hub is the Dutch capital, Amsterdam. The city has launched the Smart Citizen Lab, where citizens use sensors to monitor air quality and noise levels by using their facilities in some neighbourhoods. As of 2022, these efforts had translated into a cut of CO_2 emissions by 20% and an increase in cycling use among residents by 50% – demonstrating the success with which Amsterdam's grassroots-level marketing push worked to their advantage (Amsterdam Smart City, 2024).

4. Strategies for Effective Market Orientation Integration

Integrating market orientation into smart city planning requires strategic approaches that accommodate different city types along the continuum of governance and technological focus (Figure 3.1). Cities can shift their strategies to move along this continuum, enhancing their effectiveness in creating smart, sustainable environments. Cities can strategically shift along the continuum between technology-centric and market-centric approaches and between top-down and bottom-up governance models. This involves a dynamic interplay of leveraging technology, engaging citizens, and ensuring that urban development aligns with both strategic goals and community needs.

For instance, to become more "bottom-up," cities can work on citizen engagement, implementing participatory platforms and public consultations to gather resident insights, which are crucial for aligning urban development with community needs. Barcelona's "Decidim" platform is a good instance of an initiative that enables citizens to participate in decision-making processes, ensuring that their voices are heard and considered in city planning (Decidim Barcelona, 2021).

Understanding the needs of the main stakeholder, that is, the citizen, is also crucial. Market research can help towards this purpose by intercepting the real desiderata of citizens. Marketing myopia examples, such as the Toronto Sidewalk Labs, would not happen in a context where market research is the starting point of any service development. The process of seeking feedback should be iterative, allowing for continuous data collection and strategy adaptation to ensure alignment with evolving community needs and technological advancements.

Before introducing new services, city managers could adopt a modus operandi based on incorporating the citizen perspective, by conducting surveys, interviews, and market analysis to gain insights into citizen preferences and behaviours. For instance, market research can help cities identify barriers to adopting electric vehicles and develop targeted campaigns to address these barriers. City planners could leverage social media and digital marketing to test citizens' sentiment, obtain insights, and engage citizens. Digital marketing could be employed to develop campaigns targeting specific demographics and making sure that they reach the right target market.

Nowadays, leveraging data analytics comes in handy. Cities can use data to understand citizen needs and preferences, thus guiding both technological investments and policy decisions. The Helsinki Region Infoshare (HRI) Open Data Service is a good example of this open data usage in action and how insightful the use case is to see what people are like and think about their living environment (Helsinki Region Infoshare, 2020).

Starting with pilot projects involving community participation can also be effective. These smaller-scale initiatives give cities a way to experiment with new technologies and approaches at their own pace before rolling them out city-wide. Amsterdam's Smart City initiative, for instance, reportedly uses pilot projects to test and iterate solutions before wider roll-out (Amsterdam Smart City, 2024). Effective communication is also essential for building trust and support for new technologies and policies. Maintaining clear communication about the benefits and uses of these innovations can mitigate resistance to change. Marketing campaigns can highlight success stories and address concerns, thereby promoting sustainable initiatives.

To this end, it is highly recommended that smart city services be co-created with citizens. By including citizens in the design process, cities can guarantee that services are tailored to their needs. This citizen-centric design paradigm of a multi-stakeholder strategy is key to making smart cities happen. This approach takes into account the needs and wishes of all stakeholders, be they citizens, businesses, or government agencies. New technologies around data analytics and digital platforms offer new opportunities to engage the public, diagnose citizen needs, evaluate the execution of activities, and service outcomes (Huertas et al., 2021).

It should be noted, though, that there is overlap between citizens, businesses, and government agencies. That is, it is the citizens themselves who work in and for the businesses and government agencies, and thus can have multiple roles, acting as a city planner and as a citizen, or as an elected official and as a citizen. This chapter has treated the roles as separate for ease of illustration. However, further research should look into the multiple roles and how the overlap affects co-creation of services.

5. Conclusion

This chapter has explored the importance of integrating market orientation in smart city planning. The case studies and strategies discussed highlight how marketing can enhance the design and implementation of sustainable projects, ensuring they are well-received and effectively integrated into citizens' daily lives. Incorporating market orientation into smart city planning through these strategies ensures that smart cities are not only technologically advanced but also socially inclusive and attuned to the needs of their residents. By moving along the continuum between different governance models and orientations (Figure 3.1), cities can enhance their effectiveness in creating smart, sustainable environments that truly benefit their communities.

Neglecting to incorporate market insights and customer feedback in city planning can lead to projects that fail to resonate with community needs, resulting in underutilized or ineffective sustainable initiatives (Maček et al., 2019). In contrast, involving citizens as customers in a co-creation perspective (Alt et al., 2019) can greatly enhance the design of smart city services. The future trajectory of smart cities is, therefore, increasingly leaning towards a citizen-centric design paradigm (Becker et al., 2023) and a multi-stakeholder strategy (Oschinsky et al., 2022). Policymakers, urban planners, and city marketers need to understand the importance of market orientation in city planning. Future research should focus on developing frameworks and tools for integrating these elements into city planning processes, exploring the impact of marketing on citizen engagement and the success of sustainable initiatives, and examining the role of emerging technologies in smart city development (Sadoway & Shekhar, 2014).

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Section 2

Economy

A thriving **economy** is essential for the success of smart and sustainable cities. It drives innovation and investment, fostering technological advancements and infrastructure development. A strong economy supports job creation, enhancing residents' quality of life and promoting social equity. It enables funding for sustainability projects, such as renewable energy and efficient public transport. Economic growth also encourages public–private partnerships, which are crucial for implementing smart technologies. By attracting businesses and talent, a robust economy ensures the city's resilience and adaptability, allowing it to sustainably meet the evolving needs of its population.

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4 Circular Economy and Regional Systems

Intermediary Organizations for Environmental Protection and SME Competitiveness and Its Impact on Cities

Nobutaka Odake

1. Introduction

The increasing global demand for raw materials and energy has created an urgent need for efficient resource use. Resources include not only energy sources such as oil and coal but also metals, chemicals, and water. Measures to improve resource efficiency can strengthen the competitiveness of industries or companies, protect the environment and climate, and contribute to a circular economy. Towards a circular economy, companies can effectively combine the following: (1) improve the resource and energy intensity associated with their business activities, (2) use products and parts for longer, (3) reuse, (4) use non-hazardous materials and renewable energy, and (5) use ICT to pursue circularity. This requires companies to take a broader innovation perspective, innovating not only individual products and services but also business models and ecosystems; that is, to take the entire supply chain into consideration.

While Industry 4.0 represents the digital networking of industrial processes from the acquisition of raw materials to the recycling of products at the end of their useful life, in other words, in the circular economy sense, Industry 4.0 solutions can be fully automated without human influence, or they can be partially automated with human–machine cooperation. The German Federal Environment Ministry defines resource efficiency as "the ratio between a certain benefit or result and the resources needed to achieve it" (Jahns, 2020).

On the other hand, environmental policy is often developed on the basis of regulations, but the effectiveness of regulations alone is limited, and there is a shift towards support programmes that are triggered by environmental improvements in production processes. The decoupling of economic growth and resource consumption (environmental impact), that is, environmental responses in the industrial sector, must be compatible with the economy, and programmes to realize this direction are required. Consulting programmes are being developed in several European cities and regions to promote sustainable business activities led by the public sector.

This chapter focuses on EFA, a non-profit agent in the state of North Rhine-Westphalia (hereinafter NRW), and the Vienna Environment

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Protection Agency (hereinafter MA22), which have been continuously working to strengthen the competitiveness of SMEs from the perspective of intermediaries, such as agents, as an innovation diffusion-oriented policy aimed at regional empowerment (Chiang, 1991). The paper focuses on organizational management and consulting programmes, extracts implications for intermediaries, and discusses their relevance to smart cities.

In pursuing this study, we visited the Efficiency Agency (EFA) in March 2000, May 2006, February 2009, and September 2023, and conducted interviews with the MA22 of the City of Vienna in April 2006, November 2008 (Wien and Graz), and September 2023. The people we interviewed were EFA/NRW, a mid-level consultant engineer, and MA22, a department manager. Both are manager-level individuals who have been involved since the establishment of the organization and the project.

2. Existing Research

Intermediate organizations are also agents, and this chapter focuses on public organizations and departments. Braun (2008) argues that in principal–agent theory, the principal is the actor who disposes of many resources but not the right kind of resources to realize benefits, and thus requires an agent willing to promote the principal's interests. Coleman (1988) presents the concept of social capital and states that rational behaviour is one way to introduce social structure into the paradigm, examining three forms of social capital: obligations and expectations, information channels, and social norms. Howells (2006) presents the systemic value that innovation intermediaries can play in terms of policy for intermediate organizations. Eisenhardt (1989) argues that agency theory offers unique insights into information systems, outcome uncertainty, incentives, and risk, especially when combined with complementary perspectives, and that it is an empirically valid perspective. Regarding ecosystem and network, Baber and Ojala (2024) define: "A business ecosystem denotes a complex network of organizations collaborating and competing as they collectively and dynamically contribute to value creation and capture. A business ecosystem evolves over time as firms and organizations collaborate to create value." Tatsumoto (2017) points out that business ecosystem-type industries are characterized by (1) the existence of firms with different roles (firm types), (2) firms form a network and there are direct and indirect relationships among them, and (3) a very specific corporate species arises that has influence on industrial evolution. The characteristics of ecosystem industries are (1) the existence of firms other than product firms, (2) innovation and business are not completed by a single firm but are handled by a network of firms, and (3) there are direct and indirect relationships among firms. In this case, not only direct parts transactions but also indirect influences (i.e. network effects) exist between firms, indicating the existence of a special type of firm, the platform firm. Kawabata (2023) suggests that in order to strengthen the competitiveness of regional industries, it is important to create cross-sectoral collaboration and a large number of autonomous, mutually beneficial actors, and that the most suitable type of independent management entity for this purpose is an independent administration organization called a "Network Administration Organization" (NAO).

There is a common theme in the definition of a smart city: the combination of ICT, human and social capital, and investments in modern urban infrastructure and services to achieve sustainable economic growth and improve the quality of life of citizens. Smart cities can respond intelligently to a variety of needs, including daily life, environmental protection, public safety, urban services, and industrial and commercial activities (Harmon et al., 2015). Being a smart city measurement technology that makes the invisible visible (Harrison & Donnelly, 2011; Silvaa et al., 2018, etc.), Ahvenniemi et al. (2017) recommend using the more precise term "smart sustainable city," Nam and Pardo (2011) identify common multidimensional components underlying the concept of smart cities and the elements of smart city success as the integration of infrastructure and services through technology, social learning to strengthen the human base, and governance for improving institutions and engaging citizens (Figure 4.1).

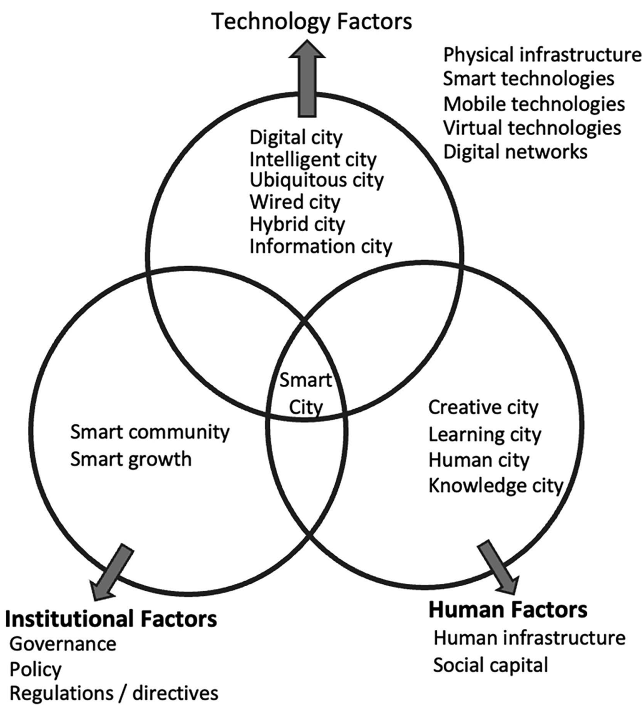

Figure 4.1 Fundamental components of smart city (Nam & Pardo, 2011)

3. An Intermediary Organization for Environmental Protection in NRW, Germany

3.1 Industrial Structure of North Rhine-Westphalia and Background of the Establishment of EFA

With an area of 34,082 km^2 and a population of 18.15 million (2023), NRW has the highest GDP of the 16 German states at € 793.8 billion (2022), accounting for 20.9% of the total of € 3,867 billion. The key industries in NRW are chemicals, plastics, machinery, steel, electric, electronics, and food industries. One-third of Germany's 500 largest companies are headquartered in NRW. Business activities in NRW are diversified, ranging from the coal mining and energy industry in the Ruhr area to traditional industries such as the furniture industry in the Lower Rhine region and Eastern Westphalia, meat processing in Münsterland, and advanced service industries in telecommunications and media in the Cologne area. It has diversified to cover most industrial sectors (Hilbert et al., 1998). The above-average decline of the coal mining, steel, and capital goods industries has led to a transformation in this region: the location of EFA in the Duisburg region (Ruhr area) is due to the concentration of chemical industries and research institutes, the concentration of small and medium-sized manufacturing companies that can provide technical services, and federal assistance programmes, consultants (technical offices). On the other hand, the Duisburg region had lost about 80% of its steel and coal production and was structurally weakened, necessitating the creation of new industries.

The impetus for the establishment of Efficiency Agency (hereinafter EFA) came from the state parliamentary elections of 1995. The Social Democratic Party (SPD) and the Green Party (DG) formed a coalition and reached a policy agreement to (1) encourage the development of environmental technologies, (2) promote economic structural reform and focus on promising technologies, and (3) match environmental needs with people's needs. Against the backdrop of this agreement, a proposal submitted by a private consulting firm to the state Ministry of Environment was approved, and the framework for the establishment of the EFA was solidified. However, because it was a large-budget programme and the company did not have the staff to actually manage the programme, a new company was established as a designated management entity to handle only the work of EFA, and new personnel were hired. EFA's efforts have remained highly regarded even after the change of state government administration, and the company has expanded from its original location in Duisburg to new locations. It has now expanded to include offices in Aachen, Bergisches Land, Bielefeld, Münster, Niederrhein, Rheinland, Siegen, and Werl in the state.

3.2 EFA's Approach

EFA is the competence centre for resource efficiency in the state of NRW, but as an independent service provider, the agency has been operating as a non-profit agent (designated management entity) of the Ministry of the Environment of NRW for over 20 years. During this time, the support company has changed from the original company to die delta consult GmbH, but the EFA team has not changed. EFA is positioned as a partner to advise businesses and policymakers, identify and set trends, develop relevant instruments for resource-efficient business, and increase resource efficiency in the state economy. As a resource efficiency competence centre, EFA introduces more resource-efficient business practices in the areas of production, product development, and costing through its resource efficiency consulting services.

With the assistance of outside consultants, EFA conducts more than 150 consulting projects per year. The consulting services include production management, product design, maintenance, and cost accounting. EFA also provides financial advice on investments and R&D projects related to resource efficiency, called "PIUS financing," with an average of €70 to 100 million invested in resource efficiency technologies each year. In addition to advising SMEs, EFA organizes events to provide information on the latest developments in the sector and offers training courses for employees of manufacturing companies and consultants. Small and medium-sized enterprises (hereinafter SMEs) in this context are defined as those with fewer than 250 employees, annual sales of less than €50 million, and balance sheets of less than €43 million (European Commission definition of SMEs).

SMEs are often poor at reducing costs through sustainable manufacturing and general resource efficiency practices, especially in resource-intensive manufacturing industries (Jahns, 2020). Adopting individualized resource efficiency measures, called PIUS®-Check, that are tailored to the company's current situation in the manufacturing industry has provided an opportunity to increase resource and cost-efficiency. On the other hand, in a digitalized society, manufacturing and work methods will change dramatically. They are being replaced by products with individualized and flexible production processes rather than classical mass production.

Industry 4.0 encompasses three dimensions, namely high-grade digitization of processes, smart manufacturing, and inter-company connectivity (Müller et al., 2018). Since 2018, the entire action approach to support companies in designing efficient processes in line with Industry 4.0 has been carried out within the programme "Resource Efficiency 4.0," a significantly upgraded version of the resource efficiency analysis tool PIUS®-Check. The "Resource Efficiency 4.0" programme can be individually controlled by a web-based process control system and a networked sensor system. Digitization is not an end in itself, but rather a useful tool to (1) record resource consumption, (2) serve as a basis for data transparency and resource efficiency improvement, (3) automate processes, improve communication, and reduce material and energy consumption. It also recommends involving suppliers at an early stage. In addition, Resource Efficiency 4.0 extracts information for more intelligent processes from millions of data points (big data) and uses it to address issues related to resource efficiency improvement.

EFA provides specific support to industry in identifying and implementing material and energy efficiency potentials through its resource efficiency consulting. The consulting covers corporate areas such as production, product design, maintenance, and costing, as well as CO_2 accounting, Industry 4.0, and value chain topics. In addition, EFA provides financing advice ("PIUS financing") to secure funding for necessary R&D projects and investments in resource efficiency measures and accompanies the project through to implementation. As part of the events, training courses, and workshops, EFA offers current technical developments, consulting services, and funding opportunities, connecting experts with decision-makers. EFA staff members, including consultants and technical firms, are present at the corresponding projects and are committed to helping participating companies reap the benefits of resource-efficient management through coaching. What began as a PIUS Check project to identify and improve resource efficiency has been ongoing for more than 20 years and is stored in EFA as a databank.

Notably, the online tool offered by EFA, "ecocockpit" for CO_2 balancing, is a free solution for measuring CO_2 emissions (Figure 4.2). With this tool, users can create a carbon footprint (CFP) of their company (CCF) and products (PCF) in a few steps, that is, identify their CO_2 emission factors and derive reduction measures in a simple and practical way, which is also available for other federal states.

The methods developed by the Dutch working group CIRCO, EFA serves as the German CIRCO hub to teach companies how to apply circular design and business model strategies. Since April 2021, EFA has been working with CIRCO to organize a series of workshops in NRW. During the workshops, knowledge applicable to the participants' products is imparted and discussed with them.

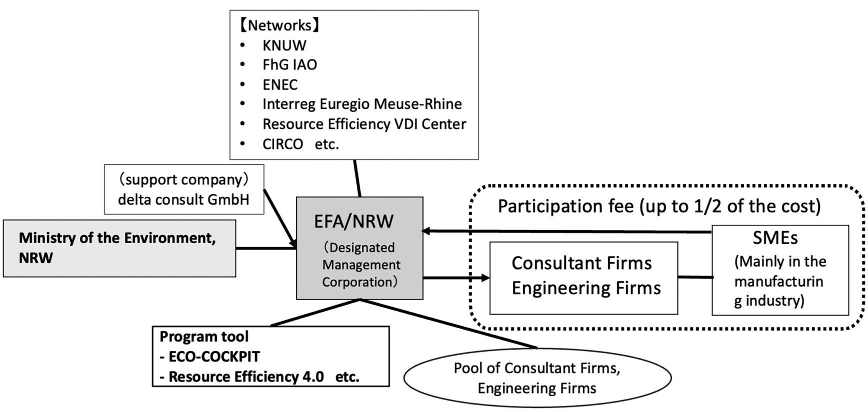

Figure 4.2 The Effizienz Agentur (EFA) ecosystem

As a result, individual action plans for practical applications are developed, and companies with promising ideas are satisfied. CIRCO was commissioned by the Dutch Ministry of Infrastructure and Water Management to conduct a workshop in 2015 based on Delft University of Technology (TUDelft)'s research on "products that last" and "products that flow" (CIRCONNECT web page).

EFA has established its own networks or actively participates in external networks. The Regional Enterprise Maintenance Centre, established by EFA, as well as the VDI Resource Efficiency Centre, KNUW (NRW Network for Environmental and Economic Competitiveness), ENEC (exchange of knowledge, experience, and best practices in eco-design), the EU internal border region Meuse-Rhein (border region integration programme), European Ecodesign Network, the North Rhine Advisor Network (created by EFA), and the aforementioned CIRCO. Some of these networks are available directly to the user SMEs.

The State Ministry of Environment, for example, also assists companies with specific advisory services provided by EFA. It also promotes collaborative activities with the Network for Environmental and Economic Competitiveness (KNUW) to design financing programmes to support green start-up companies, adapt the regulatory framework, and facilitate the transition to a circular economy (EFA PLUS-Magazin, 2021).

Grants are provided for major consulting programmes. According to the interview, "Previously, two-thirds were awarded under PIUS®-Check, but since 2018 this has changed to half awarded due to the larger ICT-related costs in Resource Efficiency 4.0."

EFA also celebrates success by awarding the NRW Efficiency Award and makes available the NRW Best Practices Overview Map, which provides an overview of successful resource efficiency projects at companies in more than 20 sectors in NRW. EFA, using the Best Practices Database, offers companies the opportunity to search for innovative and tried-and-true implementations. According to the interview, "In addition to advising individual companies, EFA organizes events to provide information on the latest developments in the field and develops the academy as a training course for employees of companies and consultants."

As an agent of the state of NRW, EFA organizes diverse partnerships to address challenges, along with full state funding. Environmental orientation will not penetrate the market unless ecological products and sustainable consumption can be made competitive both in the manufacturing industry and among customers. In this system, not only resource conservation is respected (EFA PLUS-Magazin, 2021).

4. Initiatives of the City of Vienna

4.1 Environmental Protection in Vienna (MA 22) and the Sustainability Coordination Centre of the Province of Vienna

Vienna, the capital of Austria's federal state and city, has a population of 1.98 million (as of 1 January 2023) and a city area of 415 km^2, of which

201 km^2 is green space. The GDP is €102.0 billion (as of 2021). Vienna is a world-class tourist city with 7.7 million overnight visitors every year. On the other hand, the City of Vienna, the administrative arm of the city, has its own environmental initiatives. Environmental Protection in Vienna (MA 22) works to improve the quality of the local environment as well as the general quality of life in Vienna. The department places particular value on supporting related research and cooperating with other departments as well as interest groups. The ultimate goal is to decouple economic growth from resource consumption and environmental pollution, rather than directly addressing environmental protection through regulation. In particular, it has achieved excellent results in supporting SMEs in improving their business management by reducing the MA22 is responsible for the core tasks of preventive, integrated, and partnership-based environmental protection in Vienna. This includes strategic air quality management, nature and landscape protection, sustainable development, noise protection, waste and resource management, operation of Vienna's air monitoring network, and comprehensive public, legal, and professional activities. In Vienna, the Federal State Sustainability Coordination Centre is part of MA 22 (Stadt Wien web page).

Its activities focus on cooperation with the Federal State and the Federal Government within the framework of the Sustainability Coordinators Meeting and on targeted cooperation with other departments and stakeholders in Vienna. The Sustainability Coordination Centre contributes to the materialization of the sustainability concept at the federal-state level through an advisory, integration, networking, and support approach. It sees sustainability as the essence of strategies, programmes, projects, and measures, thereby creating added value for all policy areas. The centre is the home of EcoBusiness Wien (hereinafter EBW)'s programme management and is also part of the programme management of EcoBuy (ÖkoKauf Wien). These two exemplary programmes significantly reduce the negative environmental impact of production and consumption. Vienna's programmes and procurement standards for companies are gradually expanding in the direction of sustainability.

4.2 EcoBusiness Wien (EBW)

EBW's predecessor, "ECOPROFIT," was developed in Graz (Austria) in the early 1990s by the City of Graz, represented by the Graz Environment Agency, and the STENUM working group of the Institute for Basic Process Engineering of the Technical University of Graz. The first steps towards establishing advisory programmes as an instrument of sustainability policy were taken in 1991. The "ECOPROFIT" programme was developed in Graz with the aim of promoting cleaner technologies and establishing an environmental management system (Martinuzzi et al., 2000).

ECOPROFIT combines a series of standardized workshops involving companies from different sectors with individual, personalized advice and a high-profile award as an ECOPROFIT company. After a successful start in Graz, ECOPROFIT moved to other Austrian cities for the first time in 1998 and further spread internationally. In this context, in 1998, MA 22 introduced ECOPROFIT and launched it on behalf of the Vienna city administration.

The EcoBusiness Plan (later EcoBusiness Wien), which includes ECOPROFIT in Vienna as a module, has received international attention for its results: it was recognized as a "best practice" by UN-HABITAT in 2002 and 2006, and received the EuroCities Award in 2006. The programme concept has also been implemented by the Irish Environmental Protection Agency (EPA) in County Cork (2006–2009), the EU project "IONAS for Enhancing Sustainable Development of Ports and Port Cities in the Adriatic and Ionian Region" (2004–2006), the city of Gyor, Hungary (2002–2007), and feasibility studies for the cities of Athens (Greece) and Chennai (India) (2003–2004), which were adapted to the specific requirements of other cities. EcoBusiness Wien (hereinafter EBW) has continually undergone evaluations associated with the programme: the 1999–2006 evaluations were conducted by a team from the Vienna University of Economics and Business Administration in cooperation with the Institute for Industrial Ecology, and subsequently by the Institute for Industrial Ecology.

