Smart Cities: Issues and Challenges

Mapping Political, Social and Economic Risks and Threats

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Edited by
Anna Visvizi and Miltiadis D. Lytras

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Elsevier
Radarweg 29, PO Box 211, 1000 AE Amsterdam, Netherlands
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, United Kingdom
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States

Library of Congress Cataloging-in-Publication Data
A catalog record for this book is available from the Library of Congress

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-0-12-816639-0

For information on all Elsevier publications visit our website at https://www.elsevier.com/books-and-journals

Publisher: Joe Hayton
Acquisition Editor: Brain Romer
Editorial Project Manager: Andrae Akeh
Production Project Manager: R.Vijay Bharath
Cover Designer: Greg Harris

Typeset by TNQ Technologies

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Preface

This volume and, indeed, the process of making it come to live, attest to the key topic and the key message that this book conveys, i.e., that the dialogical relationship between information and communication technology (ICT) and our lives unfolds in the theater of modern cities. ICT proved to be the key enabler in the process of conceiving this volume, working with our authors and the Publisher as we were changing the geographical venues and—by default—were testing the degree of "smartness" of the cities that we visited. Athens, Berlin, Warsaw, Rome, Trikala, Jeddah, Mons, Mexico City, Ottawa, Barcelona, and New York are just a few of the places that we had the opportunity to visit when working on this volume and see into the ways advances in ICT are employed to benefit cities' inhabitants.

Given the potential inherent in sophisticated ICT-enhanced tools, applications, and systems and the great capacity of our engineers to apply technically and technologically complex solutions to everyday problems and challenges we face, it is absolutely necessary that the remaining stakeholders follow the suit. In other words, as advances in ICT become ever more accessible and useable, it is necessary that regulators and policy-makers join the conversation and develop commensurate ICT- and smart cities–friendly frameworks and strategies. But certainly, the discussion on smart cities and the making of smart cities require also direct involvement of the citizens. Clearly, one of the challenges in this respect is that many end users of smart city applications are intimidated by the technological aspect of ICT-enhanced tools. The whole idea and the broader framework are incompressible to way too many. Thus, the relevance and the value added of smart solutions are undermined.

Central in the discussion on smart cities are questions of ethically and socially sensitive use of ICT-enhanced tools and applications in the city space, starting with issues pertinent to privacy, through questions of democracy, participation, representation, and expanding beyond questions of inclusion, well-being, and prosperity. As cities transition toward being smarter, several contentious issues arise. These include seemingly irreconcilable juxtapositions such as the one of how much surveillance and monitoring is needed to ensure safety in city space or, for instance, to what extent feedback obtained from social media and decisions infused with that feedback are legitimate. A great number of questions are bound to emerge. The good news is that research on smart cities has been unfolding for a considerable while now. Today, the momentum has come for the diverse strands of research on smart cities to engage in dialog and cross-fertilize discussion otherwise taking place in a considerable disconnect.

This volume originates in the recognition that smart cities ought to be better understood by a broad spectrum of stakeholders. The technological sophistications of several topics pertinent to smart cities research notwithstanding, the rationale behind this volume was to facilitate readers otherwise ignorant of the topic to get a fair idea of what a smart city actually is. The volume — that we are so pleased to share with our readers — today establishes a platform, a meeting point for all stakeholders involved in the making of smart cities, to acquire an insight into key topics and issues that influence the process of cities transitioning to become smarter.

The Editors
Anna Visvizi
Miltiadis D. Lytras

Acknowledgment

This edited volume is the outcome of a realization that to a large part of our societies smart city, seen as a concept and policy-making consideration, remains an under-understood concept, frequently associated only with the debate on advances in information and communication technology. This book, by promoting a truly inter- and multi-disciplinary approach to the study of smart cities, seeks to bypass this issue. In this way, it hopes to involve in the debate on smart cities audiences otherwise not particularly keen on doing so. This volume offers a comprehensive insight into what smart city is, what it is not, and how it is evolving. The chapters included in this volume attest to that. We are grateful to the contributing authors, who responded to our invitation to join this project. We would like to thank them for their hard work and patience. We are grateful to the Publisher and the entire team that dealt with the book production process.

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CHAPTER

Smart cities research and debate: what is in there?

1

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Chapter outline

1. Introduction

Several developments have led to an increased interest, and a resultant debate, on the possible use of information and communication technology (ICT) in cities and urban space. As the debate gains on momentum, a great number of new insights populate the field, thus ostensibly redefining it and delineating its disciplinary boundaries anew. Apart from scholarly research on smart cities, the topic has been skillfully taken up by think tanks and consulting firms, making smart cities one of the key topics discussed in fancy settings and environments. Interestingly, if smart cities are the buzzword of the popular debate today, sustainability has become the keyword defining the thrust of that debate (Lytras et al., 2019). The smart cities—sustainability nexus that this debate embodies has been driven by a number of factors, the validity and relevance of which have been recognized, among others, in the United Nations Sustainable Development Goals Agenda, especially Goal 11 "Sustainable cities and communities" (UN, 2015).

Following in the footsteps outlined in the 1976 United Nations Conference on Human Settlements and Sustainable Urban Development, Goal 11 highlights that it is necessary to think about urban space in a holistic manner. That is, our thinking about cities and urban space should be founded on the recognition of a dynamic nature of cities and urban space, their evolution, and hence the necessity to make both cities and urban space resilient to risks, threats, and other kinds of challenges (Klopp, Petretta, 2017; Lützkendorf, Balouktsi, 2017) and sustainable. Increasingly, the debate on smart cities, more or less explicitly, endorses the normative and

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00001-6

prescriptive components that the SDG11 entails. As a result, the specific to that debate focus on the value added of ICT-enhanced tools and applications is seen as a function of the broader concept of sustainability. Not surprisingly, therefore, given the centrality of policy-making considerations geared toward sustainability in contemporary political discourse, having endorsed the imperative of sustainability, the debate on smart cities too has turned into one of the most topical fields of academic research and popular debate.

Apart from the bigger narrative on sustainability, the exponential growth in interest in smart cities has also been triggered by such factors as increasing pace of urbanization, growing awareness of the complex challenges that cities face, followed by a reconceptualization of cities as hubs of human interaction, and indeed, centers of authority. Liberalization of trade, increasing labor mobility, increased dynamic of cluster development, and a tendency to decentralize state administration, reinforce the process of cities gradually turning into centers of authority. This is followed by "the sinking in" of the understanding that the fourth Industrial Revolution is taking place here and now, and so influences every aspect of our lives. The debate and policy-making considerations that follow endorse the recognition of the value added of ICT as an enabling and mitigating factor in city space. In other words, today, as never before, the time is ripe not only to discuss smart cities as a piece and parcel of the broader process of socioeconomic growth and development but also to devise strategies that will make cities sustainable.

In this view, also the notion of sustainability requires a few words of clarification. It is to stress that sustainability is not only about environmental sustainability but also about establishing a socioeconomic equilibrium allowing individuals, societies, and current and future generations of cities' inhabitants to grow and excel, to exercise civil liberties, to live well, and to prosper. Topics pertinent to these considerations have been long present in the debate on smart cities (Vanolo, 2016; Mattern, 2017; Deakin, 2013). Other old—new topics step in the debate too, including, for instance, the imperatives of ethically and socially sensitive ways of using technological advances in city space (Visvizi et al., 2017; Mazzucelli and Visvizi, 2017). Another issue that appears prominently in the debate is the very accessibility and usability of ICT-enhanced services (Visvizi et al., 2019) seen as a measure of cities being inclusive and democratic (Lytras and Visvizi, 2018; Barns, 2018). In brief, several avenues of research in smart cities debate can be identified (Bibri, 2019), and, as several authors emphasize, research on smart cities requires inter- and multidisciplinary approaches if the plethora of topics and issues that are pertinent to the field are to be effectively addressed (Kitchin, 2015, 2016 Visvizi and Lytras, 2018a).

The interesting point that needs to be made here is that even if over the past decade the debate on smart cities developed exponentially, respective arguments and conversations run largely in parallel to each other, i.e., they were frequently confined to very specific fields/disciplines of research effectively preempting dialog and cross-fertilization among diverse fields of research. Today, drawing on work and publications pertaining to urban geography, urban studies, architecture, engineering, computer science, but also sociology, political science, communication studies, and many more (Datta, 2015; Marvin et al., 2015; Karvonen et al., 2018; Wiig and Wyly, 2016; Cardoullo and Kitchin, 2018), inter- and multidisciplinary approaches are not only well-received but, indeed, encouraged. Clearly, only by drawing from each other's work will be able to deepen our understanding of what the concept of smart cities entails, to enhance the existing conceptual tools and frameworks, and thereby more effectively infuse the policy-making process with valid research findings.

This volume recognizes the scope, the breadth, and the illuminating insights that scholars active in the field have brought to the debate over the past decades, thereby adding to our knowledge and understanding of the variety of issues and topics pertinent to smart cities. Featuring contributions of scholars active in fields as diverse as sociology, political science, international relations, geography, urban studies, architecture, computer science, and engineering, this volume brings selected strands of the debate on smart cities together to showcase the broad conceptual and empirical framework against which the smart cities debate unfolds today. In this sense, this volume seeks to add to the ongoing debate and, by reaching diverse stakeholders, including also those otherwise not really involved with the topic, steer their interest and encourage them to meaningfully join the debate. The remainder of this chapter is structured as follows. First, the caveats related to the definition of smart cities are discussed briefly. Then, a few points on the conceptual framework underpinning the discussion in this volume are made. In the third move, an overview of key topics and issues addressed in this book is presented along with a more detailed description of chapters included in this book. Then conclusions follow.