EBW is an environmental service package for companies in Vienna that helps companies reduce their operating costs by supporting their environmental practices. Its aim is to achieve clean profits for the environment and the company through ecological business practices and to ensure high quality and economic benefits through environmental protection within the company. The programme includes expert co-financing advice, practical implementation support for measures, legal certainty, and effective public relations. It promotes the sharing and repair economy and the development of innovative and sustainable solutions.

The City of Vienna is home to 85,000 SMEs, but only 55,000 are actually operational. Being an urban area, the EBW is not limited to the manufacturing sector but also covers the service sector, tourism, private businesses, and so on. From 1998 to 2023, 1,537 companies have participated in the EBW and have implemented more than 15,000 environmental projects and activities. During this period, participating companies saved a total of 3,346,700 m^3 of water, 127,915 tonnes of waste, 832,000 tonnes of CO_2, 2.7 terawatt hours of energy, 102.8 million kW of transport distance, and €170.9 million in operating expenses. The success of EBW shows that a voluntary move to apply quality standards for sustainability that exceed legal requirements generates economic benefits (OekoBusiness Wien, 2023).

EBW is positioned within the SMART CITY VIENNA framework, a long-term, comprehensive strategy for meeting the challenges of the 21st century. Its philosophy and objectives are to help companies create "green and clean" profits through environmental management practices that benefit both the environment and the company. The point is to "maximize resource savings" while "improving the quality of life" for all Viennese through "social and technological innovation" in all areas.

The goals of EBW are:

- To reduce the negative impact of economic activities on the environment through a comprehensive environmental protection strategy.
- To increase the competitiveness of Viennese companies through more efficient use of resources (maximizing innovative potential and cost-saving opportunities) and to maintain employment in the medium term.
- To strengthen the advisory function in the relationship between the city administration and the private sector.
- To contribute to the sustainable development of the City of Vienna.
- To support and expand environmental protection efforts both nationally and internationally.

EBW's strategy is shown in Table 4.1.

To lead Vienna's business performance, consumption, transportation, and public administration in a more sustainable direction, EBW's main partners are the Vienna Economic Chamber, the Federal Ministry of Agriculture, Forestry, Environment and Water Management, AK Wien (Vienna Labour Chamber), OeGB (Austrian Trade Union Federation), WWFF (Vienna Business Promotion Fund), and so on, which provide up to two-thirds of the total programme cost (City of Vienna web page).

Data are collected by the consulting firm responsible for each company, entered into a central database, and updated on a case-by-case basis. Some

Table 4.1 The strategy of the EBW

Use of external consultants and subsidy	Diverse modules such as EcoWin for companies with 20–200 employees, Ecobonus for companies with fewer than 20 employees, and Ecolabel for tourism, schools, events, and meetings; pool of about 80 consultants; two-thirds of consulting costs jointly subsidized (up to €3,000). (In the case of the EcoWin module, 4.5 days of joint workshops + 80 hours of individual workshops.)
Connecting people and organizations	Consultants and companies, companies and governments, national ministries, cities, chambers of commerce and industry, trade unions, labour chambers, etc.
Supporting change	Starting from the status quo, define the possibilities for change, find possible measurements, and support implementation.
Measuring results	Reports as documentation of change, discussion of realized measures with reviewers, entry into a database, and monitoring by an independent external agency.
Celebrate success	Recognition of successful companies, provision of logos, and introduction of companies to the media and public through websites and social media.
Presentation of reliable data	Monitoring by an independent external agency, publication of savings, and calculation of social return on investment.

Note. Based on handouts by the Environmental Protection in Vienna and interviews quantitative data from the dataset will be used for the evaluation, while only a summary will be used for the evaluation (another part will include a verbal description of the company and its measures) and for public relations activities by EBW. Data collection is a prerequisite for companies to receive the award, and the quality of the data is regularly checked by the evaluation team and job creation at the same time as promoting environmental improvements (Oeko-Business Wien, 2023).

Networking and cooperation among all partners help to create a win-win situation for the environment and businesses in Vienna; EBW supports the environment while also contributing to economic stability and job creation (Hruschka, 2017). The City of Vienna's efforts are aimed at unlocking the potential of SMEs and strengthening their competitiveness in the wake of resource efficiency improvements, which in turn improve the competitiveness of the region. The programme is an environmental policy for a relatively small area of the city, with more than 10 modules (modified according to the situation), making it possible even for microenterprises (individual and family businesses) to participate in the programme. The programme provides detailed services that cannot be provided by the government, through the intervention of consultants. Figure 4.3 shows the overall management system of EBW.

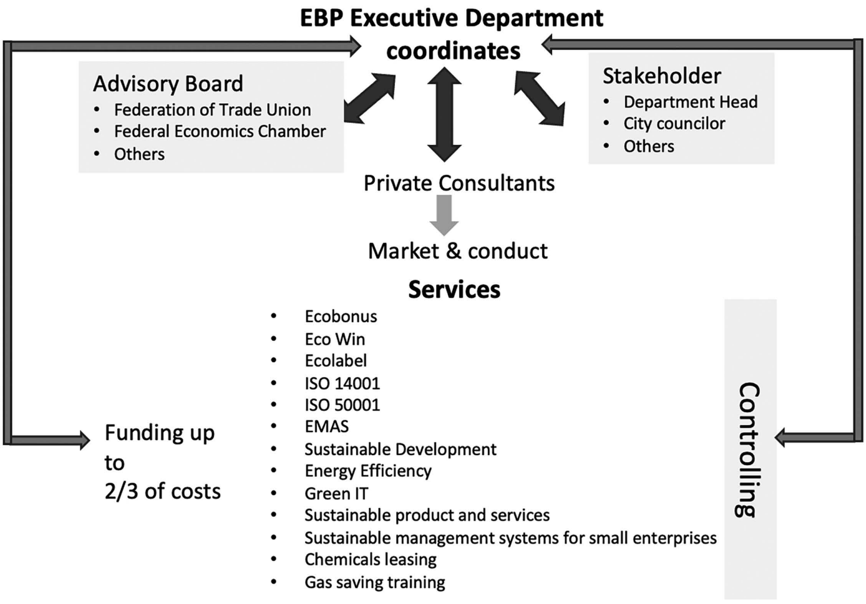

Figure 4.3 EBW management system

Source: Handouts by the Environmental Protection in Vienna

4.3 EBW and Smart City Wien Framework Strategy

EBW is enshrined in the Smart City Vienna framework (Vienna Municipal Administration, 2022), the city's long-term and holistic strategy to meet the challenges of the 21st century (Figure 4.4). The aim is to ensure the best quality of life for all of Vienna's citizens and to save resources through comprehensive innovations. An important part of this aim is for companies in the city to do business in an environmentally sustainable way (Hruschka, 2017). The Smart City Vienna strategy has two core aspects: the first focuses on projects and policies that emphasize technological aspects, especially energy efficiency and carbon emission reduction, and the second on analysing the importance of ICT infrastructure, e-government, mobile applications (public transport), e-health, and e-drive mobility (Roblek, 2019). Through "social and technological innovation," EBW is positioned to "improve the quality of life" for all Viennese while "maximizing resource savings." For this reason, attention is paid to the alignment with the 17 Sustainable Development Goals (SDGs) adopted at the UN Summit and the interrelationships among the goals, which are discussed in McCollum et al. (2018).

The Vienna Environmental Advisory Service (Die Umweltberatung Wien), a non-profit advisory organization founded in 1988 and partially funded by the MA22, is a partner of the Vienna City Government and Administration. EcoBuy Vienna (ÖkoKauf Wien), a programme for sustainable public procurement, follows ecological standards when purchasing goods and services, from washing powder to office supplies, from kindergarten and hospital meals to construction materials. These efforts have been recognized as one of the

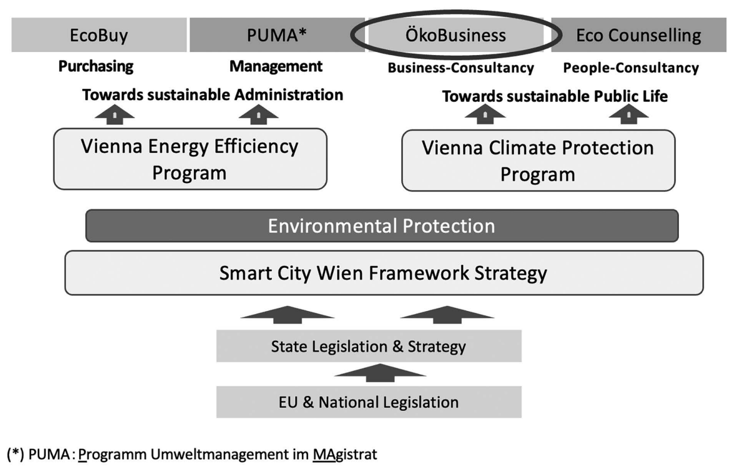

Figure 4.4 Interlinked Executive Administration Units

Source: Handouts by Environmental Protection in Vienna (MA 22) most effective resource-efficiency-promoting projects, which has been commended by the EU Commission.

The City of Vienna uses the public procurement process as a lever for innovation, for example, by requiring recyclable products, services, and business models before they are fully mature in the market. The city's ecological purchasing standards (ÖkoKauf) are scrutinized and further expanded in terms of climate protection, climate adaptation, and circular economy, and are applied mandatorily in the city administration and city companies.

Vienna's urban management programme PUMA (Programm Umweltmanagement im Magistrat: Environmental management programme in the municipal office) is active in the broad and extensive environmental protection of the entire City of Vienna. Since 1996, the City of Vienna has been promoting more efficient environmental protection activities at the municipal level. To promote a sharing and repair economy, it has organized the Vienna Repair Network and the Vienna Repair Bonus, a network of repair specialists who provide repair vouchers and subsidize the cost of repairs to encourage longer product use ("reparaturfuehrer.at" web page). Being positioned in the Smart City Framework Strategy has also made it easier for the MA22 to collaborate with other departments within City Hall.

5. Discussion

In this chapter, two cases of intermediary organizations and agents are examined that are responsible for environmental protection and strengthening the competitiveness of small and medium-sized enterprises. Both cases aim to improve the environment in terms of resource efficiency, energy efficiency, and so on, as well as to strengthen the competitiveness of small and medium-sized enterprises, but the policy-making bodies are the Ministry of the Environment of the State of NRW in the case of EFA and the City of Vienna in the case of MA22, and both are departments in charge of public sector environmental policies. The target is to form a regional system that contributes to self-organization through cross-industrial collaboration, and both organizations correspond to the management entity called the "Network Administration Organization" as described by Kawabata (2023).

The EFA in NRW and the MA22 in Vienna are positioned as keystone organizations (Iansiti, 2004), providing detailed services that are difficult for the public sector (government) to get involved in. As open organizations, they are flexible in their organizational management, introducing and implementing new ideas and know-how from outside.

When comparing the management methods, in the case of EFA, which has jurisdiction over a wide area, the target of the services is small and medium-sized manufacturing businesses, and in the case of the City of Vienna, the target is also small and medium-sized businesses, but it also includes tourism and service industries, and it also includes sole proprietors.

In terms of partnerships, EFA, which is fully funded by state subsidies, works with various organizations in Japan and overseas, and also forms its own networks to improve its services. On the other hand, in the case of MA22, up to two-thirds of the EBW budget is covered by contributions from partners, so coordination is important as the secretariat. In both cases, connecting people and organizations is seen as an important mission.

In line with the Industry 4.0 trend, EFA has upgraded PIUS Check from the perspective that digitization and resource efficiency can go hand in hand, and has positioned Resource 4.0 as its core programme. It also provides a free online tool for measuring CO_2 emissions. In addition, EFA provides financing advice (PIUS Finance) to secure funding for necessary R&D projects and investments in resource efficiency measures, and accompanies projects through to implementation. Meanwhile, EBW in Vienna offers modules for various businesses, such as Ecobonus, EcoWin, and Ecolabel.

Both programmes place importance on workshops. EFA has introduced the workshop methods developed by CIRCO in the Netherlands and is also the contact point in Germany. EBW operates a 4.5-day workshop and 80 hours of individual consulting. The joint workshops, which bring together a diverse range of companies, are a means of communicating knowledge and information, and a place where participants can learn from each other. The related individual consultations are a place for putting things into practice, and the whole thing is an academy (human resources development system).

The important thing to note here is that both of these cases are consulting programmes. The external consultants are the ones who are primarily involved with the participating companies. The consultants are also responsible for measuring the results and registering them in the database.

Rather than the NRW Ministry of the Environment directly committing to the project, it is developing and verifying its policies through the non-profit agency EFA. Meanwhile, EFA is developing tools to effectively promote policies as an independent entity, while also acting as a proxy for government departments that find it difficult to provide detailed services.

The role of the intermediary organization is to strengthen the competitiveness of SMEs in the region through activities carried out via consultants, as well as to understand the actual situation of industries in the region and provide feedback on policies. The development of highly specialized and socially conscious environmental consultants and the development of the consulting market in the environmental field can be considered secondary goals of the policy. EFA and MA22 are recognized as competent agents of the principal government department, and they have a complementary relationship that creates synergy.

Both programmes also develop various methods to motivate people, such as evaluations and rewards, and these are becoming widespread in the region. However, in order for individual projects to achieve results, it is a prerequisite that the small and medium-sized enterprises themselves, and in particular the managers, have the enthusiasm and attitude to change. Both EFA and EBW require a certain amount of financial burden from the small and medium-sized enterprises that participate in the programmes they offer. These are key factors in creating a corporate culture and structure that will lead to project success.

In addition, by having consultants involved, it is possible to provide detailed services, and it also has the element of amplifying the effects and leading to diffusion. Through the players of consultants, we aim to improve the environment and strengthen the competitiveness of small and medium-sized enterprises. EFA and EBW (MA22) can develop programmes through consultants, and the consultant side can become a social entity that takes on public interest by connecting with the public and non-profit sectors.

Table 4.2 shows the comparison of EFA and Environmental Protection in Vienna (MA22).

Individual company data is collected by consultants and entered into a central database, which forms the basis for regional data and best practice data. In order to receive on-site data from companies, a relationship of trust is required between the authorities, consultants, and company management.

In this chapter, we have looked at examples of public intermediary organizations that play a role in strengthening the competitiveness of small and medium-sized enterprises, with a focus on the environment. The EFA in NRW and Environmental Protection in Vienna (MA 22) are not only effective agents that represent the policies of the state and city, but they are also evolving entities that have penetrated the local community, developing new tools from the perspective of environmental efficiency. It is truly fulfilling the function of "Initiating new ideas and processes, Developing public policy (Filer, 1975)."

It is a complex network of organizations that contribute to the creation and acquisition of value in a holistic and dynamic way, with intermediary

Table 4.2 Comparison of EFA and Environmental Protection in Vienna (MA22).

	EFA/NRW	*Environmental protection in Vienna (MA22)*
Policy Planning Body	Ministry of the Environment of NRW	The City of Vienna
Target of service	Small and medium-sized manufacturers in the state	Small and medium-sized businesses in the city, including tourism and service industry
Partnership	Collaborating with various organizations domestic and overseas to create their own network	As the Sustainability Coordination Centre, a business management community with the partners is organized
Utilization of external consultants	Network of consultants and engineering firms covering the entire state	Pool of consultants with a background in education and experience in three projects
	Consultants enter data on on-site improvements	Consultants enter data on on-site improvements

(Continued)

Table 4.2 (Continued)

	EFA/NRW	*Environmental protection in Vienna (MA22)*
Program	In response to the trend of Industry 4.0, Resource Efficiency 4.0 and eco-cockpit are positioned as a core programme.	Composed of about 15 modules unique to tourist cities, such as Ecobonus, EcoWin, and Ecolabel
Workshops	Introduced the workshop method developed by CIRCO in the Netherlands	A combination of a 4.5-day joint workshop and 80 hours of individual consulting
Percentage of subsidy	The subsidy for consulting fees has been changed from a maximum of 2/3 to a maximum of 1/2.	Subsidizes up to 2/3 of consulting fees
Characteristics	Advice on raising the funds necessary to implement the project Best practices introduced on the website	A combination of utilizing external consultants, connecting people and organizations, supporting change, measuring results, congratulating success, and presenting reliable data
Others	Due to the wide area, there are eight offices in the state other than the headquarters More than 150 consulting projects are promoted per year	Positioned as part of the Smart City Framework, it will also be involved in urban management programs (PUMA) and eco-procurement (Ecobuy), and by the start of the program, more than 1,500 companies will participate in EBW by 2023.

organizations acting as keystones, and it forms a business ecosystem that evolves over time as companies and organizations cooperate to create value.

In order to promote innovation diffusion-oriented policies (Chiang, 1991), it is important to form various partnerships and to have capable intermediary organizations and agents that can manage flexibly, and developing them as consulting programmes is a viable option.

6. Conclusion

In this chapter, we have looked at examples of public intermediary organizations that play a role in strengthening the competitiveness of small and medium-sized enterprises, with a focus on the environment. The EFA in NRW and Environmental Protection in Vienna (MA 22) are not only effective agents that represent the policies of the state and city, but they are also evolving entities that have penetrated the local community, developing new tools from the perspective of environmental efficiency. It is truly fulfilling the function of "Initiating new ideas and processes, Developing public policy (Filer, 1975)."

Intermediate organizations such as EFA and MA22 act as keystones, creating a complex network of organizations that contribute to the overall and dynamic creation and acquisition of value, as described by Baber and Ojala (2024). By working together to create value, companies and organizations form a business ecosystem that evolves over time.

While it is important to form various partnerships and to have capable intermediary organizations or agents that can carry out flexible management, developing a human resources development system as a consulting programme that utilizes outside consultants is a powerful option for innovation diffusion-oriented policies.

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5 A Study on Roles and Functions of Support Actors in Startup Ecosystem

Yukako Harata

1. Introduction

In recent years, there have been many reports on startups that are working to solve social issues. Research on the regional impact of "startup ecosystems" and "startup consortiums," which consist of multiple organizations from different perspectives, including organizations that provide both soft and hard support for startups (hereafter referred to as "startup support facilities"), investors, local governments, universities, and companies, is also active. In Japan, as described in The Nikkei (2024/2/2), there are efforts to build a startup ecosystem, that is, an environment in which multiple parties can actively establish new businesses, within a specific region of Japan. The creation of "university-launched startups" that utilize the results of university research has attracted attention, and according to a survey by the Ministry of Economy, Trade and Industry (METI), there were 4,288 startups in FY2023, a 90% increase from five years ago, before COVID-19. The strengthening of support systems for startups has been successful not only in metropolitan areas but also in regional cities, and the base of entrepreneurship is expanding from the centre of large cities to the local cities (The Nikkei, 2024/6/21). The reason why local cities are also focusing on creating and fostering startups is that there is a positive correlation between the rate of new business startups and GDP (The Small and Medium Enterprise Agency, 2002), and it is reported to have a positive effect on the revitalization of the local economy and sustainable corporate growth. As mentioned earlier, there is a growing momentum to nurture entrepreneurs among multiple stakeholders in the region. Although there are various names for such a startup ecosystem, in this paper, we use the term "startup ecosystem" to refer to "a place where innovation and startups are continuously produced through interconnection and cooperation among five stakeholders: entrepreneurs, large companies, risk capital, universities, and government." In Japan, eight cities were designated as "Startup Ecosystem Hub Cities" in 2020. Discussions on the elements necessary for such a startup ecosystem have been held extensively and will be discussed in detail in the next chapter, but all of the "Startup Ecosystem Hub City" have elements with similar attributes. Sasamori et al. (2022) mentioned that regional

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policies based on this ecosystem concept seem to assume a uniform model and goals, and in the case of the "Startup Ecosystem Hub City" mentioned earlier, although the focus industry fields differ among the "Startup Ecosystem Hub City," they all share the same constituent entities, especially the point of advocating industry-government-academia collaboration that brings together elements of universities, private companies, and government, and the point of setting the amount of funding and the number of active startups as KPIs by 2024. It is also pointed out that the startup environment should differ from region to region, and that it would be incongruous to set common models and goals for regions with different populations, industrial structures, number and quality of universities, and other conditions. Furthermore, there is a tendency to evaluate the degree of growth of a startup ecosystem in terms of the increase in "members" or "related population." On the other hand, however, it is not only the development of such elements that is important in ecosystem research, but rather the roles and functions necessary to build an effective ecosystem. Kato (2024) describes the concept of a startup ecosystem as one in which entrepreneurial activities are influenced by various factors within the region, such as institutions, culture, and networks, and in which not only new value is created through entrepreneurial activities, but also each component may be developed. This indicates that entrepreneurial activities and the presence of stakeholders who continuously interact with entrepreneurs can serve as the axis for measuring the growth of the ecosystem, since it is described as a startup ecosystem.

In this section, we have seen that startups are believed to be one way to revitalize local economies, and that there is a growing momentum towards the formation of a startup ecosystem, with active efforts in rural areas and generous support from the government, especially in urban areas. On the other hand, there is an awareness of the problem that the startup ecosystem has not yet reached its essential stage of growth, as the focus has been on aligning the elements and the degree of growth has not been measured in terms of the number of people involved. The important thing is not to arrange the elements or to create excitement with pretended metrics, but rather for the supporters of startups to have a goal of creating startups suited to the region, and to develop and implement the means and paths to realize the goal. This chapter attempts to verify the aforementioned hypothesis by analysing the roles and functions necessary for startup support in two cities, Toyohashi and Hamamatsu, by looking at the creation of startups and the efforts to support them.

2. Startup Ecosystem Hub City

This section provides an overview of each of the "Startup Ecosystem Hub City."

2.1 Startup Ecosystem Tokyo Consortium

As of March 31, 2023, a total of 488 members have joined the ecosystem, including private companies (developers, financial institutions, operating companies, etc.), organizations (Japan Federation of Economic Organizations, Association of Corporate Executives, Japan Association of New Economy, The Tokyo Chamber of Commerce and Industry, Japan Venture Capital Association, Japan External Trade Organization, Tokyo Stock Exchange, etc.), universities (Tokyo University, Keio University, Waseda University, etc.), VCs, startups (including listed companies), Tokyo municipalities, municipalities in wide-area cooperation (Kawasaki City, Yokohama City, Ibaraki Prefecture, Tsukuba City, Wako City, Chiba City), and the Tokyo Metropolitan Government (as secretariat). In FY2022, the working group shared the initiatives and future developments of scheme verge, Inc. and Urban Waterfront Development Partners in the DX/Smart City area. Participants in the working group discussed the direction of smart city initiatives in the Tokyo area in the three areas of "healthcare," "environment," and "mobility." In the bio/wellness field, background, trends, and specific examples of recent healthcare businesses were shared, and "Directions for collaboration towards the formation of an ecosystem" were discussed in two groups: "Drug Discovery, Regenerative Medicine, and Biotechnology" and "Healthcare Services."

Support organizations include VCs and accelerators active in the region, as well as large and medium-sized companies, all of which are working to support startups by leveraging their respective strengths (Startup Ecosystem Tokyo Consortium, 2023).

2.2 Central Japan Startup Ecosystem Consortium

In Aichi Prefecture, Nagoya City, and Hamamatsu City, we aim to form an ecosystem utilizing deep tech that is generated from the accumulation of R&D in the manufacturing industry. In Aichi Prefecture and Nagoya City, the constituent organizations 244 and startup support facilities such as NAGOYA INNOVATORS GARAGE and Nagono Campus have been playing their roles in Aichi Prefecture, and also the startup support facility "STATION Ai" is scheduled to start service in October 2024. In January 2020, a support facility was opened as an advance for STATION Ai, which was expanded to PRE-STATION Ai in April 2021, and uninterrupted support has been provided until the start of STATION Ai services (Central Japan Startup Ecosystem Consortium, 2023). In Hamamatsu City, in addition to the efforts of the local government, 15 organizations and startup support facilities include the Hamamatsu Regional Innovation Promotion Organization, Shizuoka Bank, and Hamamatsu Iwata Shinkin Bank "FUSE" (Startup Promotion Division, Industry Department, Hamamatsu City, 2023).

2.3 Osaka-Kyoto-Hyogo-Kobe Consortium

The strengths of Kyoto, Osaka, and Kobe city are combined to form a startup ecosystem. Osaka has an abundance of large companies, funds, and human resources; Kyoto has traditional industries and culture that have been handed down through its long history and a supportive environment for university research seeds, prototypes, and commercialization; and Kobe is ahead in promoting demonstration experiments and public procurement. This ecosystem will focus on the fields of healthcare, manufacturing, and information and telecommunications, and will involve collaboration among universities, research institutes, and businesses, centred on Osaka University, Kyoto University, and Kobe University. Also, this ecosystem will create opportunities for startups to develop new technologies and services by building a unified support system in the Kyoto-Osaka-Kansai area, including the business community, in preparation for the "Osaka-Kansai Expo" (Osaka, Kyoto and Hyogo Kobe Consortium, 2023).