2. Smart cities: definitional caveats

Even if the academic debate on smart cities matures and ever more sophisticated insights into the sphere of the technically possible in urban space are proposed, for the preponderant part of city dwellers, smart solutions remain a misunderstood, unrecognized, or feared product of "science fiction" (Lytras and Visvizi, 2018). In other words, considerable gap exists between what citizens expect vis-à-vis ICT-enhanced solution in city space and, importantly, what they are able to use. From a different angle, many smart services have been embedded in the city space so seamlessly that their existence has become a part of the daily routine for masses. In this sense, many aspects of what would be referred to as smart city applications or solutions remains underrecognized for the very users of those solutions (Lytras et al., 2019). In brief, as the public debate is filled with references to smart cities, frequently, confusion steps in as to what exactly the concept "smart city" implies, what is at stake, and how it fits in the broader framework of debates unfolding in other fields and disciplines. This volume seeks to navigate this issue and make the concept of smart cities more approachable to those who have had the opportunity to engage in its thorough study.

Several conceptual and methodological issues have to be clarified before outlining this volume's content, including the very definition of smart city, and indeed other concepts that tend to be used—wrongly so—interchangeably in the debate. One of such concepts is the concept of megacity. Frequently conflated, there is a significant qualitative difference between megacity and smart city, with each of them triggering quite distant research questions and topics (Visvizi and Lytras, 2018a). A megacity can be defined as an "urban agglomeration with a total population of 10 million people or greater, consisting of a continuous built-up area that encompasses one or more city centers and suburban areas, economically and functionally linked to those centers" (Safarik et al., 2016). It can be argued that megacities research originates from very pragmatic considerations related to spatial considerations, urban infrastructure planning, including urban design and resilience of urban space, and related questions of governance and sustainability. The key cognitive lens applied in the debate on megacities are defined by the questions of population size, geographical location, and exposure to risks and threats, including those related to geographical location and so natural disasters, etc. (Safarik et al., 2016; Meerow, 2017; Commons, 2018). The smart cities debate—because of its emphasis on harnessing advances in ICT seen as a function of citizens' well-being—adds a qualitatively new kind of considerations to the debate on cities in general. Seen in this way, a megacity might benefit from smart applications and hence become smarter; yet, a smart city will not necessarily become a megacity. In other words, the two concepts are ontologically separate.

Although smart city is not a new concept, the past few years have brought substantial developments both in the field of research (Bibri and Krogstieb, 2017; Bibri, 2018; Reddy Kummitha and Crutzen, 2017; Kitchin, 2019 and Rose, 2017) and in the very fabric of cities, including the problems they face, how these are resolved, etc. (Anthopoulos, 2017). Therefore, as the debate on smart cities gains its new momentum, the group of stakeholders involved in the debate broadens, and new insights are brought to the discussion on smart cities. Driven by advances in sophisticated ICT and an accompanying set of considerations originating from social science, computer science, natural sciences, engineering, architecture, and so on, today, smart cities research revolves around ideas and considerations related to the possibility of generating added value to a city's inhabitants by means of ICT-enhanced services (Visvizi and Lytras, 2018b). Clearly, the focus of smart cities research is directed at new ICT-enhanced services, service responsiveness, and sustainability. However, other considerations such as agency of individual city inhabitants, society, and discourses and ideologies that come to play in the process of making a city smart form an equally important part of the debate (Cardullo and Kitchin, 2018; Cardullo et al., 2019).

Given the diversity of disciplinary, conceptual, and empirical approaches employed in the smart cities debate, there is no single definition of what a smart city entails. A smart city may be referred to as representing an "urban development model" geared toward the utilization of human, collective, and technological capital within urban agglomerations (Angelidou, 2014, 2015; Ahvenniemi et al., 2017). In this vein, a smart city may also be conceptualized as "an ultramodern urban area that addresses the needs of businesses, institutions, and especially citizens"

(Khatoun and Zeadaly, 2016). In a commonsensical manner, the concept of smart city is associated with advances in ICT and the possibility of effective use of ICT-enhanced tools and applications in city and urban space. Smart city is thus bound to be an aggregate concept that highlights the interconnectedness of diverse aspects of a city's functioning, including questions of governance, participation, and representation; economy; energy; mobility; living, and well-being; and of course environment. The imperative of sustainability, as explained earlier, frames these considerations. Consensus has consolidated that the following conceptual and policy-making pillars delineate smart city, seen as a concept and policy-making imperative: economy, mobility, energy, environment, governance, and living. A case can be made that it is the space in-between these pillars, a space populated by issues such as (tele)communication, representation, participation, safety, security, inclusiveness, transparency, accountability, access to information, etc., and that is as valid as the pillars themselves. What brings these pillars, and the space in-between them, together, and hence makes cities 'smart', is responsible, visionary, ethically and socially sensitive use of advances in ICT geared toward cities' sustainability.

3. About the book and the conceptual framework it adopts

The discussion in this volume is divided in four parts. Part 1 looks at smart cities from a broad perspective that incorporates the recognition that with the onset of the fourth Industrial Revolution, the degree of change our societies are bound to embark on is immense (Visvizi and Lytras, 2019). Considering the increasing pace of urbanization, cities and urban space are bound to serve as the venue where the nonlinear evolution of our societies will unfold. Questions of modes and models of governance, democracy and civic participation, social inclusion, intergenerational solidarity, and prosperity building form just a few of the dimensions along which that evolution will unfold. Clearly, the latter will require both physical structures and virtual space, i.e., services and platforms facilitated by advances in ICT. In this sense, the question of managing urban space acquires a new dimension. Chapters 2, 3, 4, and 5 form this section sketch and explore the key lines of the argument either already discussed in detail in the literature or still waiting to be explored, including civil liberties, participation, democracy, and social inclusion in a context infused with new ICT-enhanced tools and applications.

In part 2, questions of safety, security, and resilience of cities and urban spaces are discussed. The starting point of that discussion is the recognition that safety and security are ontologically distinct (Visvizi, 2015). That is, safety is a concept most closely associated with public space and, therefore, is best defined by reference to well-being and stability. Security, on the other hand, denotes absence of threat. The really important point that should be made here is that safety, embedded in public sphere and public space governance, necessitates quite different policy tools and policy responses than the "harder" concept of security does. In other words, whereas safety would be most closely associated with policing and relevant regulatory frameworks, security, associated with external threat, might imply the use of the military and related tools. That is, key in the discussion on safety is the acknowledgment that it is possible to identify nascent risks and, thus, preempt them (Beck, 1992). Hence, with regard to safety, most closely associated with measures and toolkits specific to internal policy, e.g., policing and rules of public order, emphasis is placed on prevention. Security, in contrast, requires measures most commonly linked to the necessity to react, i.e., to address imminent threats to our population and infrastructure. In smart city space, the distinction between safety and security is vital in that it highlights the sensitive and yet necessary issue of division of competences among agencies dealing with safety and security within the same city or the same urban space. It suggests that different sets of policy prerogatives and different logics of action will underpin respective agencies' action. It also suggests that ICT-enhanced services and applications designed to manage both safety and security in city space are interoperable. Chapters 6, 7, and 8 included in this part offer a fair insight into the most pressing issues and developments in this respect.

By means of expanding the discussion, in part 3 of this volume, new perspectives to our thinking on smart cities are presented. Founded on the recognition that following the adoption of ICT-enhanced tools and applications cities acquire a yet another tool to boast their efficiency and sustainability, the chapters included in this part frequently implicitly view smart cities as the nascent centers of power, influence, and authority. In this sense, the authors of Chapters 9, 10, 11, and 12 address issues as diverse and as salient as those related to talent management, knowledge management, cluster development, and many more. ICT-enhanced tools and applications are seen in this way as the key enablers of sustainable growth and development of cities. The volume closes with a selection of carefully conceptualized and elaborated case studies, including that of Mexico City and Riyadh, as well as Taiwan, Saudi Arabia, and the United Kingdom. The case studies add the very much needed empirical angle to the discussion in the preceding chapters. The following section offers a detailed overview of the chapters' content.

4. Review of the chapters' content

Following this introductory Chapter 1, in Chapter 2, titled "Democracy and governance in smart city," Cláudia Toriz Ramos discusses smart cities as the encounter of growing urbanization with technological innovation. As the author argues, smart cities are said to have a potential to foster "livability, workability, and sustainability" (Smart Cities Council, 2016). The salient question that Toriz Ramos poses is do smart cities also have a potential to foster democracy? To address this question, the discussion in the chapter initially addresses "smart urbanism" as functional and normative utopia and discusses whether democracy is necessary and feasible in smart city. It is argued that democracy in smart city is a matter of choice, rather than a deterministic outcome or sheer unfeasibility. There is indeed a risk that functional concerns will prevail over democratic choices, given the powerful technological instruments on which the smart city is built, and their possible connections with either market-biased options or authoritarian surveillance. Examples of democratic procedures in the smart city—networking, decentralization, increased transparency and accountability, new modes of popular participation via the virtual agora, and hence collaborative democracy and citizens' empowerment—are discussed.

In Chapter 3, titled "Civic participation in smart cities: the role of social media," Marco Moreno-Ibarra and Miguel Torres-Ruiz query the prospect of boosting civic participation in context of smart cities via more effective use of social media. As the authors argue, cities face the problems of accessibility of information. This hinders citizens' participation in the process of day-to-day governance of the city space. However, what if social media was employed more effectively, i.e., precisely, to enable citizens to acquire information necessary for both their daily lives and civic engagement? As the authors argue, social media has become a very prominent source to obtain data and information. As cities are exposed to a variety of challenges such as health care, environment, energy consumption, traffic congestion, housing, education, public safety, economic development, demographics, diversity, and inclusiveness, the ability of tapping into data and information and the prospect of engaging in meaningful discussion with all stakeholders bear the promise of addressing these challenges and risks more efficiently.

Chapter 4, titled "Citizen participation in the design of smart cities: methods and management framework," by Anthony Simonofski, Estefanía Serral Asensio, and Yves Wautelet, queries the prospect of citizens being actively involved in the design of smart city space. As the authors argue, over the past few years, smart cities have attracted considerable attention because they are considered a response to the complex challenges that modern cities face. Smart cities can provide innovative solutions in various domains such as environment, economy, mobility, and safety with technology as enabler. However, this is only possible if the citizens, the end users, are involved in the design of the smart city. The aim of this chapter is to provide a repository of methods and useful guidelines to manage citizen participation in the design of smart cities.

In Chapter 5, titled "Smart city as a platform economy: civic engagement and self-employment in focus," Manuel Nieto-Mengotti, Asunción López-Arranz, and Isabel Novo-Corti make a case for platform economy and its benefits in context of smart city. Currently, most companies tend to outsource productive resources, taking advantage of the virtualization capacity of their jobs, thanks to the extensive coverage of connectivity networks deployed in cities. This situation facilitates the entry into the market of new agents that can solve this growing demand. Accordingly, the chapter examines different business platforms capable of implementing compatible self-employment activities, to facilitate labor insertion through sustainable and quality self-employment that respond to the demand for services in cities.

Chapter 6, titled "Understanding sentiments and activities in green spaces using a social data–driven approach," by Kwan Hui Lim, addresses the question of citizens' well-being seen as a function of green space availability in cities. Green spaces are believed to enhance the well-being of residents in urban areas. Although considerable research that explores the emotional benefits of green spaces exists, most early works are based on user surveys and case studies, which are typically small in scale, intrusive, time intensive, and costly. In contrast to earlier works, the argument presented in this chapter is based on a nonintrusive methodology to understand green space effects at large scale and in greater detail, via digital traces left by Twitter users. Using this methodology, an empirical study is conducted on the effects of green spaces on user sentiments, emotions, and activities in Melbourne, Australia. Against this backdrop, a sentiment-aware activity recommendation system is developed. The novelty of this study rests in the combination of psychological theory, alongside data collection and analysis techniques on a large-scale Twitter dataset, which builds on traditional methods in urban research and provides important implications for urban planning authorities.

In Chapter 7, titled "Smart city is a safe city: information and communication technology—enhanced urban space monitoring and surveillance systems: the promise and limitations," Kwok Tai Chui elaborates on urban space monitoring and surveillance systems. As the author explains various forms of sensing devices such as closed-circuit television, smart phone and camera have become common place in cities. To use them effectively, a robust and an easy-to-manage ICT-infrastructure is needed. Smart adoption of such systems could influence, manage, direct, and protect human beings and property. Nevertheless, it may create problems of government support, data quality, privacy, and security. Today's computational world allows implementation of artificial intelligence (AI) models for big data analytics to bring cities smart (with intelligence and optimal improvement). This chapter will discuss the applications of urban space monitoring and surveillance systems via ICT. The typical limitations of the current research are discussed in detail.

In Chapter 8, titled "Risks, hazards, and disasters: can a smart city be resilient?," Ahmed O. El-Kholei examines the question of how to make a smart city more resilient. Environmental crises, hazards, risks, and disasters are among the challenges for sustainable urban development, which depends on the flow of data, generation of information, institutional framework, and mindset conducive to proper decision-making. New developments in ICT enhance city planners' capacities to elaborate and implement plans to transform a traditional metropolis into a smart city. These plans can enhance the resilience of the city once city administrators and their constituents adopt disaster risk reduction concepts and applications in their city plans to assure the resilience of a city. The chapter reviews the stages of risk assessment and management and then reviews literature that dealt with environmental problems and smart cities to argue that a smart city is capable of being resilient and thus sustainable.

Chapter 9, titled "Smart city as a steering center of the region's sustainable development and competitiveness," by Małgorzata Dziembała, looks at the role of smart cities from the perspective of a region's development. Smart cities are knowledge-intensive economies within which networks and relationships are created and through which the knowledge is transferred. Smart cities are regarded as (territorial) socioeconomic and environmental systems. This chapter discusses the concept of the smart city from the systemic perspective and different layers that create this kind of a system. It is assumed that the smart city is a highly competitive city, and the competitiveness of the city should be created in a sustainable manner. The city is a complex, dynamic, and open system in which both the regulation process within the system and its impact on the environment are necessary. It may be said that the smart city covers some subsystems, all of them linked by mutual dependencies. Creating competitiveness of smart cities is also related to their adaptability, which is not so much about adapting to new challenges but about using new opportunities they create.

In Chapter 10, titled "Smart cities and the search for global talent," Katarzyna Rybka-Iwańska and Enric Serradell-Lopez address a relatively new question pertinent to smart cities research, i.e., the question of talent management in smart cities context seen as a function of their sustainable development. As the authors argue, the concept of smart cities is traditionally associated with sustainable development and living conditions in modernizing cities: their ICT readiness, public transportation accessibility and standards, connections with other cities and states, the access to health care, high-quality education, and leisure. This chapter will focus on a particular feature of a smart city: its talented inhabitants. The authors will analyze characteristics and activities of smart cities in the sphere of pulling global talent. No city can attract highly skilled, hard-working specialists without the implementation of smart solutions so that the quality and conditions of living are at least satisfactory and present competitive advantages. Moreover, no city can become smart without learning and following good practices developed by skilled, hard-working specialists in various parts of the world. This chapter addresses the question how cities can be smart in creating, attracting, and nurturing global talent while pursuing the strategic objective of attaining ever higher levels of development.

Chapter 11, titled "Knowledge society technologies for smart cities development", by Higinio Mora and Raquel Pérez-delHoyo continues the discussion from Chapter 10 by looking at the specific ICT-enhanced tools that might prove useful in the process of talent management in smart city context. The pace of technological change requires that our societies are apt to use it. This translates in the imperative of enhancing the developments of knowledge society. A good example of the development of the knowledge society is found in the concept of smart cities. The main enabling tools of this concept correspond essentially to the area of ICTs. In this work, some key technologies of the knowledge society are reviewed, and their possibilities in developing smart cities are discussed. Among them, new communication technologies, geopositioning services, and cloud computing paradigm have enormous potential and play an important role for implementing smart city projects. Among the many applications they provide, this work focuses on e-government and Smart Urban Planning of the city for improving the quality of life of the citizens. The main issues and challenges of using those technologies are discussed, and examples and case uses are described.

Chapter 12, titled "How can artificial intelligence respond to smart cities challenges," by Ana Iolanda VODA and Laura-Diana Radu, elaborates on the value added of AI in addressing challenges smart cities face. The concept of smart city as a means to enhance the quality of life provided to citizens through the search and identification of intelligent solutions has been acquiring growing importance in the agenda of policy makers. Because of population growth and high urbanization rates, cities must enhance the quality and efficiency of services and resources provided, while at the same time supporting sustainable and long-term economic growth. However, few cities worldwide have actually becoming truly "smart," most of them being in the early stages of implementation. This chapter queries how AI technologies, such as machine learning, natural learning processing, and robotics, can be useful in overcoming the main challenges smart cities face.

In Chapter 13, Khaled A. Alshehri, Adel N. Alfassam, Bander A. Al-Saud, and Saad Haj Bakry outline a Framework of essential requirements for the development of smart cities with Riyadh city being treated as an example. This chapter introduces a framework of essential requirements for the development of smart cities and using it highlights Riyadh smart city strategy. The targeted framework is based on Bakry's STOPE (Strategy; Technology; Organization; People; and Environment) view, the five-domain structured, comprehensive, and flexible view that has been previously used for various technology and society problems. The framework provides a common base for the description of the current and targeted states of cities and for the development of plans toward transforming them from their current states to their targeted ones. It is used for highlighting Riyadh smart city strategy and illustrating its current development. Based on the outcomes, the chapter discusses future avenues of research. It is hoped that the chapter would provide an example to follow by other Gulf Cooperation Council cities and maybe by other cities around the world.

Chapter 14, titled "Definition of public safety policies based on the characterization of criminal events using volunteered geographic information, case study: Mexico," by Giovanni Guzman-Lugo, Blanca López-Ramírez, and Miguel Torres-Ruiz query the prospect and promise of using sophisticated ICT to keep city space safe. For the study of the criminal incidence and the definition of security policies focused on reducing the crime rate in a specific geographic region, authorities based their policies on both the user crime reports obtained from governmental dependencies and the estimation of the unrecorded crime rate, which are formally defined as the percentage or number of offenses that is not notified. Unfortunately, Mexico is one of the countries with the highest unrecorded crime rates worldwide. So, according to different unofficial reports, in 2016, the unrecorded crime rate for common jurisdiction crimes was greater than 90%. Thus, it is not possible to define an efficient decision-making process because the real number of crimes, specially the specific geographic location of these crimes, is not known. Two main factors that contribute with the unrecorded crime rate: corruption and lack of confidence (victim personal information) provided from government security institutions. In recent years, several web and mobile applications have been developed, based on volunteered geographic information scheme, to collect criminal anonymous information related to this issue. However, the point to define methodologies that allow us to identify multiple records related to the same crime event is necessary. This chapter is oriented to generate statistical data by applying ITC technologies to produce both good and safety policies. In addition to this, a case study focused on the application of AI algorithms to analyze and classify crime reports is presented as well.

In Chapter 15, titled "An outlook of a future smart city in Taiwan from post-Internet of things to artificial intelligence Internet of things" Yenchun Jim Wu discusses the connection between AI and the Internet of things (IoT) and applies it in the context of smart city. Specifically, the AIoT (AI + IoT) is used to analyze the objectives of future smart city construction in Taiwan and explain the supporting technologies. The future development of smart cities in Taiwan that are under planning is then analyzed, and the formation, operation, and development of the smart city system are revealed.

Chapter 16, titled "Smart energy in smart cities: insights from the smart meter rollout in United Kingdom," by Otto Vik Mathisen, Maria Sørbye, Madhulika Rao, Gerrit Tamm, Vladimir Stantchev, identifies different stakeholders in the UK smart meter rollout and how they affect public perception of smart meters by examining government, industry, academia, media, social media, and people's interest and perception of smart meters. An estimate was to some extent made on what kind of influence these entities have on social perception using business terminology, e.g., establish customer needs and measuring customer satisfaction. The results show that critical voices are negatively affecting social acceptance and dominate online platforms. End users (citizens) of smart city solutions are not being adequately informed about the long-term effects indicating that the behavior of state institutions and industry, especially in the social media context, is not resonating in the UK market. By showcasing these aspects, the aim is to extract lessons learned from the UK smart meter rollout, applicable to other smart city initiatives.