2.4 Fukuoka Startup Consortium

Since the "Startup City Declaration" in 2012, Fukuoka City has been supporting startups through public-private collaboration, including the establishment of the Startup Café and Fukuoka Growth Next. The formation of an ecosystem is accelerating, with Kyushu University playing a central role in enhancing entrepreneurial education, independent VC firms playing an active role, large-scale startup events being held, and partnerships with overseas firms being strengthened. By combining national support measures such as National Strategic Special Zones with the city's own measures, the city is providing comprehensive support for startups. The Fukuoka Startup Consortium consists of 74 companies from local governments, universities, organizations, and businesses. The consortium's current goal is to support the growth of startups mainly in the middle to late stages of their development. The formation of the ecosystem is accelerating, with the birth of unicorns and IPOs. Various support programs are being implemented to strengthen the startup ecosystem in order to broaden the scope of entrepreneurial development, create the groundwork for startups to go global, and build a mechanism for Fukuoka and the surrounding community to support them (Fukuoka Startup Consortium, 2023).

2.5 Sapporo and Hokkaido Startup Ecosystem Promotion Council

The startup ecosystem is being formed in cooperation with Obihiro City and other cities, with Sapporo City playing a central role, taking advantage of Hokkaido's strengths, such as its primary industries of agriculture, fisheries, and forestry, and the space industry, which takes advantage of a large demonstration field. By June 2023, there will be 41 organizations promoting ecosystem formation. The fields of business are diverse, including primary industries and environmental energy, but the space business is particularly active, and the "Hokkaido Space Summit," one of the largest space business conferences in Japan, is being expanded and held every year. As a new team to lead the ecosystem, STARTUP CITY SAPPORO has been reorganized as a new organization to create a Hokkaido-wide ecosystem from 2023 (Sapporo and Hokkaido Startup Ecosystem Promotion Council, 2023).

2.6 Sendai Startup Ecosystem Promotion Council

The Sendai Startup Ecosystem Promotion Council aims to create startups that contribute to solving domestic and international problems in the Tohoku region, focusing on Sendai, the "Mecca of Social Innovators," where the number of entrepreneurs who aim to solve social problems has been increasing since the Great East Japan Earthquake. The Sendai Startup Ecosystem Promotion Council is strengthening its support system and information dissemination system, and as a municipality, the mayor of Sendai has visited Silicon Valley and New York City. Tohoku University and other universities are also active in the creation of startup companies (Sendai Startup Ecosystem Promotion Council, 2023a, 2023b).

2.7 Hiroshima Regional Innovation Strategy Promotion Council

The council aims to create innovations that aim to resolve social issues in Hiroshima, a city known worldwide as a city of peace, by taking advantage of its demonstration field where the sea, mountains, and city are in close proximity, and its global recognition as an international city of peace. The project aims to create a successful case study by focusing on the strengths of the region, such as the concentration of manufacturing industries, and the cultivation of technological seeds held by universities, especially in the life science field, and to encourage global challenges (Hiroshima Regional Innovation Strategy Promotion Council, 2023).

2.8 Kitakyushu SDGs Startup Ecosystem Consortium

Kitakyushu City, which has overcome pollution, aims to become an SDGs future city, and aims to create a tech ecosystem city centred on its strengths in the environment, robotics, and DX fields. A total of 60 organizations belong to the Kitakyushu SDGs Startup Ecosystem Consortium. The future vision is to support startups that will drive the future regional economy through collaboration among industry, academia, government, and academia, to produce startups from universities, and to create a manufacturing entrepreneurship area by combining startups with companies in the city (Kitakyushu SDGs Startup Ecosystem Consortium, 2023).

3. Previous Studies

In the previous section, we have reviewed the overview of "Startup Ecosystem Hub City" in Japan, and one of the common features is the existence of startup support facilities. In this section, we will look at the roles and functions of startup support facilities, and outline the discussions that have been held so far based on existing studies. For example, Spigel (2017) uses the term "entrepreneurial ecosystem" instead of "startup ecosystem," categorizes its attributes into three: cultural, social, and physical attributes, and describes startup support facilities (entrepreneurial support organizations in the book) as categorized physical attributes. He then stated that entrepreneurial support facilities strengthen local networks and communities and contribute to the reproduction of a culture that creates and nurtures entrepreneurs. He concluded that physical attributes, including entrepreneurial support facilities, are unlikely to be successful unless they are supported by complementary social and cultural attributes. In analysing trends in startup ecosystem research, including Spigel (2017), Kanama (2022) found that the roles of startup support facilities include providing specialized support to startups at various stages as described by Patton and Kenney (2005) and the influence of startups on the expansion of local social networks as described by Brown and Mawson (2019). For professional support to startups at various stages, it is essential to have experts who are familiar with the common challenges faced by startups, especially in the early stages, to provide appropriate advice to individual startups (Patton & Kenney, 2005). In addition, as for the impact on the region, as startup support facilities actively work to strengthen the social network in the region, other regions may gradually join the network, and local companies that have been reluctant to engage in startup support and open innovation may gradually relax their stance and begin to cooperate (Brown & Mawson, 2019). Kishimoto (2021) classifies the startup ecosystem into two segments, "entrepreneurs/startups" and "support actors," and categorizes startup support facilities into support actors along with universities, research institutions, mature companies, and fund providers such as banks, venture capitalists, and investors. The roles of startup support facilities include business space, training programmes, provision of management support and expertise, and small investments. Kishimoto (2021) used Taiwan as a case study, but according to the "Taiwan Startup Ecosystem Grand Survey" (PwC & TIER, 2021, p. 21) in 2021, 60.3% of domestic startups have ever moved into (used) a startup support facility (including virtual ones). (including virtual), 60.3% of startups in Japan have moved into (used) a nurturing or support organization of a startup support facility. According to Kishimoto (2021), among startup support facilities in Taiwan, institutions called "accelerators" have been relatively active recently, offering short-term intensive training programmes compared to incubators. In Taiwan, the functions of incubators and accelerators partly overlap. Incubators are responsible for raising awareness of entrepreneurship and providing preliminary support to seed-stage teams to help them grow to a certain level by reducing their risk and encouraging them to take advantage of government assistance programmes. Accelerators provide later-stage support for developing markets, including overseas markets, and obtaining large investments. Specifically, many accelerators offer short-term, intensive training programmes for entrepreneurial teams that last a few months, and recent years have seen accelerators positioned as the hub of the startup ecosystem. Specifically, accelerators form networks among entrepreneurs and between entrepreneurs and other support actors, and since each accelerator has its own areas of expertise, startups often move between or work for multiple accelerators and training institutions. As a result, the accelerator has become a crucible for entrepreneurs and support actors to interact, transfer, and collaborate with each other, contributing to the formation of an entrepreneurial community.

While the above shows that the roles and functions of startup support facilities have been discussed and categorized in existing studies, as Kanama (2022) points out, there is room to reconsider the significance of importing best practices focusing on frameworks for forming startup ecosystems, including startup support facilities, from cases in other regions by referring to such categorization. As discussed in Section 1, it may be necessary to not only align a framework for the formation of a startup ecosystem by following the examples of other regions, but also consider the roles required of supporters surrounding startups rather than the roles of individual facilities, such as the role of support actors as suggested by Kishimoto (2021) in the Taiwan case, or the formation of a startup support context that incorporates the unique characteristics of each region as suggested by Sasamori et al. (2022). It may be necessary to consider the roles required of supporters surrounding startups, rather than the roles of individual facilities. In the next section, we will examine two examples of cities where startup supporters have developed and implemented means and paths to realize their goals of creating startups tailored to the local community.

4. Case Studies

4.1 Case Study in Toyohashi City

Toyohashi City, Aichi Prefecture, is located at the southeast end of Aichi Prefecture, with a population of approximately 370,000 and an area of 262km^2. The city has a well-balanced industrial structure, with agriculture boasting the nation's top-class production volume, industry thriving in automobile-related and other one-of-a-kind technology manufacturing, and commerce taking advantage of its favourable location at the Port of Mikawa and transportation hubs. On the other hand, the industrial structure of the region is expected to undergo a major transformation due to the accelerated development of digital technologies such as AI and IoT. Under these circumstances, it is essential for local companies to create innovations, such as entering new business fields and creating new businesses that contribute to business innovation and solving regional issues, while taking advantage of the region's strengths, and a new mechanism to support these activities is needed. In addition, Aichi Prefecture, where the city is located, launched a new industrial promotion policy in 2018 to create the soil for continuous innovation by using startups as a catalyst. In response, the Higashi-Mikawa region, which includes Toyohashi City (the Higashi-Mikawa region consists of eight municipalities: Toyohashi, Toyokawa, Gamagori, Shinshiro, Tahara, Shitara, Toei, and Toyone in Aichi Prefecture), has been discussing ways to utilize Aichi Prefecture's policy to maintain and develop industry and economic vitality in the region with the participation of local economic groups, support organizations, universities, and governments since 2020. As a result, the "Higashi-Mikawa Startup Promotion Council" was established in October 2021, and Toyohashi City has also developed a number of startup support measures centred on the local government and startup support facilities in the city. Toyohashi is also the first partner of STATION Ai, a startup support facility located in Nagoya City, Aichi Prefecture, a "Startup Ecosystem Hub City."

The Higashi-Mikawa Startup Promotion Council defines a startup as "a company and its founder aiming for rapid growth using an innovative business model," as well as "an entrepreneur within a company, a second founder, or a person who tries to solve regional problems through entrepreneurship," who can be a candidate for such a startup, and aims to "create startups from the Higashi-Mikawa region and form a startup ecosystem suited to the Higashi-Mikawa region." The council's three main initiatives are "fostering momentum to promote entrepreneurship and the creation of new businesses," "building a system of cooperation and co-creation among various regions and support groups," and "strengthening information dissemination and PR for the Higashi-Mikawa region as a whole." The council consists of a total of 11 companies, including local governments, economic organizations, educational institutions, and business companies (Table 5.1, as of July 2024).

Under a steering committee, "Higashi Mikawa UPPERS Community," "Higashi-Mikawa Regional Co-Creation Project," "Higashi-Mikawa 8 Municipalities Demonstration Experiment Support Project," "Startup Ecosystem Study," "University Collaboration Project," and "Project of structuring, visualization, information dissemination, and PR to promote Higashi-Mikawa co-creation" are operated (The relevance of each project is shown in Figure 5.1).

Table 5.1 Member of the Higashi-Mikawa Startup Promotion Council

Economic organization	*Higashi-Mikawa Wide-area Economic Federation*
Local government	Toyohashi City
	Higashi-Mikawa Wide-area Union
	Gamagori City (Supporting member)
	Aichi Prefecture (Special member)
Business company	Inochio Holdings, Inc.
	SCIENCE CREATE CO. LTD.
	emCAMPUS Co., Ltd.
	Musashi Seimitsu Industry Co., Ltd.
	MARUSHIME Co., Ltd.
Educational institution	Toyohashi University of Technology

Source: Higashi-Mikawa Startup Promotion Council (n.d.)

Note. Supporting members collaborate in areas of interest.

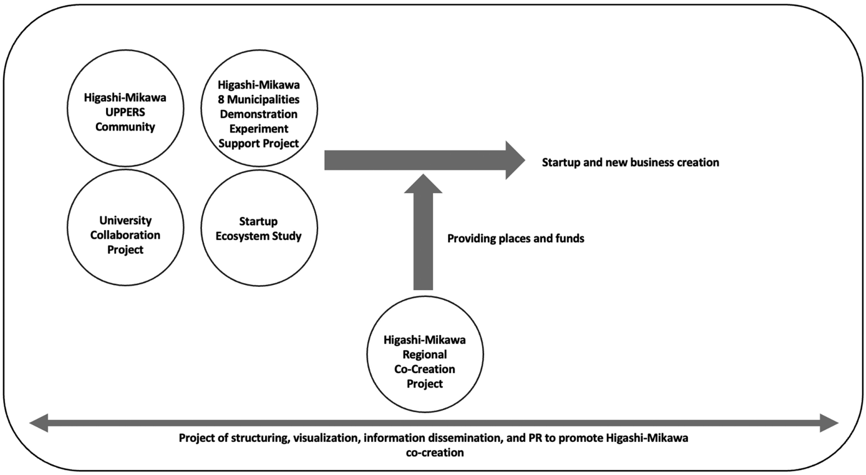

Figure 5.1 Higashi-Mikawa Startup Promotion Council Project correlation chart

Source: Based on eiicon company (2023)

This section describes the "Higashi Mikawa UPPERS Community," the "Higashi-Mikawa Regional Co-Creation Project," and the "Higashi-Mikawa 8 Municipalities Demonstration Experiment Support Project," which provide opportunities for entrepreneurs and entrepreneurs within companies to practice business creation in the Higashi-Mikawa region, and the Higashi-Mikawa Startup Promotion Council, which encompasses all initiatives related to the Higashi-Mikawa Startup Promotion Council.

4.1.1 Opportunities for Entrepreneurs and In-House Entrepreneurs to Practice Business Creation in the Higashi-Mikawa Region

The "Higashi Mikawa UPPERS Community" has three roles: initiator, supporter, and problem provider, and each initiator takes on a project in the span of four months according to his or her phase. Themes include agriculture and food, manufacturing, general regional and social issues, health care, and global issues, with students often serving as initiators. At the start of the project, an event is held to gather friends and expand the circle of sympathy and support. During the four-month activity period, the initiators will conduct surveys and tests of the products and services they envision with potential users, raise funds through crowdfunding, and hold events. In addition, if a location or opportunity for a demonstration experiment becomes necessary, it will be linked to the "Higashi-Mikawa 8 Municipalities Demonstration Experiment Support Project," and if collaboration with a local company becomes necessary, it will be linked to the "Higashi-Mikawa Regional Co-Creation Project."

4.1.2 Initiatives Encompassing All Activities Related to the Higashi-Mikawa Startup Promotion Council

As shown in Table 5.2, the Higashi-Mikawa Startup Promotion Council involves a variety of organizations and companies and conducts a variety of projects, making it difficult to know where to go for advice. In addition, there was room to focus on the dissemination of information on each project. Against this background, a project to visualize and disseminate information has been undertaken as a comprehensive effort encompassing all of the activities of the council. Specifically, the project has listed programs related to each project as well as programs held independently by each support facility, and created and operated an information aggregation sheet to report on the activities of the "Higashi Mikawa UPPERS Community." In addition, an onboarding system has been established and is in operation for new members of the council. In terms of information dissemination, in addition to the use of SNS, the council is collaborating with a local radio station to continue a program that broadcasts interviews with entrepreneurs and entrepreneurs within companies, which not only is broadcast over the radio but also has the effect of being used as a tool to introduce the entrepreneurs themselves by leaving a video of them.

4.1.3 Summary

One of the major characteristics common to the activities of the Higashi-Mikawa Startup Promotion Council is that the members devise the

Table 5.2 Member of the organization promoting the realization of the vision for the formation of a startup ecosystem in Hamamatsu City

Local government	*Hamamatsu City*
Business company (private supporter)	Yamaha Corporation
	SUZUKI MOTOR CORPORATION
	HAMAMATSU PHOTONICS K.K.
	SOMIC MANAGEMENT HOLDINGS INC.
Business company (startup)	LINKWIZ Incorporated
	ANSeeN Inc.
Educational institution	National University Corporation Shizuoka University
	Hamamatsu University School of Medicine
	The Graduate School for the Creation of New Photonics Industries
Support institution	THE SHIZUOKA BANK, LTD.
	HAMAMATSU IWATA SHINKIN BANK
	The Hamamatsu Chamber of Commerce and Industry
	Hamamatsu Agency for Innovation
	JETRO Hamamatsu

Source: Startup Promotion Division, Industry Department, Hamamatsu City (2023) objectives of each project and the method of proceeding, and then work on them themselves while repeatedly brushing up the scheme of each project. The organization has also developed an onboarding mechanism that can respond to increases in membership and turnover in members, thereby enhancing the continuity of the organization and the autonomy of its members. In addition, the efforts described in the latter half of this section are not limited to the centralized management of information and the strengthening of information dissemination, but are also considered to be the key to increasing membership and involving local businesses. The most important thing is that the members of the steering committee, in other words, people in the community, are responsible for these efforts. In addition, since the members of the steering committee work on multiple projects at the same time, it is thought that the negative effects of vertical division of labour have been reduced.

4.2 Case Study in Hamamatsu City

Hamamatsu City is located in the western part of Shizuoka Prefecture, with a population of approximately 800,000 and a city area of 1,558 km^2. The city is a microcosm of Japan, with an urban area that has a high concentration of urban functions and advanced technology industries, a plain area with flourishing suburban agriculture, a coastal area blessed with abundant marine resources, and a mountainous area with vast forests. Hamamatsu City has a long history of municipality-led support for startups. Support measures are organized in five areas: people and technology, goods, capital, information, and general, and include the "Hamamatsu Fund Support Project," "Hamamatsu Support Project for Demonstration Experiment," and "Satellite Office Operations."

Since Hamamatsu was selected as a "Startup Ecosystem Hub City" in July 2020, the Hamamatsu Startup Strategy Promotion Council (Table 5.2) has been working on the project.

The vision for the formation of the ecosystem is to fuse startup ideas and manufacturing technologies to create a succession of innovations that will lead to the sustainable development of the local economy and to accelerate the growth of startup businesses around the world through the ecosystem in the future, thereby becoming a "manufacturing startup hub" in Japan. Some of the activities to realize the vision were established after the selection of the "Startup Ecosystem Hub City," while others have been continued and expanded since before the selection. The following describes the "Startup Growth Support Project" and "Next Innovator Fostering Project," which were established after the selection of the "Startup Ecosystem Hub City," and the "Hamamatsu Fund Support Project," "Hamamatsu Support Project for Demonstration Experiment," and "'Monozukuri x Startup' Innovation Creation Promotion Project," which were continued and expanded before the selection of the "Startup Ecosystem Hub City."

4.2.1 Support for Pre-Startup and Seed Phase Startups

The "Startup Growth Support Project" has been in operation since 2022, providing startups in the city with the knowledge and know-how necessary for each phase of their business growth, as well as regular consultations and mentoring by venture capitalists and other experts.

The "Next Innovator Fostering Project," which began in 2021, provides mentoring by a team of experienced mentors and a variety of entrepreneurial support services to people who aspire to start their own businesses, startup managers who have just started their own businesses, and entrepreneurs within companies who want to grow their businesses. Three companies were selected in FY2022, and two of them achieved their first round of funding.

4.2.2 Support for Startups Expected to Grow After the Seed Phase

The "Hamamatsu Fund Support Project" has been in operation since 2019 and has attracted attention as a rare startup support programme by a municipality in Japan, under which Hamamatsu City-approved venture capital invests in startups, and Hamamatsu City also provides grants to the same startups (Figure 5.2). The maximum grant amount is 10 million yen for startups that have been in business for five years or less, half of the total project cost; 40 million yen for general startups with no restrictions on the number of years in business; and million yen for startups that are engaged in open innovation with companies in the city (as of FY2023).

The "Hamamatsu Support Project for Demonstration Experiment" provides a field, coordinates with related parties, recruits monitors, and matches

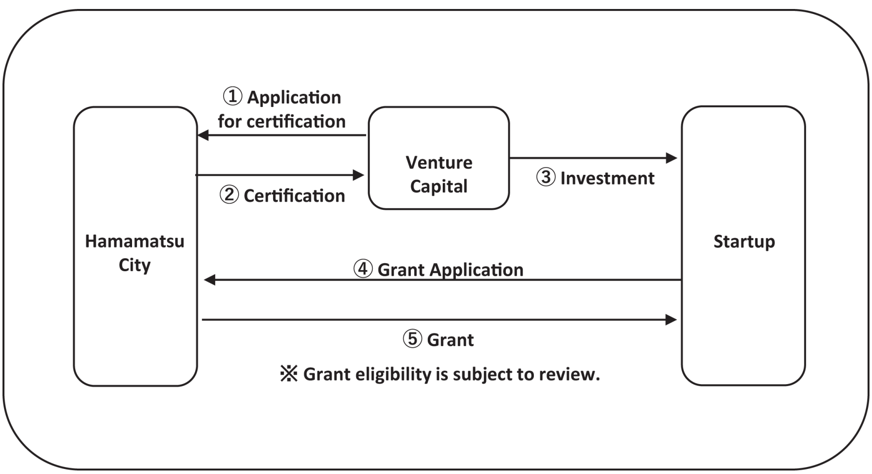

Figure 5.2 Structure of the "Hamamatsu Fund Support Project"

Source: Based on Startup Promotion Division, Industry Department, Hamamatsu City (2023)

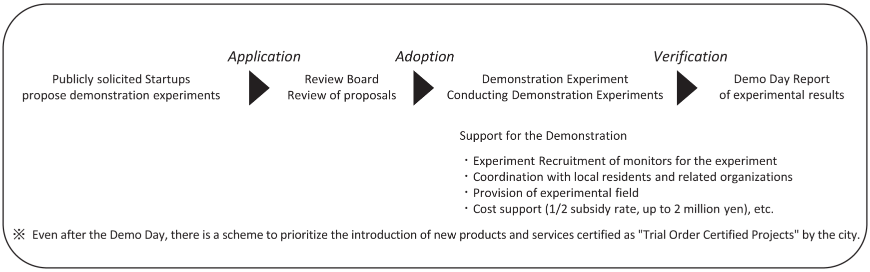

Figure 5.3 Structure of the "Hamamatsu Support Project for Demonstration Experiment"
Source: Based on Startup Promotion Division, Industry Department, Hamamatsu City (2023)

them with companies, creating an environment that makes it easier for startups to conduct demonstration experiments (Figure 5.3). In FY2024, in collaboration with the neighbouring cities of Kosai and Fukuroi, the company is soliciting proposals for demonstration experiments of products and services to solve social issues in each city. Through the "Hamamatsu Fund Support Project" and the "Hamamatsu Support Project for Demonstration Experiment," the number of startups per year has increased from 1 or 2 to 15 or 20, and the amount of equity financing has expanded to five billion yen per year in some cases (Ishin Co., Ltd., 2024).

The "'Monozukuri x Startup' Innovation Creation Promotion Project" aims to create a model case of innovation by fusing the technologies of manufacturing companies in the city with innovative technologies and ideas from startups across the country. The startups provide ideas and services, local manufacturing companies provide management resources such as technology and funds, and Hamamatsu City provides a platform. This project is a part of the Hamamatsu Valley Concept proposed in 2016, which aims to create a chain of innovation by fusing the excellent manufacturing technologies of small and medium-sized companies in the city with innovative technologies and ideas of venture companies to create a new core industry following the transportation equipment industry. However, the lack of manufacturing know-how and mismatches between startups with innovative technologies and ideas and their manufacturing partners have hindered the development of prototypes, mass production, and commercialization. In FY2022, five projects were adopted.

4.2.3 Summary

This strong support was made possible through the efforts of the city's former mayor, who had his own entrepreneurial experience and a desire to revitalize the city's growth in manufacturing. For local government officials, especially before the selection of a "Startup Ecosystem Hub City" and at the beginning of various initiatives, there were many problems and a lack of response.

However, the key to success, they recall, was to continue. Although not mentioned here, the city's efforts were supported in large part by the fact that many companies were proactive in creating new businesses that were not limited to existing businesses as the social environment changed, especially in a region that had developed in the automobile-related manufacturing industry. This is an example of a local government taking the lead in developing a variety of non-borrowed measures over the course of several years to realize a vision of synergistic enhancement of existing and emerging companies by setting manufacturing as the axis of the project.

4.3 Discussion

The two cases discussed in this section show that what is important in the formation of a startup ecosystem is the development of roles and functions rather than the development of elements. At first glance, the attractiveness of the startup ecosystem seems how fulfilled the elements, such as local governments, universities, venture capitalists, and support organizations, are, which positively influence the increase of startups and entrepreneurs. However, as Spigel (2017) states, it is not enough for startup support facilities and other support actors to exist on their own; they must be supported by social and cultural attributes. More to the point, what is much more important is whether or not each of these elements fulfils its required role and function. Conversely, if such roles and functions can be fulfilled, the form of each element does not need to be questioned. From the case study of Toyohashi City, the council operated by various organizations including startup support facilities, rather than startup support facilities alone, has realized comprehensive startup support as a region. In the case of Hamamatsu City, the city achieved this through collaboration with a venture capital firm, which would have been difficult for the local government alone to provide financial support to the startups. The roles and functions required of startup support actors are not something that can be separated within the framework of local governments, universities, venture capitalists, and support organizations. Rather, they should be fulfilled by a complex of loosely interconnected organizations. Also, in the "Startup Ecosystem Hub City" described in Section 2, it is necessary to reconsider that each city has different conditions and draw a picture of startup support that reflects the unique conditions and characteristics of each region, and to go through the process of finding a roadmap and means to realize it. The cases of Toyohashi and Hamamatsu suggest that the common feature of startup support in the two cities is intrinsic motivation. What the two regions have in common is that they have both been internally driven efforts. Both regions have worked to create and expand startup ecosystems that fit the characteristics of their regions, with local government officials and corporate employees taking the initiative, although they have also relied on professionals in the field of startup support as needed. This suggests the importance of finding a way to support startups in each region that is not bound by conventional frameworks while referring to examples from other regions, and such intrinsic motivation is considered to be one of the elements necessary for the formation of a startup ecosystem that guarantees regional characteristics, as pointed out by Sasamori et al. (2022). Furthermore, in the context of the spillover effects on local firms pointed out by Brown and Mawson (2019) in the previous section, it is also significant for players in the region to serve as support actors. In addition, the role of such support actors has the potential to be read as that of "innovation intermediaries" (Howells, 2006; Stewart & Hyysalo, 2008). This point requires further analysis through ongoing case studies.