In Chapter 17, a review of smart city vision and practices across the Kingdom of Saudi Arabia is presented. The authors, including Rahma M. Doheim, Alshimaa A. Farag, and Samaa Badawi, elaborate on smart cities in Saudi Arabia. Setting the discussion in the context of Saudi Vision 2030, the authors discuss how the vision of boosting growth and development of Saudi Arabia coincides with a carefully planned agenda aimed at boosting the development of smart cities. As the authors explain, in line with the Saudi Vision 2030 objectives, Saudi authorities planned to start the implementation of the smart city project in 10 cities across the Kingdom. By 2020, this initiative will have targeted five Saudi cities, Makkah, Riyadh, Jeddah, Al-Madinah, and Al-Ahsa, respectively. This chapter reviews and assesses the smart city practices in Saudi Arabia with respect to the six dimensions of the smart city concept with a focus on the five cities that started the implementation to address the question if and to what extent the Saudi vision reflects the smart city concept and dimensions The findings suggest that the Kingdom has a clear vision of how to manage the transformation of these cities into smart cities, while at the same ensuring that each of them retains its specificity.

By means of conclusion, in Chapter 18, the editors, Anna Visvizi and Miltiadis D. Lytras outline how the book contributes to the smart cities debate and outline the key issues that are likely to have an impact on smart cities evolution in the years to come.

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PART 1

Managing public space: democracy, participation, well-being

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CHAPTER

2

Democracy and governance in the smart city

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Chapter outline

True, the people are the city.
Shakespeare, *Coriolanus*, Act 3, Scene 1, p. 10.

1. Introduction

Smart cities are the result of the encounter between growing urbanization and technological innovation. They are said to have a potential to foster "livability, workability, and sustainability" (Smart Cities Council, 2016), but do they also have a potential to foster democracy? To answer that question, the chapter initially addresses "smart urbanism" as functional and normative utopia of the city. In that context, it discusses whether democracy is necessary and feasible. It is argued that democracy in the smart city is a matter of choice, rather than a deterministic outcome or sheer unfeasibility. There is indeed a risk that functional concerns will prevail over democratic choices, given the powerful technological instruments of control on which the smart city is built and their possible connections with either market-biased options or authoritarian surveillance. Experts' opinions are actually divided as to the positive versus negative effects of the smart city over democratic governance.

The chapter thus explores the connections between the smart city, governance, and democracy. In the first part, it addresses the context of smart cities, from increasing urbanization to technological innovation applied to the city. It briefly

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00002-8

reviews major policy areas of the smart city, notably urban planning, housing, mobility and energy issues, education, health, and security policies. In all of them, the powerful tools of technology are fairly evident and thus introduce new and major challenges to city governance and democracy, the answers to which are addressed in the second part of the chapter.

2. Smart cities: the context

The Smart Cities Council (2016) defines a smart city as one that "uses information and communications technology (ICT) to enhance its livability, workability and sustainability" (Berst and Logsdon, 2016, p. 1). Kumar, on smart cities, writes about a "knowledge based society" (2017, p. 2). Shark further describes the smart city as "sustainable, intelligent, connected, livable, resilient and innovative" (Shark et al., 2014, p. 1). Chapter 1 in this book further addresses the discussion on extant definitions of the smart cities concept. The debate on smart cities is indeed increasing at a fast pace. Two processes go hand in hand with it: growing urbanization all across the globe and fast technological innovation. Whether both can be virtuously matched and whether this will be for the benefit of the many are therefore core questions to be asked, notably from the perspective of political scientists.

City planning has often been a matter of concern, for architects, urbanists, engineers, geographers, philosophers, theorists, and politicians, but what is new is the fact that innovative tools, a truly "artificial nervous system" (Araya, 2015a, p. 11), have emerged and they take the capacities of planning and of governing far beyond traditional limits. Put in that way, it may seem that city planning and city governing are also increasingly becoming the task of experts, those whose skills enable them to master complex processes of a highly technical nature. Furthermore, smart cities are also a corporate business (or, more emphatically, as Araya, 2015b, p. 2, puts it, smart cities are "corporatization in disguise"), and indeed there has often been a tension between markets and politics. However, ICT has also disrupted conventional notions on wisdom, for their popularity and the all-encompassing use of their tools by "common people," and thus the question on whether they foster or hinder democratic procedures in the city remains open. Do technologies induce a top-down, highly centralized model of city governance or do they, on the contrary, foster bottom-up processes, decentralization, and citizens' participation?

It is undeniable that a substantial amount of the backbone of smart cities is technological and that therefore there is a risk that control over technology may extend into controlling the people controlled by technology. Nevertheless, the very same risk has been there at the time of each major "technological" revolution in human history, and the solution was hardly ever to withdraw innovation. On the contrary, technological challenges often worked as benchmarks for societal improvement, which in the case would mean that smart cities require smarter citizens.

Let us then take growing urbanization as departing point for the discussion of smart cities. It is a reckoned phenomenon that the population in the world is growing, although not in an even way. It is also undeniable that present days' lifestyles induce human concentration in cities as never seen before—the United Nations (2015) estimates that ca. 66% of the world population will be living in urban areas by 2050, which means roughly two-thirds of the humans. Both processes combined, especially in the parts of the world where demographic regimes are still undergoing transition, are leading to the creation of megalopolis that certainly beg the question of city planning (United Nations, 2017), the alternative being huge, eventually anarchic, gatherings of human beings. The use of "smart" tools therefore becomes inescapable, in the sense that it enables functional arrangements otherwise probably impossible. A different question may yet be the reality of smaller cities, some of them in highly developed countries, where going smart certainly means a quest for sophistication and increased quality of life, rather than the management of high demographic pressure (Smart Aarhus, 2015a).

Conspicuous is therefore the fact that, in addressing examples of smart cities across the world, some of them are located in highly developed and highly technological countries and areas—e.g., Aarhus or Vejle in Denmark; The Hague or Amsterdam in the Netherlands; Barcelona in Spain; Montréal or Calgary in Canada; Berkeley or Miami in the United States; Singapore; Tokyo in Japan, etc., whereas others are growing with the population growth of developing countries, e.g., Ciudad de México; Rio de Janeiro in Brazil; Istanbul in Turkey; New Delhi in India, etc (100 Resilient Cities, 2018; European Union, 2018; IDB, 2015; Kumar, 2017). Consequently, the smart city concept bears a connection with the expansion of urbanization, but not necessarily with population growth. Besides, it is interesting to remark that technology is rapidly reaching developing countries also in this way, thus paving new avenues for human development (Bouskela et al., 2016, pp. 72—73; Shark et al., 2014; Townsend, 2014).

Not only liveability, workability, sustainability, resilience, innovation, and connectivity raise issues as broad as architecture, energy, or environment but also technology in general, mobility, housing, education, security, health, and government, to mention the more outstanding (European Union, 2018; Smart Cities, 2016).

Technology is the departing point, but it is also essentially the "tool" for smart cities' development (Dustdar et al., 2017). Technological artificial intelligence masterminds the city, notably through the Internet of things (IoT), to which the Internet of governance (IoG) and the Internet of people (IoP) have been added (Kumar, 2017, p. 4).

Architecture and urbanism carry a far-reaching tradition in planning not only housing but also the city as a whole. Because they bridge functional requirements with aesthetics, they also give a major contribution for fostering the quality of life in the modern city. Architects and urban planners often face the challenge of having to adapt old cities to present days' requirements (e.g., central heating, traffic planning, etc.). Yet, they also extend cities into new or reconstructed areas (e.g., in Seville and Lisbon new urban areas were created for the world exhibitions of 1992 and 1998, respectively—BIE, n.d.a, n.d.b), and sometimes they even plan brand new settlements. A good case of the latter is the 20th century creation of Brasilia, a city built in the inner lands of Brazil as a new "artificial" capital city, carefully and beautifully designed, which has ever since attracted a substantial number of inhabitants (UNESCO, 2018), or at the heart of the smart cities debate, the Songdo International Business District in South Korea (Herzberg, 2017).

Housing is a core issue for architecture, and it is also a major concern in the smart city discussion. For such debate, it has to be coupled with demographic evolution, spatial constraints, financial resources, and social concerns (United Nations, 2017). Depending on how these characteristics build together, a different type of city may emerge. Besides, social urbanism has become a core concern of modern urbanism, and it has also been addressed within smart cities' projects as for instance in Medellin, Colombia (Flórez, 2016; Milton, n.d.).

Furthermore, the relations between buildings and green spaces, between nature and human settlements, and between the urban core and the rural or semirural peripheries are also matters of relevance for the ecology of the city and therefore for the smart city planners on issues that range from the quality of the air to accessibility, mobility, and availability for leisure activities (cf. EIP-SCC, 2018a; SCN, 2018).

Big and densely populated cities very much raise the issue of mobility, which in turn requires careful planning and high efficiency, to meet both principles of good life and of sustainability (Visvizi et al., 2017). Although not being the only subject in the smart city context that has led to debates on environment, issues such as energy use or pollution are pervasive, whenever mobility is debated. Recent discussions on the substitution of individual for collective transports, or the increasing debate on the use of electric, eventually, self-driving, vehicles (Stilgoe, 2017), or the vast array of new mobility tools are good examples of that linkage. The whole debate on clean energies and renewable sources is also much focused on cities, given that they concentrate high levels of energy consumption and of natural resources use and therefore require increased rationalization, which the smart cities technological tools may foster (EIP-SCC, 2018b; SCN, 2018).

Education and health (both from the perspective of the availability and of the quality of the services) are topics that carry major connections with demographic evolution, quality of life, and indeed with social urbanism too. Both policy areas have undergone shifts in perspective, namely from short-term approaches to medium- and long-term planning and from emergency to preparedness and prevention. Therefore, both have a lot to gain from functional and quality improvements, notably of a technological nature, be it telemedicine or IoT applied to hospitals and education (Bouskela et al., 2016, pp. 96–101; S&RC, 2018a, 2018b; Lytras and Visvizi, 2018).

Last but certainly not the least, the city is also about security. Major conurbations, high concentration of people in a given area, high mobility, and poverty coupled with major wealth distribution gaps, all account for insecurity, to mention only some of the challenges cities face (Flórez, 2016; IDB, 2015; Schreiner, 2016). In this context, surveillance as preventive strategy or tool for combating crime thus becomes quite appealing (Bouskela et al., 2016, pp. 74–77). Furthermore, security is also about data security, a major challenge for the smart city and also a major problem, from the point of view of individual rights (Kitchin and Dodge, 2017). A balanced, good to live in, city should therefore offer security as one of its attractions, while keeping a fair protection of individual freedoms.

All the topics above address major policy areas that are relevant for the cities of the present. Improved city governance, adjusted to the new realities of the smart city, is therefore also necessary. Issues such as balancing market and politics in the new scenarios or regulating the new security problems are thus major political concerns of the local level and beyond. Whether such governance can be, or ought to be, democratic is a matter further debated below. Holist approaches have emphasized that the city is an integrated body and that as such it cannot be parted into pieces (Bell, 2014). Jung, following Bell (2014), even distinguishes between smart cities and intelligent communities on the basis of “the former’s focus on urban performance as it relates to urban competitiveness versus the latter’s role in creating a more holistic approach at city and community-building and collaboration” (2013, n.p.). Smart cities are therefore a phenomenon to be connected with what might be called, in Amigoni’s terms, “collective intelligence” (2018), i.e., a collective and shared and accepted rationality, going well beyond the individual level but functioning as a guarantee for the collective well-being.

The notion thus expressed takes us back to the remote yet recurrent debate on utopias, be them functional or normative—if both can be detached at all. It is not a coincidence that utopias, despite their lack of geographical concrete references, often took the shape of spatial utopias to the point of having produced detailed mappings and plans (as, for example, in T. More’s *Utopia* or Fourier’s *phalanstery*).

It is also known that utopian authors often struggled to match individual liberty with communal arrangements, which seems to be, once again, a major problem underlying a substantial part of the normative debates on smart cities (Townsend, 2014). Is, therefore, the smart city the new utopia of the perfect city?

And can a city be functionally perfect? What are, therefore, the challenges? Planning, predicting, routinizing procedures, and resorting to automation all account for the perfectioning of the urban lifestyle, in the smart city ideology. There are many examples, as abovementioned, from mobility to health emergencies or air conditioning in houses. Drawing on a sophisticated technological infrastructure, the purpose is to reach an ecological and cultural environment (Kumar, 2017) that meets high patterns of functional performance—from saving energy to providing felicity. The social issues stemming from this process may yet raise doubts as to the stability of the “perfect” city. There is a debate on automation and the concomitant loss of jobs; there is a debate on the dimension of the cities (can the big city be truly ecological?); there is a debate on social hierarchies inside of the city; there is a debate on city governance, notably on what concerns the management of the massive data gathered for the functional purposes of smart cities (Amigoni and Serventi, 2018; Greenfield cit. by Poole, 2014). Ultimately, the overall debate is on whether individual freedom becomes only a marginal outcome, for the citizen sheltered in the “perfect” city (Kitchin and Dodge, 2017). From this point of view, liberty may have to be redefined as the retaining of the capacity to choose to be disconnected and disconnection as the new means of going back into "wilderness" even if in a temporary way—e.g., France recently had a legal debate on whether it is within the worker's right to be disconnected from the firm after working hours (cf. The Guardian, 2016).

The debate thus enters the realm of normative choices for the city. Despite the fact that the term governance carries the imprint of functional arrangements for governing, the options it entails take the discussion into the deeper level of political and ethical choices. From this point of view, the smart cities' issue is not so different from major political debates on legitimacy (Scharpf, 1999). In theory, highly efficient cities may produce high output legitimacy, in the sense that citizens benefiting from that efficiency may be more prone to overall acceptance. However, this line of reasoning does not favor democratic over authoritarian procedures (or decentralized over centralized patterns) per se. Extant cases also account for this argument, as, for example, Hangzhou in China (Revell, 2017). As a giant structure of control, smart cities growth can actually counter democracy, instead of favoring it. Therefore, democratic governance is not a logical outcome of the becoming "smart" process; it is an option, based on available tools, as will be further explained below.

3. Democracy in the smart city

The smart city is the outcome of powerful technological tools, but it is also, according to Kumar, "an ecological and cultural system" (2017, p. 4), that is, it creates a specific type of relations and a specific culture of the city. The literature on smart cities tools often stresses the fact that beyond the physical and geographic space of the conventional city, a virtual space of interaction has emerged, together with massive data bases, powerful data analysis, and highly sophisticated automation of procedures (Herzberg, 2017; Rodríguez et al., 2017; Townsend, 2014; Visvizi and Lytras, 2018). To this point, technology provides local governments with both constraints and opportunities but does not determine a specific pathway. Because it relies on powerful instruments of control, it may even be tempting to use them for reducing rather than improving individual freedoms, notably on grounds of alleged communitarian interest.

City governance thus faces major challenges. Whether answers will be kept within a democratic framework or not remains a matter of contention. However, the word governance is often used in a broader sense than government, one that entails an association with democratic procedures and civil society involvement (Palvia and Sharma, 2015; Kumar, 2015). For the context of the democratic governance of the city, Kumar emphasizes the junction of the IoT, with what he calls the "IoP" (or e-democracy) and the "IoG" (or e-governance) as major tools in the process (2017, p. 4).

To structure the debate, the text underneath first addresses city governance mainly as a top-down procedure, with reference to the citizens, and then discusses democratic participation as an inherently bottom-up process. Some of the characteristics of smart cities governance that are relevant for the debate on democracy are therefore listed below.

First, it is possible that smart cities will foster decentralization, with reference to conventional political power, because they have a potential to reinforce the infranational level of governance, vis-à-vis the state. City states not being the general pattern, the complex city of the present has to further develop its governance tools and to deal with a vast array of interconnected policies, if the smart city standard is to be attained. The adoption of an extensive and intertwined local policy agenda is often the case in smart cities (cf. Bouskela et al., 2016). This also raises the relevant issue of the financial resources available at such local level (EIP-SCC, 2018c), which in turn fuels local power efforts to promote local business and capital attraction. From this point of view, cities may become centripetal, competitive poles, within the broader regional or national framework. Attracting business, or major sports events, organizing international exhibitions, or other cultural happenings have become activities in the radar of many modern cities, often with a view to the tides of business and cultural tourism (e.g., IDB (2015); Álvarez-García et al. (2017)).

Therefore, cities both network and compete in between them. Yet, networking in an age of virtual spaces does not necessarily mean regional proximity, it rather addresses a sort of virtual neighborhood, in the sense that cities will gather together according to shared interests and exchange of experiences, in spite of physical distance—as, for example, in the "lighthouse projects" and "lessons learned," available from the EU Smart Cities Information System (European Union, 2018). The transnational network of cities thus becomes a horizontal platform eventually aiming at fostering yet another partner in globalization—the global cities network (Lebeck, 2014). There are many examples among which are the European Innovation Partnership on Smart Cities and Communities (EIP-SCC, 2018d); 100 resilient cities (2018); Local Governments for Sustainability (ICLEI, n.d.); Sustainable City Network (SCN, 2018); and the Smart Cities Council (2016). It is also relevant to mention that these networks encompass partnerships with civil society, the corporate sector, and the media.

That way, the substantial number of partnerships with the private sector, both profit and nonprofit, is broadening the number of effective stakeholders in the life of the smart cities. The criticism most often heard is that unlike established public entities, private ones, notably market-oriented companies, may bias the process from public interest into private interest's prosecution (Greenfield cit. by Araya, 2015, p.2). Therefore, governmental stakeholders recommend that the process be balanced and that the public sector managers reinforce there know how on the specific topic of smart cities (Bouskela et al., 2016; United Nations, 2017).

Wherever cities are already inscribed in democratic regimes, the issues of transparency and accountability have become ever more important. The acts of public administration, consultation and deliberation procedures at the city level, plans, and the execution of policies need to be open to the public in permanence (Bouskela et al., 2016, pp. 102−104). Furthermore, the results of interactions with the citizens may be incorporated in the routines of policy-making and in public administration. The EIP-SCC (2018e) promotes "Integrated Planning and Management." In Gujarat, for example, a platform for e-governance was created for dealing with town planning (Desai et al., 2017). There is also an ongoing debate on open data policies in the smart city (OGP, 2018). Besides, the smart city is able to produce performance indicators that help "measure, benchmark, and improve public policy" (Bouskela et al., 2016, p. 19).

Therefore, other major issues are data gathering and data management and the connected concerns with privacy and security. Efficiency and security can come at the cost of privacy, but data storage and management are sensitive issues at the political level (Rodríguez et al., 2017). For its potential to generate clashes with civil and political rights, data protection is also a crucial issue for the smart city (OGP, 2018; Wadhwa, 2015). Cyber security concerns are therefore at the center of this debate because the vulnerability of data systems has become a major political and security issue in recent years, at all political levels.

As for democratic participation, there are also some core ideas emerging from the smart cities debate. The discussion on e-democracy is part of ongoing research on democracy and participation (e.g., Goldsmith and Crawford, 2014; Sokratis et al., 2015), and the smart city is undoubtedly a privileged setting for the endeavor. In such a context, and despite some negative effects of the use of technology, there is also a number of ways in which the smart city can foster democracy, as detailed below.

An increasingly efficient city will tend to be increasingly efficient for the many: if we think of urban planning, transport networks, and communication services, for instance, it is difficult to conceive of them without their coverage being universal, within the perimeter of the city (IDB, 2015). There are of course numerous examples of cities whose citizens still undergo major income gaps and where major social conundrums are still open—but this has a lot more to do with the perfectibility of the smart city construction, than with the concept itself, which also addresses a process. The United Nations Urban Agenda (United Nations, 2017) portrays the city as inclusive, in line with other international organizations (cf. Bouskela et al., 2016, p. 102). The argument therefore is that, from the point of view of the quality of life, smart cities tend to have a democratizing effect.

A central tenet in the debate on the relation between democracy and smart cities is also that the new technological tools have a major potential to foster citizens' participation (Araya, 2015; Goldsmith and Crawford, 2014; Kumar, 2017).