5. Conclusion

This chapter attempts to analyse the roles and functions needed to support startups through case studies on the creation of startups and efforts to support them in two cities. The case studies suggest that it is important for supporters of startups to have a goal of creating startups suited to the region, and to develop and implement the means and paths to realize that goal. Further research will be conducted on an ongoing basis to deepen our consideration of the role of support actors necessary for the formation of a startup ecosystem that leads to the solution of social issues and the growth of the local economy.

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Section 3

Society

Smart and sustainable cities are vital for enhancing the quality of life for **society**. They leverage advanced technologies to optimize infrastructure, reduce environmental impact, and improve urban services. These cities promote social equity by ensuring accessible public services and fostering community engagement. They drive economic growth by attracting businesses and fostering innovation. They enhance resilience against environmental and societal challenges through efficient resource management and proactive planning.

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6 Exploring the Growth of Sustainable Homes and Sustainability

A Review

Ananya Mishra and Pradeep Kautish

1. Introduction

Sustainability can be defined as a state in which society does not undermine both the natural and social systems. This means that the organic method is not vulnerable due to the exhaustion of resources, excessive usage, dangerous materials, and associated hazards to the environment, and – perhaps more importantly – the social system is not putting people in situations that limit their capacity to fulfil their goals and requirements. Contamination, environmental deterioration, environmental neglect, declining well-being, societal unrest, inequality, and social hazards can undermine natural and social systems (Bibri & Krogstie, 2017). According to Singh et al. (2009), "The goal is to support decision-makers in the sustainability assessment process and decide which actions, if any, to assess integrated nature-society systems in order to make society sustainable from a short-and-long-term perspective on a global to local level." Preserving prosperous living for a long time, possibly even forever, becomes the definition of sustainability (Kuhlman & Farrington, 2010). This primarily addresses the environmental aspects of the triple bottom line; nevertheless, sustainability and the environment are not the same thing. While many forms of air and water pollution are currently exceedingly toxic, other forms of environmental deterioration are relatively readily remedied. These have a significant focus on well-being (Wilderer, 2007). Consumer concern over sustainability is expanding, as evidenced by the rise in initiatives with a significant green marketing focus and the increase in the availability of environmentally friendly products, or "green products." This is a new difficulty for businesses (Gomes et al., 2023).

Organizations focusing on sustainability attempt to strike a balance between achieving positive financial outcomes and their activities' effects on society and the environment. Achieving sustainable social, environmental, and economic objectives simultaneously is one of the largest problems in sustainability (Winnard et al., 2018). To put it differently, the goals of sustainable organizations are to "maintain ethical capital, enhance human capital, restore natural capital, and improve negative and positive impacts of activities" (Argento et al., 2022).

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The transformation and tactical methodology, known as sustainable development, aims to accomplish sustainability's long-term objectives, including a stabilized ecological and sociocultural system. It has arisen as a worldwide reaction to the growing social injustices and inequalities and the environmental disasters brought on by human activity (Bibri & Krogstie, 2017). A major social objective, sustainable development aims to stop environmental damage and enhance personal well-being. Numerous studies consider it a route towards social, economic, and environmental progress (White et al., 2019). As customers' concerns about sustainability grow, more businesses focus on the Sustainable Development Goals (SDGs), which drive the global sustainability movement (Gonzalez-Arcos et al., 2021). The movement also led to the adoption of the 2015 SDGs, intended to serve as a common structure for businesses to show how their manufacturing influences the surroundings, the economy, and society (Hák et al., 2016). The SDGs are a set of global objectives, metrics, and targets that all United Nations members must use by 2030 to guide their agendas and actions (Foroudi et al., 2022).

The environmental aspects prioritize protecting natural resources and encouraging responsible production and use. The SDGs emphasize this point through affordable and clean energy consumption (SDG 7) or responsible production and consumption (SDG 12) (Monteiro et al., 2021). The social dimension emphasizes issues related to community relations and motivates businesses to engage in altruistic endeavours. It also supports diversity, education, social/community health and wellness (SDG 3), and gender equity (SDG 5) in the nation of operations. Lastly, the economic dimension is based on increasing infrastructure and economic development, which can raise living standards by creating jobs and strengthening business performance through creative approaches. Sustainable industrialization (SDG 9) and sustainable economic growth (SDG 8) are included in the associated SDG (Montiel et al., 2019). To allocate more resources to their SDG-related initiatives, businesses must ascertain which of these initiatives are most positively viewed by consumers.

With individual spending rising in tandem, it is hard to argue against the non-sustainable character of continuous worldwide economic expansion (Singh et al., 2009). To increase the environmental sustainability of cities and other residential areas, promoting more sustainable lifestyles to diminish the detrimental impacts of consumption on the surroundings is a rarely used tactic (Nikezić et al., 2021).

A sustainable, developed urban environment city is planned to promote long-term improvements in social equity, quality, preservation of the environment, and human well-being. This can be achieved by implementing sustainable development methods that promote innovation and developments in planning, operational functioning, infrastructure, the built environment, the ecosystem, and the provision of human services while consistently optimizing productive gains. This means advancing social justice, safety, and stability while systematically reducing the adverse effects of heavy energy use on the environment (Angelidou, 2015). There are two primary methods for sustainable cities: the ICT-focused strategy and the people-focused strategy. There are specific sustainable city strategies that emphasize the use of ICT to improve the ability and technological advancements of hard infrastructure and transportation, energy, communication, wastewater, and so on, and strategies that emphasize people and social capital – that is, knowledge, participation, equity, safety, and other aspects of social and human capital (Ahvenniemi et al., 2017).

Today's urban scholars, planners, and policymakers are paying close attention to smart sustainable urban development. The emergence of ICT industry consortia, collaborative research institutes, and policy networks in terms of techno-urban innovation, not least in ecologically and technologically advanced nations, is shaping and influencing its insertion, functioning, and evolution as a discourse and social practice (Etzkowitz & Leydesdorff, 2000).

2. Methodology

This study employed a hybrid methodology to comprehend the development considering the increasing trend of studies on sustainable smart homes, integrating bibliometric analysis and content analysis of the most important articles in previous studies (see Figure 6.1 and 2024). The first phase's bibliometric analysis is logical because it provides readers with a quick and

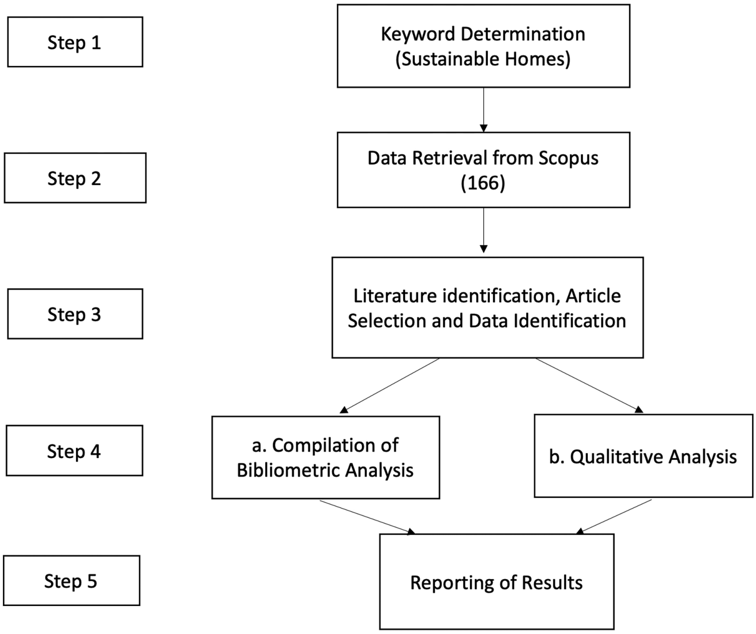

Figure 6.1 Methodological approach to analysis and data retrieval

straightforward way to gain a broad overview of the subject they want to study. In our work, we attempt to communicate these numbers and thoroughly comprehend the annual publication patterns in several categories. Data extraction from previous investigations is essential to this investigation; thereafter, it builds the data upon which the results are predicted. Consequently, much care was taken in choosing the database and literature search approach. Information from Scopus, one of the most significant academic databases, was used to establish the research's conclusions. Pre-testing the search across multiple databases to identify which were most relevant to this study's objectives confirmed a thorough and representative literature discussion. Using keywords, the bibliographic data was extracted based on the databases. The study's approach included a bibliometric analysis and a methodical assessment of the literature combined, and the literature search was conducted between 2000.

This study is divided into two main stages.

2.1 Determination of Keywords

Our next objective was to select and complete a collection of keywords to strengthen the keyword set. Next, we searched Scopus for the initial terms. We ultimately decided on the phrase "sustainable homes and sustainability" in light of these findings.

2.2 Literature Identification

We chose Scopus because of its extensive collection of publications from multiple academic disciplines, including those related to sustainable homes. Scopus also provided a robust method of filtering, which helped in the initial selection of relevant articles. We conducted two literature studies as a result of this procedure. The research's bibliographic data was assembled, comprising the published journal, the year of publication, the context of the country studied, leading authors, publishers, and funding sources. The summary of this investigation is provided by the bibliometric profile, which illustrates trends found in the literature. Second, we examined the papers with the most citations through a qualitative content analysis. The first 166 articles referencing "sustainable homes and sustainability" were found using Scopus.

3. Results and Analysis

This section presents the bibliometric analysis of the data sourced within sustainable homes and sustainability. It includes year-wise growth, country analysis, types of documents, leading journals, top affiliations, top subject areas, top authors, top publishers, top funding agencies, and influential aspects of journals and authors.

3.1 Year-wise Growth

Analysing the writers' contributions to this subject using publications was crucial to comprehend the work being done in sustainable homes. The data unequivocally demonstrate that, on average, from 2000 to 2013, there were fewer research publications in the output; the only exceptions were in 2000, 2004, and 2005, when there were none. Additionally, from 2018 to 2023, a significant increase in effort was made in this field compared to the previous five years. Publications in the sustainable home domains have generally been trending upward. Figure 6.2 depicts this expansionary pattern.

3.2 Country Analysis

Analysing the principal sources of interest in the search for sustainable homes is necessary to comprehend the role of nations. The top 10 nations and their input to the study field were discovered through a search of the subject and a comparison with the authors' origin nations. Table 6.1 presents a ranking of the top 10 countries. The number of publications indicates that the United States, Australia, China, Germany, and Canada are the leading countries responsible for the field's recent rapid expansion, followed by the United Kingdom, South Korea, Spain, Italy, and India. According to Scopus publications on sustainable homes, the United States dominates research in this area. The results unequivocally demonstrate that wealthy nations are greatly improving sustainable home research. This illustrates the need for the study within the framework of developed countries to have a more complete view of the current state of affairs.

3.3 Type of Documents

This field of research has benefited from the contributions of numerous authors (Table 6.2). Most of the contributions have been made in the form

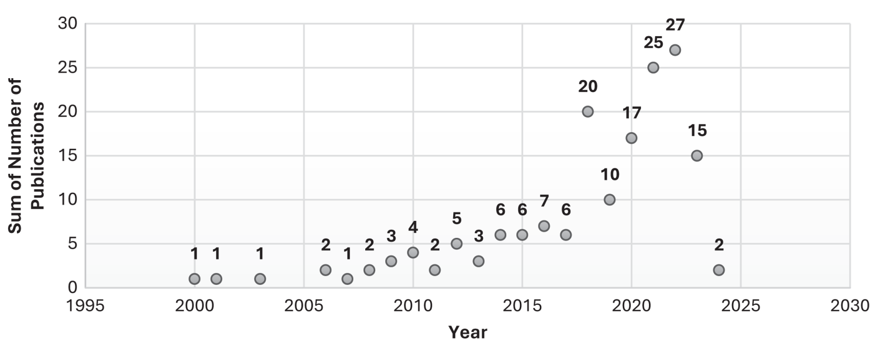

Figure 6.2 Development trend in sustainable homes (published in Scopus)

Table 6.1 Top 10 contributing countries

Country	*Publications*
United States	26
Australia	25
China	16
Germany	14
Canada	11
United Kingdom	11
South Korea	10
Spain	10
Italy	7
India	6

Table 6.2 Essential aspects of the study

Stage I	Bibliometric, evaluation of 166 papers from, Scopus
Stage II	Content analysis was conducted to analyse the extensively referenced study

of sustainable homes articles in Scopus. The additional publications include book chapters, editorial materials, papers from conference proceedings, and review articles.

3.4 Leading Journals

Table 6.3 lists the top journals and the total articles for each. The major journal in this sector, *Sustainability Switzerland*, contributes approximately 43 papers, surpassing other publications. The journal in second place, *Journal of Cleaner Production*, makes a significant contribution with 18 publications. The next three journals in line are *Sustainable Cities and Society*, *Journal of Green Building*, and *Land Use Policy*, with contributions of eight, five, and four publications, respectively. The following journals each have a similar number of articles. These include *Textile Outlook International* with four publications, *Energy for Sustainable Development* with three publications, *Smart and Sustainable Built Environment* with three publications, *Applied Ergonomics* with two publications, and *Building and Environment* with two publications.

3.5 Top Affiliations

The University of Technology Sydney, Australia, has produced the greatest number of articles in this field, with six publications, and the top five institutions that contribute are indicated in Table 6.4. It is swiftly succeeded by the Technical University Berlin, Germany, with four publications; Universiti Kebangsaan Malaysia, Malaysia; the University of Bonn, Germany; and

Table 6.3 Top journals

Journals	*Sustainable homes*
Sustainability Switzerland	43
Journal of Cleaner Production	18
Sustainable Cities and Society	8
Journal of Green Building	5
Land Use Policy	4
Textile Outlook International	4
Energy for Sustainable Development	3
Smart and Sustainable Built Environment	3
Applied Ergonomics	2
Building and Environment	2

Table 6.4 Top affiliations

Affiliations	*No. of documents*	*Country*
University of Technology Sydney	6	Australia
Technical University Berlin	4	Berlin
Universiti Kebangsaan Malaysia	3	Malaysia
University of Bonn	3	Germany
Chung-Ang University	3	South Korea

Chung-Ang University, South Korea, all with three publications. These results highlight the importance of identifying the universities, institutions, and organizations that contribute most to the advancement of sustainable homes.

3.6 Top Subject Area

Although many subject areas are related to the study of sustainable homes, from Scopus databases, the top five domains have been selected by a topic area analysis. The social sciences have been the focus of the majority of studies, as seen in the rankings for these top categories. Then come environmental science, energy, engineering, business, management, and accounting. Additionally, it has been noted that some studies have been conducted in fields like computer science, economics, econometrics and finance, medicine, decision sciences, earth and planetary sciences and so on, among others.

3.7 Top Authors

The findings pinpointed the top authors who have significantly impacted the domain of sustainable homes. The recognition of authors contributes to better knowledge of other researchers with respect to the creation of the majority

Table 6.5 Leading authors

Authors	*No. of documents*	*Author's h-index*	*Affiliation*
Nina Langen	4	14	Technische Universität Berlin, Berlin, Germany
Elizabeth Agyeiwaah	2	18	The University of Queensland, Brisbane, Australia
Katrin Bienge	2	10	Wuppertal Institut für Klima, Umwelt, Energie, Wuppertal, Germany
Jessica K. Breadsell	2	9	Curtin University, Perth, Australia
Josh Byrne	2	9	Curtin University, Perth, Australia

of the literature. The authors and their affiliations are shown in Table 6.5. Elizabeth Agyeiwaah (two publications) and Nina Langen (four publications) round out the top list of writers who have made significant contributions to research focused on sustainable homes. Following these two authors are Katrin Bienge, Jessica K. Breadsell, and Josh Byrne, who have also each contributed two documents.

3.8 Top Publishers

Since publishers are important in the reproduction and dissemination of knowledge to a larger audience, this detail serves as a guide for publishers interested in publishing works on the subject. Elsevier Netherlands has emerged as the most prominent publisher with 44 papers; the list of publishers is shown in Table 6.6. The next notable publisher is MDPI Switzerland, with 39 publications, and the third publisher is Springer, Germany, with six publications. There are five documents each from John Wiley and Sons Ltd. in the United States and Emerald Publishing in England.

3.9 Top Funding Agencies

The funding organizations are essential to the advancement of research in all fields of study. Therefore, identifying these organizations is crucial to providing future researchers with information about possible funding sources. The top five funding organizations that have contributed to the studies in the domain of sustainable homes are shown in Table 6.7. With six grants to researchers, the National Natural Science Foundation of China has emerged as the leader. The Federal Ministry of Education and Research, Germany, comes in second place with four financings, followed by the Spanish agency State Research Agency and the Brazilian organization Coordination for the Improvement of Higher Education Personnel, each with three fundings for research projects. Two funds are from the China Postdoctoral Science Foundation.

Table 6.6 Leading publishers of articles

Top five publishers	*No. of documents*	*Country*
Elsevier	44	Netherlands
MDPI	39	Switzerland
Springer	6	Germany
Emerald Publishing	5	England
John Wiley and Sons Ltd.	5	United States

Table 6.7 Top funding agencies

Top funding agencies	*No. of documents*	*Country*
National Natural Science Foundation of China,	6	China,
The Federal Ministry of Education and Research,	4	Germany,
State Research, Agency	3	Spanish
Coordination for the Improvement of Higher Education Personnel	3	Brazil,
China Postdoctoral Science Foundation	2	China

3.10 Influential Aspects of Sustainable Homes and Sustainability

3.10.1 Influential Journals and Authors

A journal's production volume is a good indicator of its efficacy, but its citation count tells us more about its impact and influence. Citation count measures how frequently a specific article is cited by other publications, providing insight into its impact, prominence, and popularity (Merigó et al., 2015). Therefore, in a given subject domain, citation analysis is frequently employed to determine which journals, papers, and authors have the greatest influence (Verma et al., 2023). The list of the most referenced periodicals may be seen in Tables 6.8 and 6.9. We have also computed the average citation per article to analyze the most referenced journals and authors with larger publications that have higher citation counts. We used VOS viewer to find eminent journals and authors. Based on the total papers, citations per year, and citations, we determine the top 10 journals and five authors. Table 6.8 lists the most prominent journals. These include the following: Sustainability (Switzerland), Journal of Cleaner Production, Sustainable Cities and Society, Journal of Green Building, Land Use Policy, Textile Outlook International, Smart and Sustainable Built Environment, Energy for Sustainable Development, Building and Environment, and Journal of Sustainable Tourism. The majority of studies on smart cities and sustainability have been published in these journals.

Based on the total number of publications, citations, and average number of citations per paper, we identify the most influential authors, which are shown in Table 6.9.

Table 6.8 Top influential journals

Panel A

Ranks	*Journal*	*No. of papers*
1	Sustainability (Switzerland)	43
2	Journal of Cleaner Production	18
3	Sustainable Cities and Society	8
4	Journal of Green Building	5
5	Land Use Policy	4
6	Textile Outlook International	4
7	Smart and Sustainable Built Environment	3
8	Energy for Sustainable Development	3
9	Building and Environment	2
10	Journal of Sustainable Tourism	2

Panel B

Ranks	*Journal*	*No. of citations*
1	Sustainability (Switzerland)	487
2	Journal of Cleaner Production	474
3	Sustainable Cities and Society	135
4	Land Use Policy	133
5	Energy for Sustainable Development	82
6	Smart and Sustainable Built Environment	43
7	Journal of Sustainable Tourism	38
8	Journal of Green Building	28
9	Building and Environment	12
10	Textile Outlook International	2

Panel C

Ranks	*Journal*	*No. of cites per document*
1	Land Use Policy	33.25
2	Energy for Sustainable Development	27.33
3	Journal of Cleaner Production	26.33
4	Journal of Sustainable Tourism	19
5	Sustainable Cities and Society	16.87
6	Smart and Sustainable Built Environment	14.33
7	Sustainability (Switzerland)	11.32
8	Building and Environment	6
9	Journal of Green Building	5.6
10	Textile Outlook International	0.5

4. Keyword Analysis Using VOS Visualization Software

A graphic presented shows a network visualization of keywords using a VOS viewer. Each node represents a different keyword in this graphic representation, and the size of the node indicates how often or how many times that specific keyword appears. The connections between nodes represent terms that occur together or the existence of two or more keywords at the same time; the frequency of these occurrences is indicated by the thickness of these

Table 6.9 Top influential authors

Panel A		
Ranks	Authors	*No. of papers*
1	Nina Langen	4
2	María Victoria de-la-Fuente-Aragón	2
3	Lorenzo Ros-McDonnell	2
4	Norina Szander	2
5	Robert Vodopivec	2
Panel B		
Ranks	*Authors*	*No. of citations*
1	Nina Langen	75
2	María Victoria de-la-Fuente-Aragón	8
3	Lorenzo Ros-McDonnell	8
4	Norina Szander	8
5	Robert Vodopivec	8
Panel C		
Ranks	*Authors*	*No. of cites per document*
1	Nina Langen	18.75
2	María Victoria de-la-Fuente-Aragón	4
3	Lorenzo Ros-McDonnell	4
4	Norina Szander	4
5	Robert Vodopivec	4

connections. The larger nodes indicate a higher occurrence of the associated term. The size of the nodes is directly correlated with the frequency of the keyword. In a similar vein, the frequency of co-occurrences is reflected in the thickness of the links between nodes; larger links indicate a higher frequency of simultaneous keyword appearances. Colours are used to identify different clusters, and studying the nodes and linkages inside each cluster reveals information about the subjects covered and how they relate to one another.

The figures' co-occurrence network diagram illustrates the connection among the various keywords and themes. The themes are represented by the more noticeable nodes, while keywords are represented by the smaller nodes that link the themes. There is an inverse relationship between co-occurrence and node distance, which means that the more the co-occurrence, the shorter the distance. The size of the node shows how often a keyword appears (Ha, 2023).

Looking at Figure 6.3, it's clear that some terms stand out more than others; these include "sustainable consumption," "sustainability," and "intelligent building." This observation suggests that the writers have used particular terms the most in their research.

Theme one, with red, had papers with keywords such as "sustainable development" as primary keywords. These were primarily associated with other keywords like "sustainability," "carbon," "quality of life," "nutrition," "land

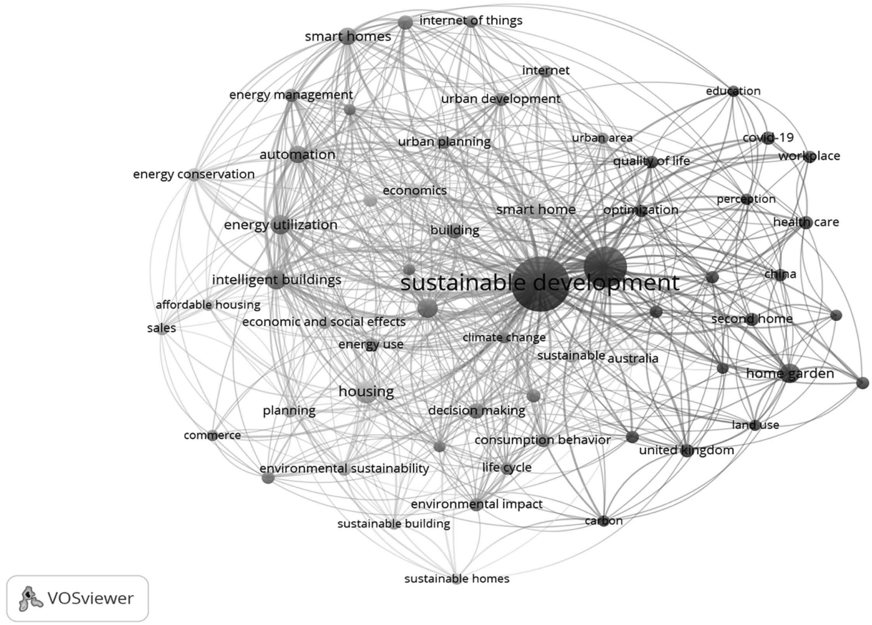

Figure 6.3 Keyword analysis

use," "home garden," "residential development," and "education." The keywords used together talk about residential development by focusing on quality of life, taking into consideration sustainable development and sustainability by reducing carbon usage, which is not harmful to the environment and people.

Theme two, with green, with keywords "intelligent buildings," has been used with keywords such as "urban development," "energy management," "smart homes," "automation," "internet of things," "urban planning," and "urban areas." These focus on urban development by using the internet so that energy can be managed appropriately.