First, more information can now be available for more people and in an easier way than in the past. Open data (Araya, 2015; Kumar, 2017; OGP, 2018; Smart Aarhus, 2015b) and digital platforms, what Kumar (2017) calls "citizen-centric Apps and web services," all provide the citizen with increased conditions for being informed and aware of political processes. This, however, does raise the issue of digital literacy, but the speed at which notably mobile phone coverage has been expanding in many parts of the world allows for an optimistic view on the effects of these new flows of information. However, beyond information availability, it must be taken into consideration whether the people are just passive receivers or mobilized citizens instead (Bouskela et al., 2016, pp. 105–106). A commitment to participate in local political processes is something that technology can facilitate but not cause.

Second, participation associated with an increased awareness on city's political processes also requires citizens' capacity to interact with the local institutions. There is a vast array of new technological answers to this, notably distance communication and virtual conversation with local authorities, which thus promote bottom-up communication and feedback on policies. Araya (2017) writes about "sousveillance" as a counterpart to surveillance, i.e., the capacity of the citizens to make their views known, to transmit upwards individual or communal information and standpoints. This is the case of the experience led in Amsterdam, as Citizen Science—The bottom-up way (ASC, 2018), or of the Digital Neighborhood of Smart Aarhus (2015b), to mention but a few. In the framework of the European Union, the EIP-SCC Citizen Focus Action Cluster believes

> *(…) in citizens as fundamental actors for the regeneration and development of smart cities. Civic engagement, empowerment, participation and co-creation are at the basis of our advocacy approach since we acknowledge that citizen voice can be pivotal in providing the demand-side pressure on government, service providers and organisations needed to encourage full response to citizen needs. It also ensures the setup of a trusted and sound relationship with local governments and a source of democratic legitimacy and transparency. In the context of smarter cities, citizens understanding of concrete problems and challenges can help local governments prioritise and respond consistently to inhabitants' need (2018f, n.p.).*

Moreover, the citizens can network horizontally, that is, there can be a reinforcement of the public space where citizens can debate their views on a peer-to-peer basis and shape their political opinions. This "virtual agora" is celebrated by some, but execrated by others, for the loopholes it creates for true conversation and exchange of ideas between "real" people (Goldsmith and Crawford, 2014). However, the argument only seems to make sense if the virtual space is to fully substitute the physical public space. On the contrary, the possibility of virtual conversation fosters the exchange of ideas and from this point of view enriches the debates.

In recent years, some local governments have sought for complementary mechanisms of democracy, such as participatory practices, as for instance with the promotion of participatory budgets (EIP-SCC, 2018g). Technology can reinforce these practices, as mentioned by Naseer et al. (2015). Other authors also point out that the amount and the crossed pattern of interactions on the basis of technology can foster "collaborative democracy" (Bergmann, 2016; Noveck cit. by Araya, 2015a). Here again, the concepts of "user-centered design" and of "collective intelligence" (Amigoni and Serventi, 2018) can be useful for explaining the process. Kumar emphasizes that "smart people are a fundamental building block of a Smart City System" (2017, p. 6).

Nevertheless, a change in the tools of democratic participation may also fuel processes of a negative nature because learning and adaptation are required, for the citizens to use the new means of communication adequately (Okner and Preston, 2017). An example could be the overload of public petitions often running in the social media, which may shift that participation tool from pertinence into banality, ultimately dictating its irrelevancy.

4. Conclusion

Some main ideas emerge from the text above as hereafter summarized. The use of smart technology in the cities, in a context of growing urbanization, seems both inevitable and virtuous because it enables planning, automation, prediction, or energy saving, only to mention some of a vast array of functional improvements. However, its connection with the reinforcement of democratic procedures is not an immediate outcome. There is even a risk that the massive gathering of information, the automation of procedures, some market-oriented options, and, in general, the prominence of functional concerns in the city may hinder rather than foster democracy. Nevertheless, there is also a major potential for the democratic development of city governance emerging from the new technological tools. In this chapter, it is argued that they can foster decentralization, network governance, and both top-down and bottom-up relations with the citizens. Transparency, accountability, and direct participation can therefore be reinforced, if there is a will (i.e., a political choice) to use the new technologies for that specific purpose. This also requires the citizens to become smarter, in the smart city context.

Some of the smart cities' literature and some of the transnational projects, as mentioned throughout the chapter, are already putting forward a normative conception of the smart city that entails governance and democracy. However, it is possibly unwise to consider that smart cities can be, from the political point of view, alike everywhere. What they have in common is their connection with technological sophistication, from which both constraints and opportunities emerge. Democratic governance, indeed democracy, is an option, and thus it will mainly emerge from the political context of each city. Nevertheless, processes such as network governance may streamline "good practices" in a horizontal and decentralized way. Furthermore, technological tools are powerful multipliers of political awareness and participation, which in turn can reinforce horizontal linkages between the many stakeholders. Last but not the least, if gains in efficiency improve the quality of life of the many, they will bring with opportunities for citizens' empowerment. Without automatically hindering authoritarian attempts to govern the city with the exact same technological tools, all the above open windows of opportunity for fostering democracy in the smart city, should the democratic smart cities movement come true.

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CHAPTER

3

Civic participation in smart cities: the role of social media

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Chapter outline

1. Introduction

For much of the 20th century, the idea that a city could be smart was a science fiction that was pictured in the popular media, but quite suddenly with the massive proliferation of computable devices across many scales and with a modicum of intelligence being embedded into such devices, the prospect that a city might become smart, sentient even, is fast becoming the new reality (Batty et al., 2012).

Cities are becoming smart not only in terms of the way that computing functions, serving people, buildings, and traffic congestion systems can be automated but also in ways that enable us to sense, understand, analyze, and plan the city to improve the efficiency, equity, and life quality for its citizens in real time.

Participation of citizens in urban modeling and policy-making builds the common top-down governance structure via promotion of bottom-up approaches to policy development and decision-making. This evolution leads social innovation in support of urban planning initiatives in more public-oriented policy specification for better governance and sustainability in smart cities. Innovative information and communication technology (ICT) solutions offer significant opportunity to ameliorate the substantial challenges arising from these developments. Smart city needs initiatives to promote the use of ICT solutions for better governance in terms of improved communication and information services, as well as offering the potential to provide policy makers and urban planners with the tools and intelligence needed to actively manage the urban spaces.

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00003-X

Traffic congestion, overcrowding, waste management, and pollution are important challenges that affect particularly urban areas, and this is even worst in big cities such as Beijing, Tokyo, and Mexico City, where millions of people live (Oatley et al., 2015). Technological advances provide new alternatives to tackle such challenges. Concepts as smart cities introduce technology into many different human activities related to health, security, information, and transportation, among others, to increase the life quality of citizens (Saldana-Perez et al., 2018). Gartner (2016) defines smart cities as urban areas where multiple entities work together to formulate sustainable solutions to human problems that include contextual and real-time data analysis.

Smart cities try to make use of technology in all their social and urban aspects such as economy, health, environment, among others. To date, mobiles devices such as smartphones and tablets are used by citizens for access data sources that keep them informed about factors and events that modify their activities and their environment (Rudinac et al., 2017). In addition, people's interest in technological issues and their participation to generate user content has become an important scope of modern scientific communities.

A key element for smart cities is the integration of data and contextual information, activities that must be carried out practically in real time. In this context, many approaches use physical devices to sense the variables and phenomena; however, recently, the use of social media has been increasing considerably (Donahue et al., 2018).

The main advantage of social networks is that citizens can collaborate voluntarily with observations about their geographic environment, which are of interest to other citizens who cohabit in space. A clear example of this situation is the traffic reports published in Twitter such as @Trafico889 in Mexico City. Due to the large number of users that can report events simultaneously in social media (AlSonosy et al., 2018), the proposed framework can be very useful in the context of smart cities. It means that we can collect a large number of observations massively in a short period, which have a location and can be represented in a geospatial database and eventually be analyzed by a geographic information system (GIS). Thus, considering that citizens collaborate voluntarily, this type of approach for collecting data from urban areas does not require large investments to be implemented, unlike traditional approaches based on surveys or physical sensors (Akyildiz et al., 2002; Ganti et al., 2011; Di Francesco et al., 2011). Thanks to the social media, people are constantly connected and can be noticed about what is happening in their surroundings; what is more is the fact that people are able to communicate what they perceive, acting like intelligent sensors (Kindberg et al., 2007). From this perspective, Twitter is considered as a new data source because it provides different points of view from many different users and topics such as health, environment, politics, economy, sports, natural disasters, among others. In addition, Twitter has more than 500 million users all around the worldwide, who post approximately 65 million tweets per day (Bernstein et al., 2013).

Social media lets the research to know the people's feelings and ideas about factors that disturb their daily activities, governments, and institutions interested in improving people's life and solving specific problems using its updated information (Saldana-Perez et al., 2018). Twitter facilitates to gather crowd sourced information (Landwehr et al., 2016) and provides information in less time than the methods used to collect data before the social media explosion, such as polls and census. In the past, people collected data related to the people's feelings and opinions about their environment by applying surveys and census (Haworth, 2016). In the present approach, Twitter is considered as a media for civic participation for recollecting and analyzing urban environments. In this case, we are focused on traffic-related tweets that are analyzed to identify the kinds of events that commonly generate road problems in an urban area.

In the context of geographic information science (Goodchild, 1992), this information is defined as volunteered geographic information (VGI). It refers to the wide creation and sharing of geographic information by citizens using web platforms, free mapping tools, mobile applications, and social media. VGI is a mean to promote the civic participation that completely changed the creation and propagation of information generated by people interested in ameliorating human's life and to prevent others from possible critical situations (Haworth, 2016). In disaster management domain, VGI is also labeled as digital volunteering, digital humanities, or civic participation via social media (Burns, 2014). Digital volunteering has become a new type of asserted geographic information used to complement geographic information from governmental agencies and private organizations (Jiang, and Thill, 2015). Some research works have used Twitter as a data source, each tweet represents a vision about what people perceive in their environment. Landwehr et al. (2016) perceive in Twitter the opportunity to get information out to the public, and such information is easy to forward, which increases the rate of dissemination.

The data processing of tweets and metadata becomes a challenge due to the complexity of structures. Users sometimes do not allow the social media to know their location, so the tweets do not have geographic coordinates. Sometimes, people only tweet comments about a topic, and this represents a problem for scientific research works because most of the times personal comments do not provide relevant information (Kumar and Ahmed, 2016). For example, when terrorist acts occur, special hashtags are created to cluster all the tweets related to this issue. Many tweets use hashtags, some of them inform about the event, and some others describe people's feelings, the latter generating noisy information. Noisy tweets affect the quality of the sample so when it is processed, personal comments must be filtered to assure that the collected tweets contain valuable information about the event. When tweets regarding a specific topic are posted far from the study area, it is important to consider the variations of space and time between them. In most developed countries, citizens volunteering and information from social media or collective systems without an official agency affiliation are undervalued

(Whittaker et al., 2015). The use of extra data sources when working with Twitter helps to validate the data of tweets and to ameliorate the accuracy of research works (De Albuquerque et al., 2015).

According to Haworth (2016), citizens who are observing, collecting, sharing, and analyzing data have led to the development of much scientific research works, which would not be possible otherwise. Similarly, to collaborate information and social media data, the quality of citizen science has been questioned, but it has been shown that by applying the adequate preprocessing procedures, the generated data by citizens can meet the same quality as data collected from official data sources and experts (Bruce et al., 2014; Danielsen et al., 2014). People's participation has led to the citizen science, which refers to engage public citizens in scientific research projects (Bonney et al., 2014).

The rest of the chapter is organized as follows: Section 2 presents some related works and the respective background. Section 3 points out the proposed framework for urban analysis based on civic participation, which is composed by three stages. Section 4 discusses our conclusion a future works.

2. Background

Nowadays, citizens play an important role to analyze the social behavior or human activities (Foth, 2009). On the internet, there are many resources to post information such as blogs, websites, and social media; beyond, some of them allow people to generate information that will be useful in the context of smart cities. The posts published by people, such as videos, images, comments, and messages, are part of the user-generated content (UGC); these data become more accessible and open to citizens in general. Technological advances have increased the interest of people to generate content. Recently, people can post information from any place, using their mobile devices, smartphones, and computers (Yang et al., 2016). Mobile devices let users add geographic coordinates of the place where they are to register the locations for multiple purposes.

VGI is composed of the UGC with coordinates or geographic references. VGI is an important data source for geoprocessing, and it communicates the user thoughts and provides extra information to locate the user at a specific geographic place (Lin, 2013). VGI has inspired the implementation of specialized websites, such as OpenStreetMap, Twitter, Foursquare, Google Maps, among others (Kunze and Hecht, 2015). So, Internet, social media, and mobile devices work together to allow human beings to act as sensors. People have different points of view, which depend on their daily life and activities. A person considers some factors interesting or not and according to his criteria reports its perceptions (Fleming et al., 2014; Mora-Cantallops et al., 2019). During last years, the idea of considering people as sensors has increased. Resch et al. (2015) defined three concepts to take into account when working with human sensors: people as sensors (the analogy), the collective sensing, and the citizen science.

There have been developed research works that merge smart approaches, cities, GIS, and Twitter with a view to developing decision-making and urban computing procedures. Nowadays, there are different GIS systems that let people handle geographic information, even if they do not have a specialized formation; so, this is one of the main advantages of GeoWeb 2.0 (Johnson and Sieber, 2017). Some GIS−Twitter research works are focused on analyzing people's reports of weather, rain, snow storms, and flooding (Basnyat et al., 2017). In other model, the activities of people in urban environments such as traffic congestion, pollution, public demonstrations, and taxis routes, among others, are analyzed (Cottrill et al., 2017; Kumar and Ahmed, 2016; Krueger et al., 2016). In addition, there exist some research works focused on studying and managing critical situations (Panagiotopoulos et al., 2016; Ngo et al., 2016; Chatfield and Brajawidagda, 2013).

One of the main problems that affect urban areas is the traffic congestion; this problem is even worst in big cities such as New York, London, Beijing, Tokyo, and Mexico, where millions of people have to displace every day (Oatley and Howell, 2015). According to the Work and Health Minister of Japan, the survival probability in a car accident gets dismissed 50% when there is traffic near the accident area, due to the delay that first aid services could experiment on the roads (Oatley and Howell, 2015). Waze is a clear example of VGI information usage; in this application, people share their personal traffic reports. Another example of the VGI system is the US Environmental Protection Agency, a New York's department of system, where people provide and also collect information about the air and water pollution in their city (Resch et al., 2015).

Machine learning (ML) methods are important tools that have been used to analyze tweets in the context of urban areas. ML algorithms are used to classify and compute regressions over the tweets; for example, in He et al. (2013), authors propose an optimization framework to extract traffic-related information from tweets using a transformation matrix. It also makes long-term traffic predictions using linear regressions; the San Francisco Bay, California, was taken into consideration as a case study.

An example, where GIS and ML are used over tweets for traffic analysis based on short texts from social media was presented in (Saldana-Perez and Moreno-Ibarra, 2016). In this work, traffic-related tweets are preprocessed by text mining and natural language processing (NLP) procedures, georeferenced and classified by ML algorithms into different traffic events. Finally, the classified tweets are geovisualized by using an open source GIS, with a view to analyze traffic in urban areas of the Mexico City. According to Escamilla et al. (2016), a methodology to geocoding traffic events reported in tweets is proposed. This approach identifies the traffic events, geographic features, and their possible spatial relations, using NLP, an ontology and classification algorithms. One of the main purposes of the main Twitter research works is to develop analytical tools to study events that represent a risk for people, to prevent them from possible damages. According to Cavalière et al. (2016), georeferenced tweets posted by users and authorities from the southeast France that provide information about extreme rainfalls and flooding are analyzed.

3. Framework for urban analysis based on civic participation

According to Feick and Roche (2013), the user-centered sensing is focused on citizens who receive benefits, increasing his access to information and implying that the government makes a more transparent and accountable management. With this empowerment and participation of citizens, they increase his quality of life. In this case, the validation or assessment can be made through visits to the interest area to verify the occurrence, which depends on the available resources.

Feick and Roche (2013) considered some aspects, which are derived from its collaboration and improved this collaboration with other stakeholders within and outside the government. In fact, the greater political legitimacy improved decision-making, enhanced service delivery, and enhanced better management and planning of land use change, as well as environmental issues for sustainable development. Both citizens and authorities can be active to participate in the application and have some degree of knowledge about the domain, for performing its activities. This framework is composed of three stages: user-centered sensing, validation, and use and exploitation. Fig. 3.1 presents a general framework that can be implemented with the civic participation and oriented toward analyzing urban environments.

User-centered sensing activity is oriented to civic participation toward collecting data from applications based on approaches as collective sensing, people as sensors, and citizen science (Resch et al., 2015). From this point of view, collaborators and

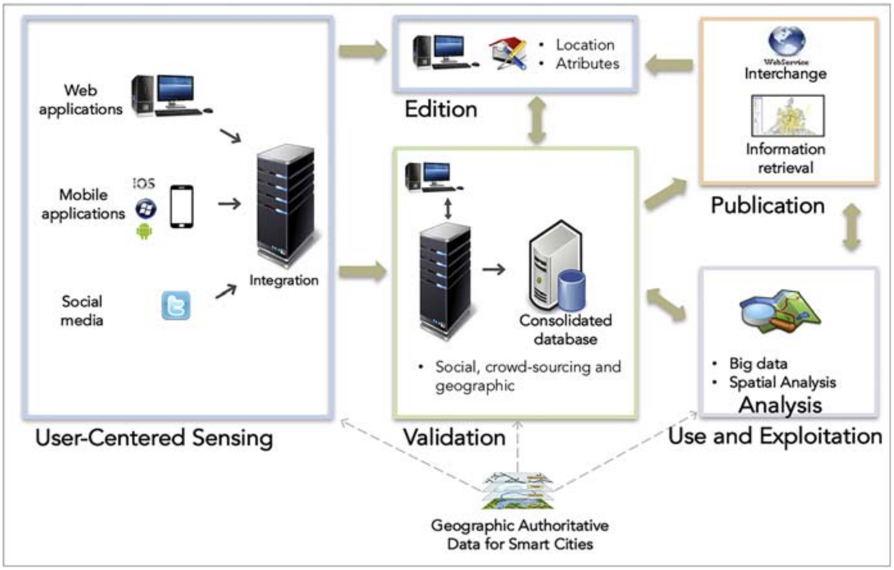

FIGURE 3.1

General framework for urban analysis.

citizens are focused on aggregating data (Goodchild and Li, 2012). Data from social networks must be geocoded by using an automatic method as is presented by Salazar et al. (2015). A geocoding method needs to consider gazetteers, geographic dictionaries, knowledge about the conceptualization of domain and techniques of NPL. Moreover, the development of web and mobile applications must be guided by a domain expert, to gain expressivity and quality for sensing. It must contain the applications, functions, or method to extract details about a phenomenon such as its location, class or a measurement. It considers an analysis of NPL techniques, text mining to detect particular phenomena such as environmental variables (Kremers, 2012) and web applications for more specialized users (Boulos et al., 2011). In the case of Twitter, some tasks are required, such as (Saldana-Perez et al., 2019) the following:

- *Parsing of the text elements:* Each text is divided into words; the text is converted into a sequence of strings.
- *Special characters and stop words removal:* If tweets are written in Spanish, they contain special characters such as accents, questions marks, among others. So, they must be removed from the texts to improve the analysis. Stop words are removed because they do not provide useful information about the phenomenon and can add noise for the later tasks.
- *Uppercase substitution:* Lowercase letters replace the uppercase letters to normalize the textual elements.
- *Keywords identification.* Domain-related words are identified to classify the tweet. Moreover, contextual words are considered, such as road names, and points of interest are identified to geolocate to the registry if needed.