Theme three, with blue, has keywords "energy efficiency," "energy use," "decision making," "consumption behavior," "environmental impact," "climate change," "environmental," "environmental management," and "life cycle."

Theme four, with yellow, has keywords "energy conservation," "sales," "planning," "economics," "economic and social effects," and "sustainable development goals."

Theme five, with purple, with keywords "sustainable homes," "sustainable building," "sustainable," "smart homes," "housing," and "environmental sustainability." These keywords have been used to focus mainly on smart housing while keeping the welfare of environmental sustainability a top priority.

5. Content Analysis

This section provides the content analysis for 166 papers which have been divided into five broad themes in which most studies have been done so far. The themes have been identified from the keyword analysis (Figure 6.3): need for home garden; urban development using Internet of Things (IoT); environment-related; effect of not adapting sustainable home practices; sustainable home practices. Most of the papers out of 166 in the year 2000 to 2024 are from these themes only.

5.1 Need for Home Garden

The study has been done for various countries, from Barcelona, Spain, and Poland, to examine how tourism affects cities and residential areas (Miszewska et al., 2023). The past research has focused on the significance of social sustainability and pertinent policies. Along with suggestions for promoting sustainable practices, the factors impacting households' sustainable food waste disposal behaviours have also been looked at. The relationship between migration and tourism, specifically second-home travel, has also been explored (Ericsson et al., 2022). Additionally, the COVID-19 pandemic's consequences on consumer behaviour – including meal replacements prepared at home – are examined, and recommendations for sustainable consumption practices are made. The application of sustainable land management techniques and the trade-offs associated with creating diets for nursing homes that are both sufficiently nutrient-dense and environmentally responsible are also taken into account (Musvoto et al., 2022). According to research on traditional home gardens and rural livelihoods, well-managed home gardens can enhance people's quality of life and means of subsistence, lower rates of poverty, and promote long-term, sustainable economic growth. The potential of home gardens in preserving valuable plants is demonstrated by the large collections of plant biodiversity found in some of them (Hale, 2018).

5.2 Urban Development Using IoT

The idea of the Family Business Garden is justified by the experience in the Western Province of Sri Lanka, which shows how to live with limited urban infrastructure amenities, environmental circumstances, and socioeconomic problems. The concept, which strikes a good balance between environmental and commercial agricultural concerns, opens the door to producing for markets under liberalized economies as well as meeting family food needs. It does this by encouraging agro-entrepreneurship and attempts to develop social capital in urban areas (Ranasinghe, 2003). The rapid growth of urban populations and technology has resulted in an increase in energy consumption, particularly in the production of electricity. However, there are barriers to meeting energy needs, such as monetary, technological, and ecological constraints. One approach to solving these issues is to use Home Energy Management Systems (HEMS), which are driven by the IoT and optimize energy usage by controlling household appliances. The Grey Wolf and Crow Search Optimization method (GWCSOA), a cutting-edge method that minimizes peak-to-average ratio, increases customer satisfaction, and reduces power costs, enhances HEMS performance (Huang & Jin, 2024). Furthermore, the process of digitalization has consequences for sustainability objectives, which are assessed using the digitainability assessment framework (DAF) to gauge how digital interventions affect the SDGs (Gupta et al., 2023). E-commerce requires sustainability as well, and urban agriculture helps create a sustainable food chain. Opportunities for sustainable mobility through telework and digital technologies are presented by the COVID-19 pandemic (Song et al., 2022). It also emphasizes the significance of knowledge and behaviours in sustainable practices, together with social and environmental externalities. Addressed are several sustainability-related possibilities and difficulties, including supply chain management, route optimization, and sustainable living (Singh et al., 2021). To accomplish sustainable practices and goals, these studies highlight how crucial it is to integrate sustainability objectives across several industries.

5.3 Environment Related

According to the literature, changes in consumer behaviour and economic growth have led to a rise in worldwide energy demand despite energy efficiency initiatives. Nudging is one of the behavioural strategies being studied to encourage sustainable choices. After testing, it was discovered that digital nudges in smart home applications may encourage energy conservation, and consumer preferences for longer-lasting products were motivated more by self-interest than by environmental considerations. Good opinions towards product longevity are enhanced by biospheric values. It has been established that energy affordability acts as a moderator between substandard housing and health (Jacobs, 2023). A study on automated technologies and renewable energy systems made clear how crucial it is to include social theories in the construction of energy-efficient buildings (Patchell & Hayter, 2021). Scholars are investigating how environmental benevolence and being exposed to information about sustainability can impact the uptake of sustainable technologies, like Residential Energy Management Information Systems (REMIS) (Yew et al., 2022). Studies on the effects of remote and office workers' and seniors' acceptance of sustainable technology use have been spurred by the COVID-19 epidemic. Healthcare workers in assisted living facilities for the elderly have also been impacted by the health crises (Martínez-López et al., 2021). Based on wireless sensor networks, a sustainable data analysis approach for intelligent cities is put forth. Fostering corporate social responsibility and designating a unique class of "Recognized Sustainable Investors" are two ways to boost foreign direct investment (FDI) for sustainable development.

Examined were the viability of solar mini-grids from an economic standpoint as well as the impact of domestic and international shareholders on environmental initiatives taken by businesses (Chance, 2009).

The link between the development of new products and the sustainable performance of small and medium-sized manufacturing businesses (SMMEs) in Asian nations was investigated. An assessment of the environmental impact of tapas meals in a Spanish restaurant brought attention to the advantages of switching to plant-based diets (Batlle-Bayer et al., 2020). In developing nations, it has been discovered that product quality plays a significant role in the shift to cleaner energy technology. There was a discussion of creative business plans and approaches to service design for home energy management systems (McGill et al., 2015). A review was conducted on the sustainability of meals served by the outside caterer industry, with a focus on how recipe adjustments could lower carbon and material footprints (Weinberger, 2013). With an emphasis on Canadian mining corporations, the debate centred on the role that home governments play in regulating foreign investors in extractive industries. The significance of routine household activities in connection to sustainability was also underlined by the study. Finally, a comparison of two Net Zero Energy homes in the US was conducted, emphasizing the necessity for thorough measurements to support sustainable residential design.

5.4 Effect of Not Adapting Sustainable Home Practices

Residential automation and energy management systems aim to reduce energy consumption by aligning with human behaviour. Energy-efficient buildings face limitations, leading to a focus on design methodology based on individuals' routines and habits. A study in Australia monitored a home with renewable energy and automated systems to reduce grid electricity use, analysing interactions with occupants' routines. Machine learning techniques identified energy consumption patterns, highlighting the need for design improvements in automation systems (Malatesta et al., 2022). The literature talks about the laundry balls which have been shown in studies to not affect microfiber contamination and may potentially promote shedding. It highlights how crucial it is to inform customers about appropriate washing choices (Salahuddin & Lee, 2022). Positive findings emerge from an evaluation of the viability of a multifunctional experimental smart house in promoting the Sustainable Development Goals of the UN, especially related to energy and water conservation (Kee et al., 2022). Transit-oriented developments (TODs) can lower CO_2 emissions for travel pertaining to job and school, nonetheless, not for leisure-related travel, according to a study conducted in Dhaka, Bangladesh (Ashik et al., 2022). This finding suggests that ecologically friendly TOD designs are necessary. Affordable, environmentally friendly smart homes improve community well-being, according to a Malaysian study (Mohamad et al., 2020). More research has been done on subjects like shared mobility for home delivery services, food safety, property taxes for local sustainability, and sustainability in micro-tourism (Mayett-Moreno & Oglesby, 2018). In general, these studies support sustainable development across a range of sectors and domains.

5.5 Sustainable Homes Practices

The literature presents Data Homebase (DHB), a circular web application that visualizes home data, including energy use, carbon emissions, and building affordability, using home Passports (HPs). By showcasing data-driven narratives that highlight the circularity and environmental potential of a building improvement, DHB hopes to advance the Circular Economy (CE). The literature suggests a secure blockchain-based energy trading system for residential dwellings in addition to DHB (Keena et al., 2023). To protect privacy during energy trading, this system uses an analytical energy pricing strategy and a proof-of-computational closeness (PoCC) consensus procedure. To assess how well the system promotes sustainability and energy efficiency, simulations are run (Warren-Myers, 2017). Architects, consultancies, and contractors are encouraged to work together to provide inexpensive and sustainable housing solutions through the "So You Think You Can BUILD" initiative. This problem highlights the significance of novel materials, production processes, and residential buildings that are both biobased and circular. The study investigates the ongoing adoption of smart home services and also looks at the Chinese housing market. It sheds light on how perceived utility and service quality affect user happiness and habit development, which advances our knowledge of how users behave concerning smart homes (Du & Sun, 2015). To address sustainable methods within the fashion industry, highlighting the requirement to make thoughtful decisions, decrease environmental effects, and recycle has also been explored. It also looks at what influences sustainable development education in the context of food education, highlighting the significance of teaching the next generation about food consumption that is sustainable as well as what influences teachers' capacity to include sustainable viewpoints (Gisslevik et al., 2018). Using data from the LEED certification programme, a study examines the features of sustainable residential societies in the US and recommends more studies on local practice support for the shift to low-carbon societies (Rakha et al., 2018). The NAHGAST Meal assessment instrument is presented, and the sustainability performance of food products in professional kitchens is also covered. The paper delves into several other subjects, such as energy storage systems in smart homes, energy-related campaigns and regulations, forecasting electricity consumption in smart grids, the impact of densification on households' reliance on second homes (Paetz et al., 2011), strategic placement for home healthcare services, evaluation of the environmental impact of energy-efficient alternatives, and variables influencing the acceptance and dimensions of solar home systems in rural Bangladesh (Engelmann et al., 2018); (Qviström et al., 2016). All in all, these studies add to a thorough knowledge of sustainable development in some domains, such as the adoption of solar power, certification, energy use, smart houses, regulatory frameworks, and resource evaluation (Komatsu et al., 2011).

6. Conclusion and Recommendation

The growth of sustainable homes and publications connected to sustainability that are indexed in the Scopus and WoS databases are examined bibliographically in this study. Using a keyword search, the study has gathered all pertinent published articles from 2000 to 2024. It is clear from the studies that have been taken out of context that scholars from a wide range of academic fields have significantly advanced our understanding of this topic. There is also a discernible upward trend in the research contribution in this area, which corresponds with the expansion of scholarships in the evaluation and measurement of sustainable homes and sustainability. To determine the present state of research contribution in this field, the collected publications were analysed. Regarding the analysis of the country, the major countries that have contributed to this field of study include the United States, Australia, China, Germany, Canada, and the United Kingdom. On the aspects of journals that have provided the most papers, *Sustainability Switzerland* has been identified as the top-ranked journal. *Journal of Cleaner Production*, *Land Use Policy Journal*, *Journal of Green Building*, and *Sustainable Cities and Society* are contributing to the top five journals. It has also identified five themes in the field in which there are some studies done and some can be explored. In order to address the more general issues of urbanization, climate change, and energy use, the field of sustainable homes is essential. This study demonstrates how goals related to sustainability can be included in a number of industries, including energy management, housing, and urban planning. The study's conclusions have broad ramifications and highlight the value of interdisciplinary approaches in addressing challenging sustainability issues. The international goal for smart, energy-efficient cities might be advanced by, for instance, using IoT integration in household energy management systems as a model for more extensive urban applications. By focusing on topics like the social effects of sustainable housing on marginalized communities or the function of local government in advancing sustainable practices, future study might build on these findings. Ultimately, the study underscores the rationale for more investment in research and infrastructure to hasten the worldwide shift towards more sustainable and resilient living environments. The key to implementing these sustainable practices globally will be the integration of technologies, regulations, and community participation.

7. Limitations and Future Direction of the Study

This study has several limitations, just like any other exploration. First off, there may have been a few linked documents overlooked because the dataset only consists of 166 papers. Secondly, the study may have benefited from the application of additional analyses, such as co-authorship analysis and bibliographic coupling. These might have offered some thought-provoking and thorough analysis of the published work in the area of sustainable housing and sustainability. Third, the study's carefully thought-out definition may restrict the keywords that can be used. The established criteria have been used to determine the keywords, even though the researcher's judgement is exercised during the keyword selection process. However, it's possible that the study missed some additional avenues. Therefore, more research might be needed to find additional directions based on a more comprehensive analysis; the first step would be to broaden the keyword search. Additionally, a predetermined inclusion and exclusion criterion has limited the number of papers to provide a rigorous process. Consequently, there's a chance we missed out on relevant books or book chapters. Adding more pertinent terms to the search string could further improve it. Eventually, the combination of databases will allow for a thorough content analysis to be done.

In spite of all of its shortcomings, this study offers a review analysis in the area of sustainable housing and sustainability, and it establishes the framework for future writers to continue their research in the same direction.

We anticipate that scholars will value the current research and use it as a basis for additional analysis to deepen our knowledge of this area of study. Additionally, governments and policymakers may find this analysis useful in the creation of smart and sustainable cities. Bridging the gap between the policymakers, city authorities, and citizens' needs, and providing tools and strategies as marketing strategies may contribute significantly to the creation of sustainable cities, which are part of the global competition (Moglia et al., 2021). Utilizing emerging technology as a catalyst for smart and sustainable city growth, the city must design a sound plan to boost its reputation.

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7 Smart Cities and the Prediction, Prevention, and Progression of Solutions to Homelessness

Brian Stewart and Anshuman Khare

1. Introduction

The problem of homelessness in rich countries has grown significantly in the first two decades of the 21st century, driven by the banking crisis of 2008 and the COVID-19 pandemic of 2020 to 2021. To the overwhelming majority of experts, this was not only unforeseen but also not considered to be a credible risk to urban development and growth, burdened by other concerns, including transport, land speculation, declining infrastructure, inadequate social amenities, and the shifting of tax bases. This unexpected turn of events has created a challenge for municipal governments as they seek to remedy the impacts on those experiencing homelessness and the citizens and institutions they affect. From the growth of the problem, several questions arise that this chapter will try to address and provide potential ideas for smart cities to consider in their attempts to wrestle with this problem. In short, how can Smart Cities reduce homelessness among their citizenry? And the related question: why and how are Smart Cities better positioned than more traditional cities to deal with homelessness?

In response to these questions, the objective of this chapter is to analyse the phenomenon of homelessness, considering its causes, impacts, and existing interventions, within the framework of smart city initiatives. By examining the intersection of homelessness and smart cities, we intend to explore how smart cities leverage technological innovations, data-driven approaches, and collaborative strategies in a three-part approach to predict, prevent and progress in addressing homelessness, thereby enhancing the overall well-being of vulnerable populations. Through an examination of relevant literature, case studies, and current practices, with an emphasis on Canadian studies, this paper seeks to provide insights into the potential of smart city initiatives to address the multifaceted challenges associated with homelessness, ultimately contributing to informed policymaking and urban planning efforts.

2. Research Approach

Secondary data research plays a pivotal role in advancing smart city initiatives aimed at addressing homelessness by providing evidence-based insights, supporting data-driven decision-making, and fostering innovation in urban

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governance. By harnessing the wealth of data available in smart city ecosystems, policymakers can develop targeted strategies, monitor progress, and enhance the overall well-being of residents experiencing homelessness.

This research involved a systematic approach to gathering and analysing relevant information using secondary sources. The research questions that were addressed included:

- What are the key factors contributing to homelessness in urban environments?
- How do smart city initiatives aim to address homelessness?
- What are the challenges and limitations of using technology to solve homelessness?
- What are some successful case studies of smart city approaches to tackling homelessness?

The authors conducted a thorough review of existing literature on homelessness, smart cities, and the intersection between the two topics. This involved searching academic databases, government reports, policy documents, and relevant publications to understand the current state of knowledge, key concepts, theories, and debates in the field.

The secondary data sources that were relevant to our research questions included statistical data on homelessness, reports from government agencies and non-profit organizations, case studies of smart city initiatives, and scholarly articles on related topics.

3. Homelessness: How Is It Defined?

There is no singular definition of homelessness when considering it as a topic of research, despite a commonly understood concept that borders on vagrancy. There can be considered three types of homelessness:

- temporary, usually the result of an event that displaces individuals;
- cyclical, affecting those faced with recurring changes to their status, such as regular loss of employment, family violence, and runaways; and
- chronic, deemed to include individuals who are homeless for a year or more.

The definitional problem at its core relates to what can be considered a home. At one extreme, it is described as being without shelter, which would be the more commonly accepted definition (Casavant, (1999). At the other extreme, adopted by the United Nations, it has a broader meaning, expanding the shelter requirements to include the basic criteria essential for health and human and social development. These would include secure occupancy, protection against bad weather, personal security, access to sanitary facilities and clean water, education, work, and health services. The Universal Declaration of Human Rights also sees housing as a human right.

There is more agreement regarding the term "chronically homeless." In Canada, this is reported to be only 2% to 4% of the homeless population, while the corresponding figure for the US is 10% (Homeless Hub, 2019). For the purposes of this chapter, a categorical definition is not required; however, we need to be aware that there are differences, and these need to be noted when interpreting research findings and published statistics. For example, homelessness is defined by the Canadian Observatory on Homelessness as "the situation of an individual, family, or community without stable, safe, permanent, appropriate housing, or the immediate prospect, means, and ability to acquire it." A StatsCan General Social Survey shows that 8.8% of Canadians answered yes to ever being homeless. A shift in definition would likely materially change the survey results regarding the numbers of homeless individuals, without any change in the observed situation.

4. Homelessness: Key Contributors

Homelessness has no single cause, although a single event, such as a natural disaster or war, can precipitate the forced relocation of people to temporary shelters. As mentioned earlier, we are dealing with chronic homelessness here, and it is these causes that we need to articulate. The literature has converged on the major contributors to homelessness, which can be considered under three main themes: economic, social and health.

4.1 Economic Causes

At its simplest, not having permanent shelter is created by the inability to afford to buy or rent appropriate space to meet the needs of individuals, families, or groups. As with all economic questions, there are supply- and demand-side forces behind this outcome. On the supply side, the stock of available residences is below what is required to meet the needs of the population. The forces influencing the supply of residences include land values, zoning by-laws, property rights, municipal regulations and procedures, rent controls, construction costs and the overall economic environment that stimulates risk-taking. On the demand side, those seeking shelter do not have the economic means to effectively demand from the available stock and cannot sustain a long-term contract to reside in a location. From an individual's perspective, difficulties can arise due to a change in income resulting from unemployment or insufficient earnings from available low-wage jobs. Institutional factors also impact would-be borrowers, as the banking sector's policies on loan allocation, including deposit and repayment terms, heavily influence an individual's ability to access sufficient capital to acquire permanent shelter. In addition, broader cyclical economic conditions increase the effective demand for housing, leading to price inflation, often combined with speculation, which further increases home prices.

4.2 Social Causes

These include domestic issues such as family breakdowns, domestic violence, and divorce or separation, which can require persons to leave a family dwelling without the ability to find an alternative place to live. This category also includes individuals with criminal records, who find access to employment and financing denied to them, forcing them to live peripatetically as best they can. Institutional factors play a role here as well, as governmental policies relating to social safety nets can forestall individuals or families from having to move out of their permanent residences due to intermittent failures to meet their debt obligations. Discrimination based on race, colour, gender, religion, disability and sex – often disguised within economic constraints – also plays a role.

4.3 Health Causes

Physical and mental health issues, whether temporary or chronic, often lead to an inability to meet the financial requirements to maintain a home. In particular, mental health problems can force a change of employment to a far lower pay range, or even to permanent unemployment. Unless well insured, the cost of medication, combined with the inability to work in certain employments, will cause an increase in outgoings and a reduction in income. Housing in North America is estimated to take 30% of the median income (Statistics Canada, 2023; US Census Bureau, 2022). Any reduction in disposable income is likely to have a major impact on the ability to retain a home. Similarly, drug addiction fits within this category, as an addict's inability to retain employment, combined with the cost of acquiring drugs, can all but eliminate their ability to afford housing.

5. Homelessness: Why Should We Care?

Homelessness is not a universally experienced problem, whether in the global, national, or municipal context, as it demonstrates a spatial dimension seen in the uneven distribution of the geography of the cities it impacts. In particular, there is a positive correlation between larger cities and larger populations of persons experiencing homelessness, as these tend to reinforce the problem by enabling a sustainable critical mass to be reached. In relation to the geographical pattern of effect, downtown cores show far greater densities of homelessness than peripheral areas around the city (National Alliance to End Homelessness, 2023). Thus, there are patterns at both national and municipal levels that exert differential influences and pressures on local communities. In many ways, this can be seen as a reason for the slowness in dealing with the problem; essentially, it has been ghettoized into manageable and acceptable areas. Broader spread to areas considered more socially or economically valuable forces, or where temporal exigencies such as major events elicit more concerted action. For those residing in the impacted areas, the effects can be significant in terms of economic, social, safety and overall quality of life. More specifically, these impacts include:

- Decline in property values.
- Increases in theft and vandalism.
- Compromised accessibility to public areas.
- Closure or downsizing of commercial enterprises.
- Increase in disease spread.
- Increase in drug-taking.
- Increase in healthcare cost.

From a public health perspective, homelessness is closely associated with health disparities and infectious diseases, presenting challenges for public health systems and resources. Individuals experiencing homelessness are at a heightened risk of Hepatitis C infection and other health issues due to their living conditions and limited healthcare access (Gelberg et al., 2012). Loroño-Leturiondo and Illingworth (2023) posit that homelessness not only impacts the well-being of individuals experiencing homelessness but also creates unwelcoming environments that can discourage outdoor activities and affect the overall quality of life in cities. Individuals experiencing homelessness often encounter stigma and social exclusion, perpetuating a cycle of poverty and marginalization within society (DeVerteuil et al., 2009). This social exclusion can result in a variety of issues, including mental health challenges, substance abuse, and limited access to healthcare services (To et al., 2016). Addressing homelessness is not only a social obligation but also an economic consideration for cities, as the expenses linked to providing emergency services and support to homeless individuals can strain local resources and impact economic stability.

Adopting an ethical and humanitarian standpoint, tackling homelessness is a moral imperative for cities, as every individual has the right to safe and secure housing. Legal obligations and policies mandate the provision of support services for homeless populations, highlighting the importance of collaborative efforts between government agencies, non-profit organizations and community groups to develop long-term solutions (To et al., 2016). The urban context and specific conditions in a city play a crucial role in addressing homelessness, emphasizing the significance of localized approaches to addressing this complex issue (Knutagård & Kristiansen, 2019).

In summary, homelessness is a pressing concern for cities due to its wide-ranging consequences across various sectors. It is significant for cities because of its multifaceted impact on social cohesion, economic stability, public health, human capital loss and ethical, moral and legal obligations, all channelling into policy enactment and enforcement.

6. Smart Cities and Homelessness

The concept of Smart Cities was borne out of Los Angeles' *A Cluster Analysis of Los Angeles* in the 1970s, with Amsterdam creating a digital city in 1994 (Verdict, 2020) and Songdo in Seoul, South Korea recognized, as the first smart city in 2014. The concept has grown into a worldwide movement, with an IMD Smart City Index (IMD, 2023) estimate of 141 smart cities an estimate that by 2050, 70% of the world's population will live in smart cities. Interestingly, there are no North American cities in the Index's top 20 smart cities. The route to smartness is filled with difficulty and risk, presenting a seemingly endless number of challenges for city governments to overcome. Homelessness must now be added to this list for a range of associated concerns that need to be addressed.

Smart Cities hold promise in addressing homelessness through a blend of technological innovation, policy adjustments, and community involvement. In essence, the smart city is the infusion and pervasive use of digital technology to improve the functioning of cities from a human perspective. To date, however, the focus has been on improving the city's infrastructure, communication networks, and transportation, rather than on the social problems of poverty and homelessness (Khayyatkhoshnevis et al., 2020). The increasingly digitized city opens up an opportunity to gather, analyse and test data to address social issues and broaden the focus of a smart city to further improve the lives of citizens. Early examples of improving information flows are demonstrated by the cities of Seattle (City of Seattle, n.d.) and New York using smartphone Apps (e.g., NYC311) to enable real-time feedback from citizens to report homeless issues and events, allowing an ongoing aggregating data set that can be used in conjunction with other similarly rich data sets (Daileda, 2017).

The ability to improve data-informed decisions and feedback loops includes the issue of homelessness (Khayyatkhoshnevis et al., 2020). To effectively address homelessness in Smart Cities, a comprehensive approach that integrates technology, policy, and community engagement is crucial. Smart Cities can harness digital technologies to enhance the well-being of their residents, including individuals experiencing homelessness. Through smart city initiatives, cities can pinpoint the underlying causes of homelessness, offer tailored interventions, and improve service delivery to support those in need. These practices are in evidence with technologies such as artificial intelligence, big data analysis, and IoT networks to enhance urban governance, improve services, and elevate residents' quality of life (Bokhari & Myeong, 2022). These technologies enable data collection from various sources, like sensors and digital platforms, to aid decision-making processes and optimize resource allocation (Dembski et al., 2020; Cvar et al., 2020; Gade, 2021). Understanding the underlying causes of homelessness has therefore become part of the smart city agenda and they must adapt solutions to address them. This will require a deep understanding of the problem to formulate effective solutions to the issue (Byrne et al., 2013).

7. Prediction, Prevention and Progression in Dealing with Homelessness

7.1 Technologies and Data-Driven Approach Making an Impact

The convergence of technologies such as artificial intelligence, blockchain, cloud computing, artificial and virtual reality and ubiquitous connectivity through cellular or public/private Wi-Fi networks presents a promising avenue for smart cities to gather data that can lead to hypothesis formulation and testing through experimentation, culminating in the development of comprehensive strategies to address homelessness and enhance the overall well-being of urban populations. In their research from India, Ghosh and Kumar (2021) highlight the importance of information and communication technologies (ICT) in epidemic management in the face of challenges such as the COVID-19 pandemic. This use of ICT, including mobile health applications, has shown promise in improving epidemic management and could be adapted within the framework of smart cities to address public health crises that may impact vulnerable populations like the homeless.

7.2 Prediction

Data is the key to prediction, as there are no substitutes for having sufficient and applicable data sets on a timely basis to enable accurate prediction. Thus, smart cities have, by definition, a superior position to traditional cities in gathering and storing data for predictive analytics (Ullah et al., 2024). Homelessness is just one of several urban problems they may choose to address. Identifying the critical data sets is a prerequisite before gathering data, and this is directed by theory as to what is understood to be the determining factors leading to homelessness.

The theoretical foundations for data collection come mainly from social science and medical literature, forming a framework of sociology, social policy, social work, psychology, psychiatry, urban studies, and housing construction (Rakhimbekov & Abdikerova, 2018). While our understanding of the phenomenon is still imperfect, the theoretical framework can provide a basis for initial data collection. As empirical analysis proceeds and theories are challenged, new data requirements will undoubtedly be uncovered. One data survey currently being collected in North America is the Point in Time, which is a community-level data set of sheltered and unsheltered homelessness (Government of Canada, 2024). This geographically based survey can be used to determine a regional and national perspective while also creating a longitudinal time series to see if actions in a given area are having the planned impacts. This is an important data source, one that can be augmented by technology to enable at least a subset to be repeated in shorter timeframes, moving either to the comparative statics of repeated surveys or even to a dynamic real-time continuous measurement. This would allow for more proximate causes of shifts in trends to be identified.

Having access to aggregated relevant data sets and the theoretical foundations for explaining the problem provides analysts with the ability to begin the process of predicting the conditions likely to favour homelessness. This represents the core of any successful approach to dealing with homelessness in smart cities. The determination of triggers identified to engender individuals and families to move to a non-stationary residence state greatly allows for timely interventions that either stem the flow or remediate the worst effects.

Unfortunately, there is a wrinkle about data gathering in this area, as a major impediment to enabling any digital analysis or forecasting of homelessness is caused by those living in a homeless state having an instinctive distrust of self-identification and often lacking any personal identification. This impedes the ascertaining of root causes, as information gaps will lead to incorrect causal formulations and imprecise or incorrect predictions. To overcome this constraint, the City of London, Ontario's Information and Technology Services Division used an AI model, the Chronic Homeless Artificial Intelligence model (CHAI), to identify the factors that lead to chronic homelessness and to predict its likelihood (Wray, 2020). Using data for four years from the City's Homeless Individuals & Families Information System (HIFIS), key dynamic and static variables influencing behaviour were identified. These included the number and sequencing of services a person used over a given period, personal events/attributes, and demographic data. Factors that were identified included the number of stays over 30 days, total shelter stays, the aggregate days of receipt of housing subsidies, and advancing age. This is consistent with Shinn and Cohen's (2019) review of the homeless prevention literature, which stated that the single best predictor of eventual homelessness is having previously been in a shelter. Other important predictors identified were being doubled-up with another household or not being a leaseholder, having a pending eviction, receipt of public assistance, and high levels of rent arrears or debt (Shinn et al., 2013; Greer et al., 2016; Greer, 2014).

There is a growing emphasis on the deployment of ICT to find sustainable solutions to urban challenges (Perera et al., 2014). These technologies enable efficient city management and can support initiatives aimed at tackling homelessness by optimizing resource allocation and service delivery. Integrating cloud computing and building information modelling (BIM) technologies enhances collaboration and project integration in smart cities, which is pivotal for devising effective solutions to address homelessness (Onungwa et al., 2021). By leveraging these technologies, cities can streamline processes, enhance communication among stakeholders, and boost the efficiency of service delivery to homeless populations.

Smart city initiatives are instrumental in addressing homelessness by deploying smart technologies to address urban challenges like limited access to essential services, unemployment, and social inequalities (Kutty et al., 2020). These initiatives aid in identifying the root causes of homelessness, offering data-driven insights for policymakers to design targeted interventions (Kar et al., 2019). Additionally, the concept of smart sustainable cities underscores the use of digital technologies to meet the needs of communities and foster socio-economic progress sustainably (Viale Pereira & Schuch de Azambuja, 2021). The ability to predict with high levels of accuracy provides municipalities with the ability to develop interventions that can prevent citizens from falling into a homeless state. These can be provided through case worker reports and the use of questionnaires to assess an individual's current state, combined with statistical modelling to identify those most at risk. In addition, the nature of the risk and appropriate mitigation can also become clearer as more evidence is gathered and shared across jurisdictions, further personalizing the response to a deteriorating situation. This leads to the consideration of prevention and how smart cities can help to prevent homelessness.

7.3 Prevention

Prevention of future homelessness is critically linked to the ability to understand the forces that engender it. Current research tends to focus on the more proximate causes when individuals and families have progressed to being in danger of becoming homeless. These are important, as they allow timely interventions to prevent further escalation and potential immiseration. The potential to use additional macro-data sets to broaden the search for more indirect actors in systemic social, economic, and political causes would enable greater accuracy and timeliness in predictions, creating longer warning periods and allowing governments to take more effective mitigating action.

In the context of tackling homelessness, research offers valuable insights into urban dynamics, population movements, and service utilization patterns, which are crucial for designing effective interventions. By analysing data on factors such as housing availability, social services utilization, and demographic trends, policymakers and urban planners can devise targeted strategies to combat homelessness (Myeong et al., 2022). By examining data on urban infrastructure, public spaces, and community engagement, cities can pinpoint areas for improvement and implement tailored solutions to support homeless populations. For example, the use of digital twins and urban simulation models can aid in scenario planning and policy evaluation to assess the impact of different interventions on homelessness rates and urban development (Dembski et al., 2020). These tools allow stakeholders to visualize complex urban systems, test hypotheses, and co-create solutions collaboratively. Additionally, by integrating e-money systems and digital payment platforms, cities can streamline financial transactions, enhance service access, and promote social inclusion for vulnerable populations (Putra et al., 2022; Sukmadiansyah & Noviaristanti, 2022).

Baskin (2020) viewed structural determinants contributing to the homelessness of Aboriginal youth in Toronto, Ontario, Canada, examining the intersection between smart cities and homelessness in Canada by shedding light on the underlying factors that lead to homelessness within specific demographics. Research undertaken outside Canada shows that factors such as a lack of affordable housing, poverty, and systemic inequalities contribute to the problem of homelessness in urban areas (Benjaminsen & Andrade, 2015). In addition, correlations between housing costs and homelessness emphasize the role of city and county governments in addressing the growing homeless populations (Glynn & Fox, 2019). The Government of British Columbia has responded in alignment with this research. They are seeing homelessness in Victoria, Vancouver, and the lower mainland become endemic, with city blocks having become enclaves of homelessness. A cause of this is the shortage of available residential spaces, leading to excess demand that is increasing the cost of housing purchases and rentals, exacerbating the homelessness problem. The Canada Mortgage and Housing Corporation estimates the housing shortage to be over 600,000 homes in the province by 2030. To address this through increasing the supply of houses, the BC provincial government has introduced new zoning rules that increase the density of traditionally single-family zones to allow condominiums and multiplex housing for communities with populations of more than 5000 (BC Government News, 2023). This NIMBYless (not in my backyard) ruling will have significant repercussions on traditional neighbourhoods and local skylines, in addition to the economics of land values. Having access to relevant predictions earlier may have offset the degree of the problem in BC; however, it may be that NIMBY would have forestalled such efforts, and only when the situation reached a level of sufficient egregiousness was a significant legislative act perceived to be acceptable. While the BC provincial government managed to implement a progressive policy in this instance, it is by no means to be expected as probable, even when the correct action is identified and agreed upon. Biases in city services are widespread, affecting how cities are planned and managed. Corinth and Finley's New York study highlighted the role of centrality and median income in explaining variations in unsheltered homelessness across neighbourhoods, also indicating that police response times to homelessness-related calls are quicker in more affluent and central neighbourhoods, potentially influencing the overall city response to homelessness. Ghosh (2019) found that homelessness is exacerbated in cities due to neoliberal policies, leading to the denial of basic human rights and necessities for those affected, pointing out governance failures and urban restructuring that contribute to the problem of homelessness.

The Los Angeles County's Homeless Prevention Program used an AI predictive model, accessing data from six county departments to create a list of the county's most vulnerable population, those appearing in health and justice records and who access food stamps. The program has successfully prevented 86% of 700 participants since 2021 from becoming homeless (Moran, 2024). Smart City AI initiatives have also been initiated in the city of Austin, looking at how services can be improved (Bridging Barriers), the city of Calgary identifying at-risk chronic homelessness (Messier, 2022), and the city of San Jose using images captured from driving throughout the city to assess vehicles and areas experiencing homelessness (Guardian, 2024).

It is to be expected that policy development and implementation exist in a political and social context that predictiveness may not be able to overcome. Similar challenges were experienced in response to COVID-19's impact on homelessness (Kopec, 2023), which serve to emphasize the need to understand the pathways and available levers of policy change. Nonetheless, the value of accurate and timely forecasts will greatly enhance the effectiveness of reducing the incidence, duration and degree of impact of homelessness.

7.4 Progression

Progression represents the increased ability to deal with the problem coming from the accumulated learning of jurisdictional actions. In the context of dealing with homelessness, it encompasses alleviating the human and societal impacts through increasing our understanding of the causes that allow coherent and meaningful action to improve treatments that both prevent and address the problem. Information flows, once again, are to the fore here, requiring municipalities to report on their activities in a timely and accurate manner. In essence, turning the global smart city network into a vast laboratory of interconnected experiments, yielding a constant stream of results that can inform subsequent hypothesis formation and testing. This ability is even more applicable in this case as homelessness is considered a non-static problem in so far as the ends are similar, but the causes may shift due to changing socio/economic/political contexts that marginalize sections of the population, forcing them to move to a non-permanently domiciled existence.

There are signs of progression from several studies representing a variety of approaches in differing countries. The integration of blockchain technology has been proposed as a means to empower smart homes within the context of sustainable smart cities (Aldribi & Singh, 2022). By leveraging blockchain, smart cities can create scalable and decentralized solutions that enhance the overall efficiency and effectiveness of urban services, potentially including support systems for individuals experiencing homelessness. A sample of current initiatives shows the diversity of approaches that presage future usage.

- In Austin, Texas, a research initiative used blockchain to provide individuals with the ability to have control over their transaction history, providing a digitized medical record for homeless persons (Mercer & Khurshid, 2021). Biometrics were used as identifiers to allow access to their records. While used to provide health services, blockchain can similarly be used to access other services in a low-trust environment.
- Using technology to increase the availability of housing, a San Francisco non-profit is building 3D-printed houses using concrete to build the walls, with other structural elements added conventionally. The construction cost of the homes is substantially less than having them stay in shelters (Smart City Governments, 2019).

- To break the cycle of no job leading to no home leading to no future job and difficulty receiving social benefits, Finland instituted a policy of "Housing First." This allows people undergoing homelessness to get an apartment without preconditions and to receive social support, which facilitates their ability to regain employment and permanently keep their apartment. As of 2020, 4,600 such homes were provided, and homelessness has continued to decline in Finland under the program (Better News, 2024).
- A benefit to the homeless and a conduit to ever-enriched data sets is through the provision of Wi-Fi for the homeless. Generally, not seen as the most critical need in addressing the problem, access to the Internet is nonetheless a critical communication access to locate job openings, shelter conditions, counselling services and food provision essential for those who are homeless whose networks are otherwise severely limited. In New York, Women in Need are creating Smart Shelters through their provision of Wi-Fi, providing a functionality conducive to their ability to move out of the shelters and allowing greater understanding of the impacts of mobile technology to address the problem (Pyzyk, 2017).
- Virtual Reality (VR) has been used in two similar cases to create empathetic experiences. Filmmakers, One to One Development Trust, working with the West Northamptonshire Council (2024), created a documentary and VR experience to raise awareness of what it is like to be homeless. Streets of Change followed people's journey on the streets in Northampton, England, as they attempt to address a growing homeless problem. The VR scene creates an evocative experience by also using the art and poetry of those living on the streets.
- According to Carter (2019), Stanford University's Virtual Human Interaction Lab used VR to create an eviction experience, playing a scene where the participants start in their apartment, have the landlord evict them for failure to pay rent, and are then forced to live in their car and spend a night trying to survive on the streets. VR offers the capability to train and enhance social workers' ability to deal with persons under stress due to either the threat or actuality of being homeless.

The cases demonstrate singular technology uses. However, the strength will ultimately lie in the convergence and combination of technologies to help address the problem. For example, technologies that can provide an integrated and holistic approach involve using BIM, which provide the ability to design shelters, temporary housing, and long-term affordable housing in conjunction with VR, 3D modelling, and geographical Information Systems (GIS). The design of new spaces can be envisaged and modelled, and once agreed, estimates of construction and maintenance can be developed for determining budgetary and resource allocation. Incorporating VR and GIS can allow shelter designs to be experienced by potential residents and gain feedback on design aspects and locational preferences before proceeding.

Collaboration among public and private institutions will be required in any effective response, encompassing tri-level governments, banks, housing authorities, law enforcement, non-profit organizations, and active research from post-secondary institutions, as exemplified in the more compassionate dismantling of tent cities (Solensten & Willits, 2019). Smith (2022) underscores the need for such efforts to be contextual, multifaceted and community-driven solutions to address the persistent nature of the problem. This collaborative model can serve as a blueprint for other cities tackling homelessness. It is considered imperative to shift away from punitive measures towards homelessness, focusing on understanding the consequences of such strategies and embracing more compassionate and effective approaches (Wilking et al., 2018). According to Carneiro (2021), the Canadian federal government's leadership has been instrumental in fostering collaboration between various stakeholders to address homelessness, as seen in St. John's, Newfoundland. The shared funding model employed by Ottawa has successfully aligned efforts and objectives among governmental and non-governmental entities, showcasing effective collaborative governance in tackling homelessness, while also providing insights into the effectiveness of collaborative approaches in addressing homelessness, demonstrating how smart cities in Canada can leverage partnerships to combat homelessness.

All the above approaches are multidimensional and require coordinated and systemic action based on the application of experience, synthesized through theory that takes advantage of the range of tools available within the smart city context. That smart cities are in a greatly enhanced position to deal with the problem has been outlined earlier; it should also be taken into account that they also have a greater requirement to do so. Should the benefits of a citizen-engaged urban environment continue to marginalize a section of its community, it will have not only failed those groups but also the underlying promise that is the foundation for the concept of smart cities.

8. Dystopian Risks

The benefits of technology to improve the functioning of cities and the general welfare of their residents must be tempered with the risks that accompany their usage. An early example of their potential is the use by Chinese authorities of CCTV cameras, facial recognition systems, and Internet monitoring tools for extensive surveillance in Rongcheng City in the Shandong province to support a social credit system that drives desirable behaviours. A similar use to deal with errant behaviours, such as homelessness, in other jurisdictions is not hard to imagine. It will also prove increasingly difficult, even for democratic governments, to refrain from deploying these technologies as they seek to deal with economic, social, and political problems. The massive data sets that are yet to be gathered from biometric and locational monitoring, interfacing with health, financial, employment, and entertainment data stored and analysed by ever more capable AI tools, present a challenge that is a real and present danger. Addressing these dangers will require strong multi-tiered governance with robust legal frameworks that balance society's right to security with individual rights, ensuring accountability, oversight, transparency, and public discourse of the use of surveillance technologies. There is a very real risk here, and one that AI has brought into stark relief. Smart cities will need to address these risks if their promise is to be realized, or else they may unavoidably be the entrepôts for a dystopian future of anonymous autocratic control that diminishes personal freedom and overturns the fundamental value of the city.

9. Conclusions and Recommendations

Technological initiatives are necessary but are insufficient on their own to meet the homelessness challenge. A many-sided approach is essential. Perhaps the greatest challenge in dealing with the problem is the failure of the imagination of city leadership, governments, corporations, institutions, and their citizenry to tackle it holistically, with each seeing it as the purview of another. Just as the causes are multihomed, the solutions must also be multi-owned. It is fair to state, however, that technology's role can be to act as the catalyst and integrator for the various groups to work collaboratively, just as they do with other smart-related projects, to overcome the challenge. The ability to document, articulate, measure, and provide trends is fundamental to gaining a fuller understanding of root causes, demonstrable impacts, and the nature of the phenomenon as it adapts to ever-changing forces. Recommendation: data sharing across institutions, agencies, and departments, public and private, within and across jurisdictions, be encouraged, pursued, and supported with effective levels of funding.

Smart cities are in a better position to address homelessness due to their access to an enhanced toolset and knowledge base to both identify potential issues and monitor and provide feedback on initiative performance. The availability of more relevant and immediate feedback provides a level of agility to remedial initiatives, allowing more rapid adaptations to responses, particularly those unforeseen at the outset. Such do not invalidate more traditional cities from attempting their initiatives; however, the ability to react will be significantly lowered. Recommendation: have smart city initiatives act as a proving ground for traditional cities to learn from and to adapt successful practices. While success is not guaranteed to be transferable, their chances are greatly enhanced.

The problem is non-constant, being a result of the interplay of several disparate forces, and it would appear reasonable to assume that it will continue to be a response to changing conditions that individuals find themselves unable to cope with. The ability to aggregate data flows will provide continuous feedback on the broad range of forces that initiate, intensify, and ultimately inflict homelessness on marginalized citizens. The advances in technology, most notably cloud computing, ubiquitous connectivity, low-cost mass storage, and generative AI, which undergird smart cities, are also those that can help to provide an effective response to what currently appears to be a permanent attribute of urban life.

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8 Reshaping Resilient Cities from an Educational Perspective

The Case of iZJU

Lijuan Qu and Yuwen Dai

1. Introduction

In our complex and dynamic global environment, climate change and sustainability have become critical factors that can shape the future of urban development. Today, some 56% of the world's population – 4.4 billion inhabitants – live in cities. This trend is expected to continue, with the urban population more than doubling its current size by 2050, at which point nearly 7 of 10 people will live in cities. With more than 80% of global GDP generated in cities, urbanization can contribute to sustainable growth through increased productivity and innovation. Globally, the rapidly increasing urbanization process, together with climate change-related hazards from the increased frequency, intensity, and severity of extreme weather events, has challenged cities to implement plans to progress economically while remaining ecologically viable and socially impartial (Owens & Halfacre-Hitchcock, 2006, p. 114). With both mitigation and adaptation benefits, sustainable cities have an important role in combating climate change and fostering sustainability, thereby developing a society where natural resource conservation is balanced with social justice, and economic development ensures the planet's existence in the future (Owens & Halfacre-Hitchcock, 2006, p. 126).

As a microcosm of society, universities and colleges are important sites of transformation as centres of discourse and vehicles of social change (Finlay & Massey, 2012, p. 150), and they can be regarded as 'small cities'. Understanding how to implement sustainable practices at this scale is useful for understanding how to successfully apply sustainable principles at a citywide scale (Owens & Halfacre-Hitchcock, 2006, p. 115). As a mirror image of cities, university and college campuses resemble cities on a smaller scale, and they can serve as living laboratories for cities to take lessons from (Konig & Evans, 2013; Evans et al., 2015; Hansen, 2017; Cohen et al., 2021). Parallels between campuses and cities include unique history and culture, an independent governing body, diverse-use infrastructure, a security force and support system, and an independent communication network. Moreover, the economic influence and environmental impact of campuses also mirror those of cities on a smaller scale (Finlay & Massey, 2012, p. 156). Hence, campuses

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are considered an ideal place to begin to inform society about sustainability (Owens & Halfacre-Hitchcock, 2006, p. 126).

Whilst there is no single system that will simultaneously deliver economic progress, environmental viability, and social justice, universities and colleges strive to find the best combination of imperfect mechanisms to guide future development (Finlay & Massey, 2012, p. 162). Both as 'agents for change' and as 'catalysts of change' for sustainability, higher education institutions have a key role in creating and disseminating the knowledge that is required to address the global challenges faced by global society, as summarized in the UN Sustainable Development Goals (SDGs, Qu & Dai, 2024a). In the 'Sustainability 2.0' age (Leal Filho, 2015), universities and colleges are practising different models of change to achieve campus sustainability, which include centralized 'top-down' approaches (Lo, 2015), decentralized 'bottom-up' initiatives (Xiong & Mok, 2020), and institutional 'middle' efforts (Brinkhurst et al., 2011; Chambers & Walker, 2016). For example, Canada focuses on eco-efficiency and green architecture for campus sustainability (Fonseca et al., 2011). Australia advances campus sustainability through the strategies of climate change mitigation, transport, and paper reduction (Atherton & Giurco, 2011).

In this chapter, we contribute to the line of research on campus sustainability and conduct a case study on the International Campus of Zhejiang University (iZJU) in China, which is an exemplar of a sustainable campus globally (Qu et al., 2019; Qu & Dai, 2024a). In our study, we explore the sustainable practices at iZJU as a living laboratory for sustainability and as a Sponge campus in a Sponge City. Overall, our case study draws practical implications for how campuses can contribute towards creating model future cities that are sustainable, resilient, and smart.

2. Case Study: The International Campus of Zhejiang University (iZJU)

Located in the Yangtze River Delta of China, Zhejiang University (ZJU) is among the top 50 universities in the world. At the forefront of higher education, ZJU has been striving to become a pioneer of reform and an exemplar of development, and it has set its goal of becoming a world-class university. To accelerate its efforts, ZJU began to build its international campus in 2013, and the International Campus of Zhejiang University (iZJU) came into use in 2016, which is a pioneer of 'Internationalization at Home' (IaH) in China (Qu & Dai, 2024a) and an exemplar of sustainable campus globally (Qu et al., 2019; Qu & Dai, 2024a).

As a pioneer of IaH, iZJU is China's first campus for transnational higher education (Qu & Dai, 2024a, 2024b). Compared with cross-border education, IaH aims to bring the benefits of internationalization to all beyond just the mobile few, as physical mobility is still limited to a small minority of students. Thus, the IaH practice at iZJU is linked with SDG 4.3, which calls for equal access for all students to affordable and quality technical, vocational, and tertiary education, including university. Moreover, the practice of IaH at iZJU is linked with SDG 13 on climate action. Empirical evidence suggests that the global carbon footprint generated by international student mobility was estimated to be between 14.01 and 38.54 megatons of CO_2 equivalent per year in 2014, which roughly doubled from 1999 – with the lower estimate comparable to the annual emissions of Latvia or Jamaica, and the upper estimate comparable to those of Croatia or Tunisia (Shields, 2019). Thus, cross-border education is environmentally unsustainable in terms of academic mobility. The reduction of the carbon footprint associated with the practice of IaH at iZJU contributes to the value of SDG 13.

As an exemplar of a sustainable campus, iZJU has fully integrated sustainable principles into the overall plan and design of its campus. Since the construction of its campus, dating back to 2014, iZJU has set up a Green Office, with a series of measures adopted to minimize the impact on the environment. Since the entire campus was put into operation in 2017, the sustainable practices at iZJU have continuously gained recognition from international authorities (Qu & Dai, 2024a: Table 3, Figure 7). In 2019, iZJU became the world's first educational building case to be awarded the Leadership in Energy and Environmental Design (LEED) v4.1 O+M Platinum certification. In 2020, iZJU became the world's first campus outside the UK to receive the EcoCampus Platinum certification. In 2021, iZJU received the ISO14001:2015 certification, which is an internationally recognized standard for environmental management systems. This indicates that iZJU has continued its commitment to leading in the operation of a sustainable campus. In our case study, we explore the sustainable practices at iZJU as a living laboratory for sustainability (Section 2.1) and as a Sponge campus in a Sponge City (Section 2.2).

2.1 A Living Laboratory for Sustainability

> We shape our buildings; thereafter they shape us.
>
> Winston Churchill

Originally an outgrowth of the green building focus in architecture, the concept of a 'living laboratory' refers to the use of new campus buildings as a platform for sustainability education (Hansen, 2017, p. 224). The use of greener buildings can be seen as a major step towards a greener campus (Amaral et al., 2015, p. 158). Many schools have been intentionally developed as teaching tools using the LEED, which is the most widely recognized green building rating system worldwide. It provides a framework for campus sustainability planning (Ried, 2008) and has synergies with the SDGs (Varnadore, 2020; USGBC, 2022). In the case of iZJU, the green features of its campus primarily focus on sustainable site development, energy efficiency, water conservation, building energy conservation, and waste management. By implementing these sustainable practices on campus, iZJU shows its commitment to environmental responsibility, its contribution to the reduction of carbon footprint, and its promotion of sustainable living. In 2019, the Library and Teaching North A at iZJU became the world's first educational building case to be awarded the LEED v4.1 O+M Platinum certification.

In addition to green buildings, iZJU has transformed its campus into a living laboratory for sustainability, through which it seeks to contribute to a wider societal transition to sustainability (Konig & Evans, 2013).

Since the construction of its campus in 2014, iZJU has been committed to building a zero-carbon learning and working environment (SDG 13; Qu & Dai, 2024a: Figures 5, 6). As part of the third mission of universities, it is also the university's social responsibility to build zero-carbon campuses. In practice, iZJU is the first university campus from China to have joined the EcoCampus certification system. In 2020, iZJU was the world's first campus outside the United Kingdom to receive the EcoCampus Platinum certification. As university campuses are small-scale models of cities (Guerrieri et al., 2019), the campus-city relationship likely has the potential to influence changes in the city environment and create a great impact on city-level sustainability (Islam et al., 2023, pp. 4–5). Thus, the campus-based action for a zero-carbon campus at iZJU, in turn, contributes to the acceleration of the transition towards zero-carbon cities (Islam et al., 2023; Voytenko et al., 2016).

There are also student green initiatives and activities at iZJU, which engage the university community in sustainability, including the initiative of the 'Sustainable Campus Learning Base' with data support for scientific research (SDG 4; Evans et al., 2015); the initiative of the 'Eco Club' for green actions, with activities such as the bio-investigation project (SDG 14, 15), the 'bird watching' group (SDG 15); the initiative of the 'Green Campus Ambassador' programme for community outreach, which develops student leadership skills for sustainability (SDG 17; Shriberg & Harris, 2012). In 2019, the first batch of Green Campus Ambassadors from iZJU participated in the first conference of the Asian Sustainable Campus Network and won the 'Excellent Student Activity Award'. By turning its campus into a living laboratory for sustainability education, iZJU can both educate students and offer potential solutions for the challenges of sustainable development (Hansen, 2017, p. 238).

2.2 A Sponge Campus in a Sponge City

Urbanization and climate change led China to propose the concept of Sponge City in 2012 (Xia et al., 2017; Li et al., 2018; Zha et al., 2021) as a new strategy for integrated urban water management (Wang et al., 2018). In theory, a Sponge City essentially soaks up rainwater and retains excess stormwater, then filters and releases the water slowly, much like a sponge – with good flexibility in adapting to environmental change (Hou et al., 2019) and responding to natural disasters. By steering the water underground, Sponge Cities could help fight flooding and manage surges of water from storms supercharged by climate change. In 2013, China's President Xi Jinping formally proposed the construction of Sponge Cities at a central urbanization work conference (Xia et al., 2017), and the Chinese government has been supporting the development of Sponge Cities since 2014 (Rau, 2022) for urban water resilience and sustainability (Ma et al., 2020). The first batch of 16 pilot Sponge Cities was announced in 2015, and the second batch of 14 pilot Sponge Cities was nominated in 2016. Based on the experience of these 30 pilot cities, China began to systematically promote the demonstration of Sponge Cities on a national scale (Yin et al., 2022, p. 2).

With the implementation of Sponge Cities in China's urban planning, the construction of Sponge campuses has become necessary for many university projects, which is the application of Sponge Cities on a micro-scale (Luo et al., 2024, p. 2). In the case of iZJU, the location of its campus is situated in the wetland area on the east side of Haining City in Zhejiang Province. Adjacent to wetland parks on the north and south sides, the iZJU campus is connected with the city through a water system, with river green belts on the west and east sides. Amid wetlands and lake views, the entire campus enjoys a superior natural environment, and it is rich in water resources, so the concept of 'Sponge City' has been incorporated into the design of the campus, with the utilization of nature-based solutions and integration of green infrastructure (Rau, 2022), as effective and efficient means to improve water management and enhance climate resilience, while delivering many other ecosystem benefits. The design of the Sponge campus at iZJU includes a rainwater harvesting system, bio-retention areas, concave green land, pervious pavement, and the use of non-traditional water sources.

2.2.1 Rainwater Harvesting System

In Sponge Cities, rainwater is considered an important part of the urban water resource. Many water storage facilities, like rainwater harvesting systems, are built throughout these cities to collect and store rainwater for later use, which restores the ecological function of the natural environment of Sponge Cities (Liu et al., 2017, p. 3). At iZJU, the central lake is the main rainwater harvesting storage on campus, and it is designed to flexibly control the water level of the internal water system through the two gates and pumping stations in the north and south of the lake, thereby reducing peak flow and improving flood control capacity while lowering pollutant load. The two gates in the north and south of the central lake are equipped with automatic water exchange systems to ensure stability in the quality and temperature of the harvested rainwater on campus.

How the rainwater harvesting system at iZJU works is that when the water level is high in the central lake, the stored rainwater will be discharged from the north gate. During heavy rainfall, the excess rainwater in the central lake may not be discharged through self-drainage in time, and it will be forced to drain into the north wetland park through the pumping station near the north gate of the central lake. The rainwater will be pre-treated in the north wetland park first and then discharged along the river green belts on the west and east sides of the campus, before converging with the south wetland park, the Juan Lake.

In China, the water and energy consumption per student are two and four times as large as that of Chinese residents, respectively (Tan et al., 2014, p. 646). With the water-energy nexus (Gjorgiev & Sansavini, 2017), the water efficiency and energy conservation at iZJU are reflected in its rainwater harvesting and energy saving in water recycling (Fei et al., 2023: p. 5), which draws practical implications on how to tackle the increasing water and energy shortages in flat urban areas (Ali & Sang, 2023) and contributes to the value of SDG 6, 7, 11, 13 (de Sa Silva et al., 2022) for sustainable urban development.

2.2.2 Bio-retention Areas and Concave Green Land

Bio-retention areas, which are also known as bio-filters or rain gardens, are designed to simulate natural hydrological processes (Chan et al., 2018, p. 773; Hou et al., 2019, p. 574). As small sponges for cities (Nguyen et al., 2019, p. 154), bio-retention areas can be flexibly integrated into the landscape to beautify the environment and offer advantages in retaining surface runoff, reducing peak flow, improving runoff quality, and replenishing groundwater resources (Li et al., 2021, p. 2). At iZJU, there are bio-retention areas installed between the main ring road and the sidewalk on campus, with rainwater inlets set apart roughly every 30 metres. When it rains, the rainwater enters the bio-retention areas first, and then it penetrates into the soil. After the soil is saturated, it then enters rainwater outlets into the municipal rainwater system. The installation of bio-retention areas can improve urban greening and increase the overall area of urban green space, as well as enhance ecological function and encourage urban ecosystem diversity by providing new habitats for a wider range of organisms (Chan et al., 2018, pp. 773, 776), which in turn contribute at a local scale to the value of the SDG 6, 11, 13 (de Macedo et al., 2021, p. 1107).

Similar to bio-retention and rain gardens, concave green land, which is also called low-elevation greenbelt (Ren et al., 2017, p. 4), is another key technology in Sponge Cities. It refers to vegetated land that has a lower elevation than its surroundings and can temporarily retain stormwater, and it is an effective tool in mitigating pluvial floods (Du et al., 2019, p. 774). At iZJU, the green land along the periphery of the roadway is designed to have a lower elevation than its surroundings, which in turn forms a concave green land on the inside of the roadway, so as to prevent rainwater on campus from flowing into the river green belts on the west and east sides of the campus.

(3) Pervious Pavements

Sponge Cities provide broad hydrological functions to alleviate urban flooding and other water-related problems (Li et al., 2022). In addition to bio-retention areas, pervious pavements are designed to mimic natural hydrological responses (Chan et al., 2018, p. 773). From the perspective of pavement engineering, Sponge Cities have the requirements of infiltration, retention, purification, evaporation, and drainage (Guan et al., 2021, p. 2). Unlike conventional pavements, pervious pavements use permeable materials to build ground pavement (Nguyen et al., 2019, p. 155), and they offer primary benefits such as increasing stormwater infiltration, drainage, purification, groundwater recharge, and microclimatic amelioration (Li et al., 2022). At iZJU, pervious pavements, like permeable concrete and permeable bricks, are used for large-area paving and roadways on campus. The use of pervious pavements allows rainwater to penetrate into the ground during rainfalls, replenishing groundwater, reducing runoff, and reducing peak flow. As an urban infrastructure solution for mitigation and adaptation against climate change, the installation of pervious pavements contributes to the value of SDG 11 and 13 (Cacciuttolo et al., 2023, p. 15).

(4) Use of Non-Traditional Water Sources

At iZJU, rainwater is collected from the roofs and roads on campus during rainfalls, and then the collected rainwater is disposed of and filtered before being discharged into the central lake, which is the main rainwater harvesting storage on campus. The collected rainwater is then pumped to the rainwater catchment area located in the basement of the east complex of the central lake, where it is purified, stored, and later used for irrigation, garage cleaning, and road flushing on campus. It is estimated that the utilization of non-traditional water sources can reach 15%, which is equivalent to saving approximately 100,000 tonnes of water resources per year.

3. Conclusion and Discussion

In the midst of our increasingly interconnected and rapidly evolving global environment, climate change and sustainability have become critical factors that can shape the future of urban planning. Both as 'change agents' and as 'catalysts of change' for sustainability, higher education institutions have a key role in creating and distributing the knowledge required to address the complex global challenges as summarized in the SDGs (Qu & Dai, 2024a), and in transforming societies aimed at a more sustainable future (Berchin et al., 2021). As a mirror image of cities, university and college campuses resemble cities on a smaller scale and can serve as living laboratories for cities to take lessons from (Konig & Evans, 2013; Evans et al., 2015; Hansen, 2017; Cohen et al., 2021). Given the parallels between campuses and cities (Finlay & Massey, 2012, p. 156), campuses are considered an ideal place to begin to inform society about sustainability (Owens & Halfacre-Hitchcock, 2006, p. 126). In the 'Sustainability 2.0' age (Leal Filho, 2015), universities and colleges are practising different models of change to achieve campus sustainability, so as to re-engineer campuses of today for sustainable cities of tomorrow (Lipschutz et al., 2017).

In this chapter, we contribute to the line of research on campus sustainability and conduct a case study on the International Campus of Zhejiang University (iZJU) in China, which is an exemplar of a sustainable campus in the world (Qu et al., 2019; Qu & Dai, 2024a). Located in the Yangtze River Delta, iZJU is China's first campus for transnational higher education (Qu & Dai, 2024a, 2024b). As a pioneer of 'Internationalization at Home' (IaH, Qu & Dai, 2024a), it aims to bring the benefits of internationalization to all, beyond just the mobile few, as physical mobility is still limited to a small minority of students in China. This in turn also contributes to the reduction of the carbon footprint (Shields, 2019), and the value of SDG 13 on climate action (Table 8.1). As an exemplar of a sustainable campus, iZJU has fully integrated sustainable principles into the overall plan, design, construction, and operation of its campus. The sustainable practices at iZJU have continuously gained recognition from international authorities (Qu & Dai, 2024a: Table 8.3, Figure 7). In our case-based analysis, we explore the sustainable practices at iZJU as a living laboratory for sustainability and as a Sponge campus in a Sponge City.

As a living laboratory for sustainability, iZJU has used the LEED as a roadmap for its campus sustainability planning (Ried, 2008), which has synergies with the SDGs, including SDG 3, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17 (Varnadore, 2020; USGBC, 2022). By implementing these sustainable practices, iZJU shows its commitment to environmental responsibility and its promotion of sustainable living. In 2019, the Library and Teaching North A at iZJU became the world's first educational building case to be awarded the LEED v4.1 O+M Platinum certification (iZJU, 2019). Moreover, sustainable activities at iZJU include its sustainability efforts towards a zero-carbon campus (SDG 13; Qu & Dai, 2024a: Figures 5, 6), to accelerate the zero-carbon transition at the city scale (Guerrieri et al., 2019; Islam et al., 2023; Voytenko et al., 2016); the initiative of the 'Sustainable Campus Learning Base' with data support for scientific research (SDG 4; Evans et al., 2015); and the

Table 8.1 The iZJU model of campus sustainability and its linkages with the SDGs.

Sustainable practice at iZJU	*Sustainable development goals (SDGs)*
'Internationalization at Home' (IaH)	SDG 4, 13
Leadership in Energy and Environmental Design (LEED)	SDG 3, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17
Zero-carbon campus	SDG 13
Green initiatives and activities	SDG 4; 14, 15; 17
Sponge campus: rainwater harvesting system	SDG 6, 7, 11, 13
Sponge campus: bio-retention areas	SDG 6, 11, 13
Sponge campus: concave green land	SDG 6
Sponge campus: pervious pavement	SDG 11, 13

initiative of the 'Eco Club' for green actions (iZJU, 2022). By turning its campus into a living laboratory for sustainability, iZJU can educate students and offer potential solutions for the challenges of sustainable development (Hansen, 2017, p. 238).

As a Sponge campus in a Sponge City, the design of the iZJU campus has integrated green infrastructure and utilized nature-based solutions, so as to improve rainwater management, enhance climate resilience, and deliver many other ecosystem benefits. First, the implementation of the rainwater harvesting system on campus at iZJU draws implications on how to tackle the increasing water and energy shortages in flat urban areas (Ali & Sang, 2023), which contributes to the value of SDG 6, 7, 11, 13 (de Sa Silva et al., 2022) for sustainable urban development. Second, bio-retention areas, as small sponges for cities (Nguyen et al., 2019, p. 154), can improve urban greening, increase the overall area of urban green space, enhance ecological function, and encourage ecosystem diversity by providing new habitats for a range of organisms (Chan et al., 2018, pp. 773, 776). The installation of bio-retention areas contributes at the local scale to the value of SDG 6, 11, 13 (de Macedo et al., 2021, p. 1107). Moreover, the design of concave green land contributes to the value of SDG 6. Third, the use of pervious pavements is an urban infrastructure solution for mitigation and adaptation against climate change, which contributes to the value of SDG 11, 13 (Cacciuttolo et al., 2023, p. 15).

As a microcosm of society, campuses are small-scale models of cities. In our case study, the sustainability efforts at iZJU as a living laboratory draw implications on how campuses can contribute towards creating model future cities that are sustainable, resilient, and smart. The design of the Sponge campus at iZJU focuses on 'retention' and 'storage', which improves water management and enhances climate resilience while delivering many ecosystem benefits. This offers possible avenues for upgrading to urban water system 3.0 (Ren et al., 2017), and integrating the concept into the broader context of urban and regional planning (Rau, 2022), with the goal of advancing sustainability on a highly urbanized planet.

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9 How Climate Anxiety May Impact the Implementation of Smart Cities

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1. Introduction

The environment and climate we are living in continue to change at a pace that feels alarming. The information on this climate change crisis is also more readily accessible to the public than it ever has been before. With the reach of the internet, and the easy access many have to any and all information regarding climate change, this can contribute to intense overwhelm for individuals. For some, this can become a well-labelled phenomenon known as climate anxiety (also referred to as eco-anxiety but referred to as solely climate anxiety throughout this writing). In its simplest definition, climate anxiety involves grief associated with the loss of predictable places and traditions, as well as uncertainty associated with ongoing changes due to climate change (Clayton, 2021). It can impact pro-environmental behaviours (PEBs) in citizens and leave many in paralyzing helpless or hopeless states – a term known as eco-paralysis (Innocenti et al., 2023a, 2023b). This concern is on the rise.

Smart cities pose a possible solution to the climate change crisis through the use of technologies. However, questions arise on the implementation of these smart cities in communities where climate anxiety is also on the rise. The objective of this chapter is to explore and consider how policymakers may consider those with climate anxiety when proposing smart cities. It will answer questions such as: How may climate anxiety hinder the willingness of citizens to engage in smart city initiatives? How can those implementing smart cities consider and adjust for climate anxiety when introducing these concepts to citizens? And finally, how can smart cities be implemented in a way that increases PEBs and avoids increased eco-paralysis in the communities they are created in? These questions will be addressed through a thorough review of the literature on climate anxiety and eco-paralysis. The writer will also use understanding from therapeutic work to incorporate suggestions for climate anxiety management and consideration in smart city initiatives.

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2. Defining Climate Anxiety

Fully understanding the influence that climate anxiety may have on smart cities involves clearly defining climate anxiety. Innocenti et al. (2023a) begin the definition of climate anxiety in a simple form, by sharing it as an emotional distress response to climate change. The Climate Psychology Alliance contributes to this definition, stating climate anxiety occurs when an individual experiences chronic fear of oncoming "environmental doom" (2020). With the climate in continual change, this emotional response can become increasingly distressing to individuals (Stanley et al., 2021). This emotional distress can lead individuals to experience increased helplessness and hopelessness, substance use disorders for coping, increased suicidal ideation and attempts, panic attacks, obsessive-compulsive disorders, depression, complicated grief, and increased inter-partner violence, among other mental health comorbidities (Cianconi et al., 2020; Clayton et al., 2017; Mathers-Jones & Todd, 2023; Ursano et al., 2018). Individuals may experience a decrease in memory, an inability to concentrate, and an overall lack of function in daily activities (Innocenti et al., 2023b; Whitmarsh et al., 2022). Neurological concerns are also noted with climate change, including neurological deficits (Whitmarsh et al., 2022). All these concerns are often summarized into one phrase: climate anxiety.

Anxiety itself is an emotion that alerts those who experience it to a perceived threat or concern in the environment surrounding them. In terms of climate anxiety, this is relevant as well. Although some form of climate anxiety can be adaptive, as it can be an appropriate response to a threat posed to populations, it can become maladaptive when the degree of anxiety is large enough to produce the symptoms and comorbidities mentioned earlier (Mathers-Jones & Todd, 2023). Climate anxiety is maladaptive and will lower overall wellbeing (Stanley et al., 2021). Stanley et al. (2021) state that in these maladaptive cases, climate anxiety may promote active avoidance of care for self, leaving individuals in paralyzing states of fear, also defined as eco-paralysis.

Climate change may contribute to climate anxiety development through three different routes. These include: indirect, direct, and alternative influences (Ogunbode et al., 2022; Qin et al., 2024; Ursano et al., 2018; Whitmarsh et al., 2022). Direct influences include personal experiences of extreme weather events or natural disasters, with the consequences of the same being extreme distress (Cianconi et al., 2020; Clayton, 2021; Ogunbode et al., 2022; Qin et al., 2024). Indirect influences include social reactions to climate change, increased famines or lower crop yields contributing to lower quality of life, or other effects that may happen to an individual without them directly experiencing a climate event (Clayton, 2021; Ogunbode et al., 2022) Finally, alternative influences can contribute to climate anxiety. This effect occurs when media and technology affect an individual's reaction to climate change (Qin et al., 2024). Media may contribute to increased climate anxiety when it draws intense attention from its consumers (Ogunbode et al., 2022). Any and all of these three influences can impact the development of climate anxiety in a maladaptive form.

3. Climate Anxiety Adaptive Coping: Impact on Climate Action

Emotions exist on a spectrum of positive to negative experiences. Negative emotions often work to motivate human behaviour and action, assisting individuals to make major changes. However, when negative emotions are experienced as increasingly distressing to individuals, they can become pathologized, maladaptive and paralyzing (Dodds, 2021). Climate anxiety is one of these emotional experiences. Specifically, anxiety can lead to passive responses from individuals as a way to cope. These passive responses can often exist as avoidant behaviour (Sangervo et al., 2022). An individual distancing themselves from the reality of the situation, pretending climate change is not happening, can be a way they cope with potential climate anxiety (Dodds, 2021). Climate anxiety, however, is not innately a negative experience. Like all emotions, climate anxiety can play a practical role in climate action when processed and coped with in appropriate ways.

The more individuals are aware of the threat climate change has on the environment, and the more they may feel it personally, the more climate anxiety may be increased (Dodds, 2021). Contrarily, the more understanding an individual has of the environmental crisis, the more they may hope to act on climate change movements (Kałwak & Weihgold, 2022). When felt "at the right time" and "in the right way," climate anxiety can make important differences in an individual's ability to engage in climate change behaviours (Kałwak & Weihgold, 2022), such as smart cities. Adaptive coping needs to be present with these emotions, which is defined as the ability to manage climate anxiety without increased distress, or behaviours that may harm the environment.

Learning to cope with climate anxiety to make positive use of it is crucial for policymakers and individuals alike to understand. One of the ways an individual may be able to adapt to climate anxiety, and not have it affect climate action negatively, is through strengthening social supports (Clayton, 2021). Strengthening social support allows individuals to feel part of a bigger collective, and therefore may create more motivation to engage in climate action the collective may be engaging in. Coping with climate anxiety in isolation is not an easy task (Mah et al., 2020), with more vulnerabilities noted than when able to cope within a community setting. Although social security with others experiencing similar anxiety may be an adaptive coping mechanism, it is also important to remember there is not just one approach to assisting and teaching coping to those with climate anxiety. Some may feel more empowered by self-reliance, and others more empowered by community support (Mah et al., 2020). Understanding the population that you are working with may be crucial in beginning to understand coping for individuals.

Smart cities are the form of climate action that is the focus of this chapter. These policies are proposals that allow climate change to be addressed in a unique way. Like any proposal for climate change initiatives, these will come with the challenge of addressing possible climate anxiety within the population that they are hoping to implement these cities. Not considering climate anxiety, and its possible impact on climate action, may affect how smart cities are embraced by populations. Understanding the role of climate anxiety in the implementation of smart cities matters. Finding a balance between perceiving risk, but not being paralyzed by it, is the dichotomy that will have to be discovered. If an individual does not perceive any risk, the need to change decreases, and these individuals may engage in behaviours that hurt the environment (Dodds, 2021). Anxiety is needed to see the importance of change but cannot be so large that it creates inaction from constituents. Of course, hope is more likely to increase compliance with climate action (Sangervo et al., 2022), and policymakers should consider how to increase hope in their populations above all else.

4. Climate Anxiety Consideration on Smart Cities

When implementing smart cities, one needs to consider how the climate anxiety of its constituents may affect successful initiatives. In this section, three considerations will be explored. Firstly, eco-paralysis will be defined and explored further to note its impact on smart city initiatives. Next, pro-environmental behaviours and how climate anxiety impacts these will be explored. Emphasis on citizen willingness to engage in smart cities as a pro-environmental behaviour will be specifically explored. Finally, the role of self-efficacy in the context of smart cities will be noted.

4.1 Eco-Paralysis

Eco-paralysis, as previously discussed, is defined by increased helplessness, despair, and intense hopelessness at the state of the environment and planet (Innocenti et al., 2023a; Qin et al., 2024). For many, this contributes to a weakening of an individual's ability to react appropriately to the threat at hand (Qin et al., 2024). When individuals experience eco-paralysis, they are unlikely to engage in any behaviours that are pro-environmental (Innocenti et al., 2023b). Instead, behaviours may be more restrained, with individuals taking little to no action when experiencing eco-paralysis (Innocenti et al., 2023a). Individuals will not be able to respond with meaningful action when experiencing eco-paralysis, and may experience increased overwhelm when presented with conflicting options as to how to take action against climate change (Ágoston et al., 2022).

Proper education may play a key role in the treatment of eco-paralysis. Those with a balanced perspective of climate change and academically based education will be more likely not to be impacted by eco-paralysis than those who are entrenched in fear-based messaging and exaggerated environmental change claims (Innocenti et al., 2023a). Despite this, climate change messages are often created in a way that works to elicit a strong emotional reaction, as we see in fear-based campaigns (Stanley et al., 2021). In regard to smart city proposals and participation, governments and policymakers should be mindful of campaigns they put forward, considering the emotional responses of constituents. When proposals are created in a way that may perpetuate misinformation, or are created in a fear-based way, policymakers may find populations less likely to be agreeable to smart cities. Instead, they may find individuals experiencing higher levels of climate anxiety, and in turn, eco-paralysis. Proposals should be made in a way that conveys the truth about climate change, while remaining hopeful in their messaging. Presenting smart cities as an option in isolation may also contribute to less eco-paralysis, as there will not be multiple options for right and wrong engagement in change during this time.

4.2 Pro-Environmental Behaviour Impact

Pro-environmental behaviours are important in reducing emissions in the environment, decreasing the waste of natural resources, and weakening damage to the environment overall (Tian & Liu, 2022). These behaviours can also improve environmental quality (Qin et al., 2024). These actions may include personal choices such as recycling or reducing household waste, or they may exist on a larger social scale, such as smart cities. These behaviours are heavily influenced by the mindset of the individual and can be affected by mental health concerns such as climate anxiety and eco-paralysis. Understanding why individuals engage in PEBs is crucial, as this can affect engagement in climate change protocols such as smart city implementation.

Research is mixed on how climate anxiety affects the PEBs of individuals, with some research showing this anxiety improves PEBs, and others showing it hurts these behaviours (Qin et al., 2024). For example, Stanley et al. (2021) see climate anxiety as a factor for lower engagement in any environmental action, as it is a less activating emotion than emotions such as anger, and therefore may be more prone to disengagement from the feeler. Ogunbode et al. (2022) note people who cannot engage in PEBs are likely the same population who have high levels of climate anxiety. In addition, those who actively deny or avoid climate change may be less likely to engage in PEBs (Qin et al., 2024). Notably, Ogunbode et al. (2022) also note PEBs are tied to wealthier countries over those with lower socio-economic status. This may also have to do with cultural influences, noting individualistic societies are more likely to engage in PEBs than collectivist cultures and societies (Tam & Chan, 2017). This finding shows climate anxiety as a possibly motivating factor for some PEBs, as individualistic societies may be prone to climate anxiety over collectivist groups, as they find more personal responsibility for climate action (Kałwak & Weihgold, 2022).

More activating emotions, such as anger, may be better drivers of PEBs (Stanley et al., 2021). Stanley et al. (2021) notice this phenomenon, calling anger related to climate change concerns "eco-anger." Anger may also be an adaptive response to unfairness and injustice noted in climate change, and leaning into this emotion as opposed to climate anxiety may preserve mental strain (Stanley et al., 2021). Contreras et al. (2024) go as far as to determine that eco-anger is the only emotion that can predict positive engagement in pro-environmental behaviours. Therefore, policymakers may be more successful if they rely on anger-based messaging, versus fear-based messaging, when implementing smart cities (Stanley et al., 2021). Anger is more likely to motivate, less likely to create eco-paralysis, and will therefore be an important emotion to consider in these initiatives.

Smart cities are one form of PEB that may be influenced by climate anxiety, and therefore, climate anxiety must be considered in implementation. If the population officials are attempting to create a smart city within a community that consists of those with high climate anxiety, special considerations around the messaging of these policies need to be done. Instilling confidence through messaging may be one way for officials to consider this. When individuals are more confident in their ability to engage and be successful in green initiatives, such as smart cities, they may experience less climate anxiety and engage in PEBs (Meloni et al., 2019; Qin et al., 2022). Perception and understanding of all risks associated with a change in behaviour, and belief in an individual's ability to enact this change, may also allow them to engage in PEBs (Meloni et al., 2019; Ursano et al., 2018). When messages invoke anger towards the changes that need to be made instead of fear, eco-anger may increase PEBs as they lower depressive and hopeless feelings, and decrease stress (Stanley et al., 2021). Finally, more accurate knowledge regarding the environment is associated with higher levels of PEBs (Qin et al., 2022). By educating the public, and treating them as academic, policymakers will be providing accurate information on environmental change, and citizens will be more likely to engage with smart cities as PEBs as a result.

4.3 Self-Efficacy

Much of the research states the importance of self-efficacy in PEBs when an individual is experiencing high levels of climate anxiety. Self-efficacy is defined as an individual's ability to have confidence and belief in their ability to execute behaviours and achieve certain outcomes (Lopez-Garrido, 2023). Along with this, self-efficacy may help individuals adapt to the situation at hand successfully and adapt to changes in policy (Innocenti et al., 2023b). Self-efficacy may also increase self-esteem, prevent perceived vulnerability to the circumstances around a population, reduce stress, and possibly even prevent or delay the development of mental health concerns such as climate anxiety (Innocenti et al., 2023a). In regard to climate anxiety, self-efficacy can combat this concern, as it brings control back to the "out-of-control" feeling that anxiety presents with (Reese et al., 2022).

Although individuals with larger amounts of self-efficacy believe they have more power over the situations they are involved in, those with lower levels have doubts that they will be able to cope, which will increase the amount of anxiety they are experiencing (Qin et al., 2024). Alongside this, chronic fear of the fate of the environment, or anticipation of future problems, can create increased distress and rumination of painful thoughts (Innocenti et al., 2023b). These mental states can become increasingly difficult to navigate when self-efficacy is absent. Therefore, many researchers, Qin et al. (2024) being one of them, state self-efficacy is essential to the protection of the wellbeing of citizens.

The improvement of self-efficacy can promote PEBs in individuals (Qin et al., 2024), regardless of whether climate anxiety is present. Those who can balance the fear associated with climate anxiety with self-efficacy and hopefulness may see the highest engagement in PEBs (Sangervo et al., 2022). Those with higher climate anxiety may also have the highest forms of self-efficacy, due to developing the same as a coping mechanism, if they are able to engage with materials that continue to bolster this quality (Maran & Begotti, 2021). Feeling empowered to engage in PEBs through belief in self-efficacy can stop individuals from ruminating about choices out of their control (Innocenti et al., 2023b). When options are presented in a way that allows individuals to believe that they can make a difference to combat their own rational fears, this too can improve self-efficacy (Innocenti et al., 2023b), and may increase willingness to work with smart city developers. Therefore, it can be concluded that the fostering of self-efficacy should be a treatment goal for those with intense climate anxiety (Innocenti et al., 2023b).

Of course, self-efficacy should be considered in the implementation of smart cities. The data presented regarding the effect self-efficacy has will be crucial for mass communication about smart city policies. When those who are working to implement these policies communicate in ways that build up the population's self-efficacy, they may be more persuasive (Heald, 2017). For example, when a large amount of data is presented at once, whether about the impact of climate change, or the policies being put into place to combat climate change, individuals will more likely experience eco-paralysis than self-efficacy. Qin et al. (2024) note this especially in teenagers, finding that when adolescents experience a large amount of information about the threat posed by environmental change, anxiety increases, and they may respond by feeling weak and helpless, as opposed to developing feelings of self-efficacy. Furthermore, Reese et al. (2022) note the importance of groups in the fostering of self-efficacy. Higher normal social behaviour that consists of participating in environmental change means that individuals will be more likely to engage themselves (Reese et al., 2022). Being involved in a group can increase self-efficacy and encourage people to act (Reese et al., 2022). All of this considered, individuals will be much more likely to engage with smart city proposals if they believe that the action of engagement will combat climate change, or create other meaningful change (Heald, 2017). Interestingly, groups may assist with this and may be important factors to consider when fostering self-efficacy for communities who are having smart cities implemented.

5. Limitations and Future Research

The research on climate anxiety is not without its limitations. It is interesting to note that much research done regarding climate anxiety is conducted within predominantly White and Westernized communities (Ogunbode et al., 2022). However, smart cities are posed for a variety of different cultures and communities. Examining the impact of climate anxiety on any culture where a smart city may be implemented will be crucial to the successful implementation of this type of structured change. Future research considerations that could be made, and limitations that are noted in the research are as follows:

- Climate anxiety is more commonly researched in younger demographics versus older generations (Whitmarsh et al., 2022). This means much of the research noted in this chapter is related to young populations. Considerations with climate anxiety may look different for older generations, and thus policy creation may look different for these groups.
- Vulnerable populations also need to be heavily considered when implementing smart city initiatives. Certain groups, such as those with co-occurring mental health concerns (Whitmarsh et al., 2022), may be more prone to the development of climate anxiety, and the consequences that come along with it. Although the research speaks about young demographics as part of a vulnerable demographic, not all vulnerable populations are discussed at length, or even completely researched. Understanding the full population a smart city hopes to be implemented in will be necessary, as accommodation for these vulnerable populations needs to be considered.
- Other vulnerable groups, such as females, the elderly, those with lower socio-economic status, children, Indigenous communities, and some different nations (Cianconi et al., 2020; Clayton et al., 2017; Whitmarsh et al., 2022), may be more prone to the effects of climate anxiety. Having an understanding of the demographic you are hoping to implement a smart city within is key. If the nation is vulnerable in itself, or fuller with young, elderly, Indigenous, or women, climate anxiety may need to be considered in a different regard. Many gaps in the research still exist with these communities.
- Unique considerations should be made around young populations and the use of the internet. Younger demographics may be more prone to alternative effects of climate change, and in turn climate anxiety (Qin et al., 2024). Since much information is available on the internet, and young people are spending an increased amount of time on these platforms, the different messages seen by these demographics may influence climate anxiety. Extended attention paid to helpless messages about climate change, as often found in fear-based messaging, can contribute to increased climate anxiety (Heald, 2017). Likewise, academic climate change messages that have hopeful connotations may contribute to PEBs.
- There are some gaps in technology self-efficacy for other demographics who are less fluent with the internet (Deng & Fei, 2023). Confidence in digital skills can greatly improve the self-efficacy of individuals (Deng & Fei, 2023), specifically in the context of smart cities. Considering populations

with less awareness of the digital space, policymakers of smart cities will need to be aware of how to balance new implementations without perpetuating a helpless feeling regarding technology. This could lead to eco-paralysis and non-compliance with protocols.

Demographics are underrepresented in many cases of climate anxiety research, as noted in the above limitations. Considering vulnerable, younger, and older populations, those who are creating smart cities may have a fuller picture of how to implement policies. These demographics all come with their unique challenges and should be heavily understood and researched when considering how to properly implement climate policy changes.

6. Conclusions and Recommendations

As the climate continues to change, action needs to be taken to address and work towards solutions to prevent continued destruction of the environment. Along with this, as the climate changes and individuals are exposed to the threat that this poses, climate anxiety will also notably increase in the population. Climate anxiety is an adaptive response to the ever-changing concerns in our environment and does not need to be treated as a threat when implementing climate-addressing behaviours, such as smart city development. Instead, policymakers should consider how to discuss these heavy topics in a way that creates feelings of self-efficacy in the changes that will be made within city infrastructure. Self-efficacy can increase pro-environmental behaviours, and thus may have the impact of increased participation in these initiatives. Messaging needs to be considered, as fear-based messaging, hopeless or helpless environmental conversations, or messaging that takes away the self-efficacy of its listeners may increase climate anxiety, and therefore may not be effective in creating compliance with smart city initiatives.

Certainly, policymakers need to consider limitations to research and understanding around climate anxiety and its subsequent concerns. Limitations in the research include the populations that have been studied regarding climate anxiety, noting younger demographics being heavily represented in studies over other groups. Since cities involve a variety of populations, policy creators will need to understand more than just the younger demographic's relationship to experiences such as climate anxiety. More research will need to be done in this area to allow for a fuller understanding of it, and policymakers should continue to remain up to date on these studies.

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Section 4

Technology

Technology is vital in making cities smart and sustainable by optimizing infrastructure, enhancing transportation, and promoting sustainability. It uses IoT, AI, and big data for efficient management. Smart grids and buildings support renewable energy and reduce waste, while traffic systems reduce congestion. Environmental sensors maintain air quality. Digital platforms engage citizens in decision-making and service access. Data-driven decisions enhance resilience. These technologies boost economic growth and innovation through collaboration among governments, businesses, and academia, improving urban quality of life.

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10 APIS

A Data Ecosystem to Manage Distributed Energy Resources

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1. Introduction

1.1 Overview of the Global Installed Capacity of Distributed Photovoltaic Systems

As of 2023, the global installed capacity of solar photovoltaic (PV) energy has reached approximately 1,200 gigawatts (GW). This substantial growth reflects increasing investments in renewable energy technologies and highlights their critical potential for driving global decarbonization efforts. According to the International Energy Agency (IEA), further expansion of distributed photovoltaic (DPV) capacity could yield annual reductions of between 2 and 4 gigatons of CO_2, significantly contributing to international climate goals (IEA, 2023). Conversely, a 1% decrease in global DPV installed capacity could result in the emission of up to 20 million metric tonnes of CO_2. This scenario underscores the severe implications of reducing generation capacity. In various countries, such reductions could exacerbate air pollution and elevate greenhouse gas emissions, adversely impacting public health and overall air quality.

1.2 Facilities of Distributed Photovoltaic Systems

Currently, DPV facilities (Figure 10.1) typically comprise three core components:

- Solar Panels: These devices convert sunlight into electricity through photovoltaic technology.
- Photovoltaic Inverters: These inverters transform the direct current (DC) produced by the solar panels into alternating current, which is suitable for integration into the electrical grid. In addition to their conversion function, they manage the energy flow and the overall system performance.
- Monitoring Systems: These tools provide continuous oversight of the facility's performance, enabling rapid identification of anomalies and facilitating prompt interventions when issues arise.

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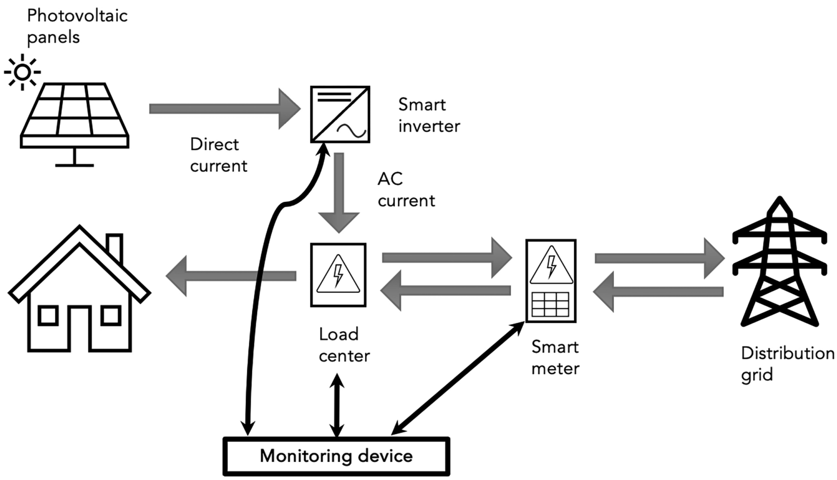

Figure 10.1 DPV facilities

1.3 Real-Time Monitoring for Energy Transition to Distributed Photovoltaic Systems

Real-time monitoring is essential for ensuring the optimal performance of DPV installations (van Sark, 2023). It allows for the immediate identification of issues such as dirt accumulation on panels or inverter failures, thereby enabling quick recovery and maintaining efficient energy consumption. In the absence of effective monitoring systems, DPV installations face significant reductions in energy production, which can negatively affect profitability and hinder their capacity to contribute meaningfully to global decarbonization efforts.

This chapter provides further details of the APIS digital platform, which features an IoT energy auditor for collecting distributed photovoltaic systems' (DPVs') operation data and grid parameters on a blockchain. The remainder of this chapter is structured as follows: Section 2 presents the challenges that DPVs are currently facing. Section 3 describes the living labs of distributed energy resources (the DER living labs). Section 4 provides a technical description of the APIS platform. Section 5 concludes this chapter by drawing a number of conclusions from the implementation and piloting of the APIS platform.

2. Challenges of Distributed Photovoltaic Systems

This section provides a list of the most prominent challenges currently faced by distributed photovoltaic systems, more specifically DPV facilities, photovoltaic installers, and grid operators (E2BIZ, 2021).

2.1 Challenges Faced by DPV Facilities

DPV facilities encounter various significant challenges that can impact their efficiency. These include:

- Dust Accumulation: Dust and debris that accumulate on panels can significantly reduce sunlight capture, leading to decreased energy output.
- Physical Damage: Panels may suffer damage due to external factors such as flying objects or hail.
- Grid Variations: Fluctuations in the electrical grid can disrupt energy production and compromise stability.
- Cloud Cover: Variability in sunlight exposure during cloudy weather can result in significant drops in energy generation, occasionally by as much as 50% for prolonged periods. This inconsistency complicates the ability of facilities to achieve expected energy outputs and can hinder effective energy management strategies.

2.2 Challenges Faced by Photovoltaic Installers

Currently, PV installers face additional challenges, which include:

- Disconnection of Monitoring Systems: A lack of real-time performance data can impede timely interventions.
- Diversity of Inverter Brands and Models: Variability among equipment types complicates data accessibility and management, making system integration more difficult.

2.3 Challenges Faced by Grid Operators

Grid operators grapple with the effects of climate variability, which can lead to grid instability (Centro Energía, 2021). Likewise, grid operators also face challenges related to grid failures. These issues in transmission and distribution may arise from irregular influxes of renewable energy, creating potential risks for grid reliability.

3. DER Living Labs

The DER lab is a collaborative framework designed to facilitate the real-world testing and development of distributed energy technologies. This innovative approach brings together a diverse array of stakeholders, including researchers, energy providers, technology developers, and community members, to co-create solutions for modern energy challenges. The lab's hands-on environment allows for experimentation with a wide range of technologies and strategies aimed at enhancing the efficiency, resilience, and sustainability of DER systems (Fulli et al., 2022).

A DER Living Lab typically includes the following key features:

- Collaboration: By uniting a diverse group of stakeholders, the DER Living Lab fosters a collaborative environment where innovative solutions can be developed and tested. This collective input is crucial for addressing complex energy issues, often requiring multiple perspectives and expertise.
- Real-World Testing: The lab provides a platform for experimenting with new technologies in conditions that closely mimic real-world scenarios. This practical approach helps identify potential challenges and optimize solutions before broader implementation, ensuring their effectiveness and adaptability.
- Focus on Sustainability: The primary goal of the DER Living Lab is to enhance the sustainability of energy systems. By testing various DER technologies, the lab aims to find efficient and resilient solutions that can be seamlessly integrated into existing infrastructures, minimizing environmental impact.
- Diverse Technologies: The lab supports a wide range of technologies, including renewable energy sources (such as solar and wind), energy storage systems, and smart grid technologies. This diversity allows for comprehensive testing and development of integrated energy solutions, fostering interconnection and efficiency.

The following list shows the benefits of the DER Living Lab:

- Enhanced Efficiency: By testing and refining technologies in a collaborative environment, the lab aims to develop more efficient energy systems that can improve efficiency and lower costs, aligning with sustainable economic goal.
- Increased Resilience: The lab's focus on real-world applications helps identify strategies that enhance the resilience of energy systems, making them more robust against disruptions, such as natural disasters or grid failures.
- Community Engagement: Involving community members in the development process ensures that the solutions created are not only technically sound but also socially acceptable and beneficial, increasing adoption and positive local impact.
- Innovation Acceleration: The lab serves as a catalyst for innovation, allowing new ideas and technologies to be rapidly prototyped and tested. This accelerates the development cycle, promoting quicker and more effective adoption of advanced solutions.

The DER Living Lab represents a significant step forward in the integration of distributed energy resources, aligning technological advancements with the needs of communities and the environment. By fostering collaboration and experimentation, it aims to create a more sustainable energy future, ensuring a secure and clean energy supply for current and future generations.

3.1 Challenges in Integrating DER Living Lab

The following list shows the challenges that DER living labs are currently facing:

- Infrastructure Adaptation: The existing grid infrastructure was primarily designed for centralized power generation, making it ill-suited for the decentralized nature of DERs (David & Schönborn, 2018). Modifications or complete overhauls are often necessary to accommodate smaller, distributed energy sources such as solar panels and wind turbines, as well as large battery storage systems. This adaptation can be complex and costly, impacting the reliability and efficiency of grid operations.
- Operational Complexity: The rise of DERs introduces significant operational challenges for distribution system operators. As the number of connected devices increases, so does the complexity of managing them (Gordon et al., 2022). This complexity is exacerbated by the variability in generation and demand, particularly from renewable sources, which can lead to unpredictable fluctuations in power supply. Traditional centralized control methods may no longer suffice, necessitating advancements in grid management technologies and strategies.
- Power Quality and System Protection: The integration of DERs can affect power quality and system protection mechanisms. For instance, the addition of DERs can desensitize existing protective relays, leading to challenges in detecting faults and maintaining system stability. Moreover, the direction of power flow changes with DERs, complicating traditional protection schemes that were designed for unidirectional flow from centralized plants to consumers.
- Data Management and Cybersecurity: The deployment of smart meters and IoT devices in a DER-rich environment generates vast amounts of data. Managing this data effectively is crucial for optimizing grid operations but requires significant computational resources (IEA, 2022). Additionally, cybersecurity becomes a pressing concern, as the integration of various technologies increases the potential for cyber threats, necessitating robust security measures to protect grid infrastructure.
- Regulatory and Market Frameworks: The shift towards a more decentralized energy model challenges existing regulatory and market frameworks. Utilities must navigate new business models that account for the role of prosumers – consumers who also generate energy. This transition requires careful planning and investment to ensure that all stakeholders benefit from the integration of DERs, which may involve significant changes to pricing structures and regulatory policies.

3.2 Importance of Interoperability

Interoperability is a fundamental aspect of DER living labs, allowing disparate systems and devices to communicate and function cohesively. This capability fosters a more integrated energy ecosystem where various distributed resources – such as solar panels, energy storage systems, and electric vehicle (EV) chargers – can share data and collectively optimize performance, ultimately enhancing grid reliability and operational efficiency.

3.3 Importance of Standard Communication Protocols and Cybersecurity

Establishing standard communication protocols is essential for ensuring compatibility among the diverse technologies in the energy sector. These protocols facilitate reliable data exchanges and maintain system integrity. Additionally, prioritizing cybersecurity is crucial to protect sensitive data and ensure the secure operation of DER systems, thereby safeguarding them from potential cyber threats.

3.4 Importance of Standard Datasets

Utilizing standardized datasets is critical within DER living labs, for example, NASA POWER Project and the Openmod initiative (NASA, n.d.). These datasets ensure consistent collection, storage, processing, and sharing of information across various platforms. Standardized formats promote data quality and accessibility, ultimately supporting informed decision-making and enabling research efforts aimed at improving DER technologies.

3.5 Role of AI and ML in Addressing DER Challenges

Artificial Intelligence (AI) and Machine Learning (ML) play pivotal roles in analysing the vast amounts of data collected within the living lab (Hall, 2023). These technologies enable predictive analytics, optimizing energy generation and consumption patterns, proactively troubleshooting issues, and enhancing the overall performance of DER systems. By leveraging AI and ML, stakeholders can navigate the complexities of energy management more effectively and respond dynamically to varying operational conditions (Dodge et al., 2022).

3.6 Role of Blockchain in Traceability, Certification, and Security

Blockchain technology introduces an additional layer of transparency and security to the DER ecosystem (Fulli et al., 2022). It ensures data traceability, allowing stakeholders to verify the authenticity and integrity of information shared across the network. This technology fosters trust in the system and guarantees that the data used for decision-making and regulatory reporting is reliable.

4. The APIS Platform

This section presents the APIS platform. It first describes the main technical components, the ongoing piloting, testing, and validation process, and the current maturity status (Technology Readiness Level (TRL)).

4.1 Lab-Living Open-Access Data

The APIS platform (see Figure 10.2) works as a living lab for open-access data, providing key functionalities for the effective management of distributed DPV systems. The core features of the APIS platform include:

- Real-Time Monitoring: APIS enables continuous tracking of energy generation metrics and performance indicators, facilitating timely interventions to improve efficiency.
- IoT Communication: Integration of Internet of Things (IoT) technologies to perform data collection and systems management.
- AI & ML Integration: Employing advanced algorithms to analyse data for improved operational decision-making.
- Blockchain Technology: Ensuring data integrity and traceability to allow auditing while also improving security and trust.

4.2 Description of Pilot Programs in Mexico and Chile

APIS is currently piloted in grid-connected facilities in Mexico and Chile, allowing for comprehensive real-world evaluations of its functionalities. These pilot programs validate APIS's capabilities in energy monitoring and performance optimization.

4.3 Testing and Validation of APIS at Facilities Connected to Distribution Grids

The testing phase focuses on evaluating APIS's performance across diverse operational contexts, assessing its effectiveness in managing data and enhancing the functionality of DPV systems connected to distribution grids. Initial results from these pilot programs have provided valuable insights into system performance, user interactions, and potential areas for improvement, paving the way for further development and refinement of the APIS platform.

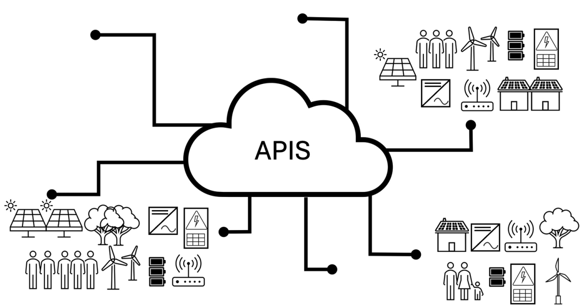

Figure 10.2 High-level view of APIS platform

4.4 APIS – Technology Readiness Level (TRL)

APIS is currently positioned at a TRL of 6, indicating that it has been successfully validated in real-world environments and is ready for further optimization and broader deployment.

5. Conclusion

This chapter emphasized the critical role platforms like APIS play in advancing distributed renewable energy systems, providing robust data management, monitoring capabilities, and real-time analytics. APIS serves as a vital tool in the transition towards a more sustainable energy future, enhancing the management of distributed resources and optimizing their impact on the grid. Digital platforms like APIS represent the future of DER management, harnessing advanced technologies and collaborative approaches to pave the way for a cleaner, more efficient, and resilient energy ecosystem. Future development of APIS will involve integrating additional functionalities for smart meters and EV chargers, enabling comprehensive energy management across the ecosystem. Broader adoption of APIS and similar platforms has the potential to significantly impact the electricity sector. By facilitating efficient DER management, these tools support the transition to a more sustainable energy landscape, reducing reliance on fossil fuels and promoting the integration of renewable resources.

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