After this procedure, the tweets are stored in a spatial database and are ready to be used in the next activities. Each record describes an event related to a phenomenon, such as in the case of traffic, a crash, a traffic jam, or a pothole. These data are evaluated in the validation activity, by means of the criteria and approaches proposed by Goodchild and Li (2012). This stage is related to quality, which can be defined as fitness for a specific purpose, or for a community, or how it is satisfying special requirements to solve a problem (Elwood et al., 2013). Harvey (2013) proposed the term contributed data to describe any data generated by users "activities on social media platforms." Consider the case of Twitter, where tweets are part of soft data, which defines all information created and shared on social media platforms. Contrary to hard data (traditional data sets made by governmental agencies), tweets come from heterogeneous sources that cannot be all confirmed. Moreover, the process of the acquisition is undocumented and there is no data quality assertion (Elwood et al., 2013). Two recurrent questions are presented: Are tweets trustworthy? What is the degree of trust of tweets? The quality of the tweets is therefore heterogeneous and highly variable, while some tweets report a mere observation with no further information (e.g., "It's raining" without any detail about the rainfall intensity), others may include accurate information (e.g., "Hail cracked the windshield" which may provide clues about hail size and intensity). Thus, the georeferences given in the text tweets sometimes are vague or their description is general, e.g., "Earthquake in Mexico," this message does not provide the exact area or location where the event occurred, meanwhile "Earthquake in Chiapas Southwest of Mexico" provides more partially information to locate the event.

An important issue is the spatial content of contributions. It depends on an application, but it must be analyzed to combine multiple spatial sources (Van Exel et al., 2010). It is related to the success of analysis and decision-making and its impact on economic and legal issues. From a spatial point of view, quality frequently is related only with the positional accuracy of geographic data, but other aspects can be considered such as attribute accuracy, currency, completeness, logical consistency, lineage, accuracy, and resolution (Bolstad, 2005). *Accuracy* is related to the discrepancy between observations and real values; it applies to characteristics (attributes) and geographic coordinates of entities or events. *Currency* is related to the temporal validity of data for a time period; it depends on the underlying dynamic of an urban area. This topic is more relevant for events that can exist for hours or just a few minutes such as a traffic jam. *Completeness* describes how well the data contain all the universe of entities or events. *Lineage* is related to the background of the data, taking into consideration sources, transformations, and people involved in the process at different stages. *Resolution* refers to the smallest unit that can be represented according to the scale and propose the minimal resolution that can be represented and visualized in a spatial partition.

In this context, it is a mean to voluntarily capture and share data among users. However, because of a large number of users, it is difficult to evaluate the trustworthiness of each contribution (Bordogna et al., 2014). So, it is required to evaluate the quality of contributions, and from the perspective of VGI, three approaches have been identified to this purpose: crowdsourcing evaluation, social measures, and geographic context evaluation (Goodchild and Li, 2012).

According to Goodchild and Li (2012), crowdsourcing may not be useful for the geographic domain, due to the errors produced by the great number of contributors and the required local knowledge for users who validate data. On the other hand, the same authors pointed out that geographic context evaluation can be more useful because it is constrained by spatial relationships and geographic extension, and it can be automated by many GIS-software. In addition, other aspects of data can be included to enrich and refine the constraints, such as temporal properties.

The development of methods focused on crowdsourcing evaluation is required. Thus, we propose the use of social measures based on the ranking of contributors and the integration of members of the government (authority) for specific themes. Geographic context evaluation is used to validate spatial relations to verify the semantic invariants of a domain (Moreno-Ibarra, 2007). In addition, we point out the possibility to build a method that combines the approaches to validate the user-sensed data, which means to take advantage of each one of them for specific applications.

Once data are validated, they are consolidated in a repository. If it is required, some data can be edited and updated to promote the integration of the data using GIS operations. In this case, it is necessary to consider the aspects defined to check the quality of data (Coetzee et al., 2013).

To integrate data from different sources is important to consider the implicit semantics of data and the VGI representativeness. This has to be tackled by analyzing the conceptualization of each data set, considering entities and its relations and how it is related to other conceptualizations, to define semantic rules and ontological relations between conceptualizations and then link the entities via object relations (Resch et al., 2015). It can imply to consider aspects as an urban ontology such as objects, relations, events, and processes that are presented by (Fonseca et al., 2000). In addition, some conceptual issues oriented to promote the interoperability must be considered (Fonseca et al., 2002).

Use and exploitation is an activity, which includes several facets that consider spatial analysis sharing and visualization of user-centered sensing data. According to Jiang and Thill (2015), this kind of applications represents a new paradigm to promote the use of big data composed by data from various sources.

This stage includes the analysis, which is focused on processing the data to extract or detect some patterns in such data. Mainly, two different approaches can be included in the application: spatial analysis and big data techniques. *Spatial analysis* refers to operations for detecting locations, entities, attributes, and spatial relationships through the overlying layers and other analytical methods such as interpolations. These kinds of operations are including in almost any GIS (Bolstad, 2005). On the other hand, big data techniques are proposed because this application is oriented toward collecting, integrating and analyzing a very large set of data that cannot be treated using traditional methods (Jiang and Thill, 2015). According to Gartner (2016), big data presents three properties that are the follows: (1) it has a high volume, (2) it is collected with high velocity, and (3) it includes a variety of information asset. Big data has advantages of revealing individual characteristics rather than a general feature of traditional statistics, and it is consistent with the idea of people-oriented urbanization and urban-rural planning (Hao et al., 2015). From this perspective, data must be processed with advanced tools to reveal meaningful information by means of tools such as ML methods.

ML methods are an important tool used to analyze this kind of data, most of the times they are used to classify and compute regressions. For example, according to He et al. (2013), the authors proposed an optimization framework to extract traffic-related information from tweets using a transformation matrix. In addition, they made long-term traffic predictions using linear regressions. The case study was implemented by taking into account data from San Francisco Bay, California. An example where tweets are handled by GIS and ML methods is used to classify data into classes that represent different traffic events. On the other hand, a regression analysis lets to investigate the relationship between a dependent and an independent variable (target and predictor features). Usually, such analyses model and find the causal effect relationship between variables (Seber and Lee, 2012). The regression models allow forecasting data regarding the possible relations between a target and a predictor. There are two main benefits that regression analysis provides. The first is the regression that allows us to know the relation between a dependent variable and an independent variable. The second indicates the strength of the impact of multiple independent variables on a dependent variable (Seber and Lee, 2012). Most of the times, the regression processes consider data related to the current and past status of the element of interest for the forecasting. Two of the mainly used regressions models are the linear and the logistic models. The main advantage of the logistic regression is that it does not require a linear relationship between variables because it makes use of the nonlinear log transformation over the data. The logistic regression uses the maximum likelihood; there must not be multicollinearity between data. If the dependent variable is ordinal, the regression is called ordinal logistic; if the dependent variable is multiclass, the regression is called multinomial logistic (Menard, 2018).

According to this operation, the framework attempts to enhance the following tasks: acquisition, integration, presentation, and analysis. It is important to say that the validation of data is a key element that delineates the quality of data and subsequent analysis. To analyze the data, classic GIS methods of spatial analysis are considered, but it is necessary to consider big data techniques because this approach will generate a large amount of data. Based on this proposal, it is possible to build big data repositories composed of data from various sources. For governments, it is a promising approach because it reduces the costs and time at the difference to traditional approaches such as surveys. A general procedure to link the civic participation and the democracy and governance for smart cities is depicted in Fig. 3.2.

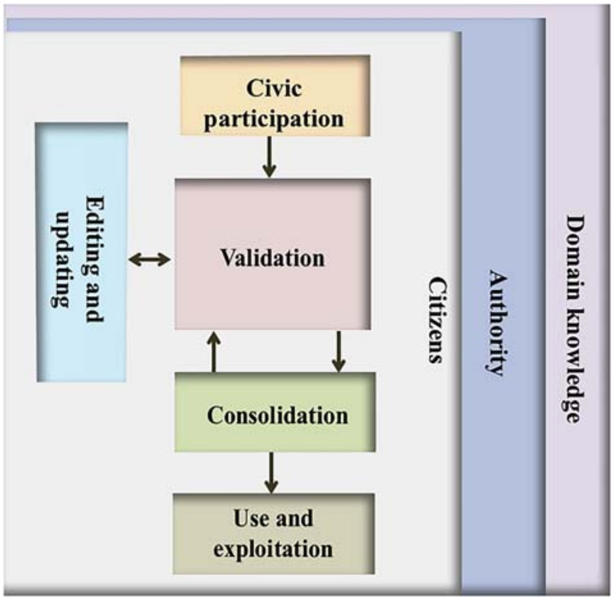

FIGURE 3.2

Civic participation and activities to promote the democracy and governance for smart cities.

In this figure, the civic participation plays an important role to promote the democracy and social governance for smart cities. So, social media, such as an ICT innovation, supports the citizen participation in local and global social and economic phenomena that are embedded in the big cities. The validation process defines the way in which data are envisioned and the main focus and profiles that they are empowered to consolidate real and useful information, to be exploited to improve the decision-making in the context of e-government.

4. Conclusion and general discussion

Nowadays, cities are facing many problems that can be tackled by new approaches such as smart cities, which can involve the participation of citizens, who collaborate actively to voluntarily collaborate in the continuous monitoring of their environment (cf. Lytras and Visvizi, 2018). Public participation is a long-standing tradition in institutionalized planning, but the emergence of the digital world has turned the activity on its head. The ability for all citizens to communicate with one another and with agencies and groups that represent them has provided a new sense of urgency and possibility to the idea that smart cities are based on smart communities whose citizens can play an active part in their operation and design.

We have envisioned many research opportunities to face challenges that smart cities have committed such as a new understanding of urban problems, effective and feasible ways to integrate and coordinate urban technologies, models and methods for using urban data across spatial and temporal scales, developing new technologies for communication and dissemination, new forms of urban governance and organization, critical definition problems related to villages, transport, and energy, and risk, uncertainty, and hazard in the smart city.

This is the case with social media that can be a useful tool to massively capture a great number of simultaneous observations about a diverse phenomenon in urban areas. People are getting more interested in participating in social media; they think their information helps others. However, alternatives should be sought for citizens to collaborate with their observations so that they can be useful for the authorities. Thus, it will eventually be possible to achieve benefits for the community, ranging from a decrease in associated costs to greater certainty in the analysis, which leads to a better definition of public policies. Much social research studies the self-centered and social information tweets because they provide information about people's feelings, activities, and opinions.

This chapter tries to reflect on the concerns and importance of ICT innovation by means of a general framework surrounding the governance of smart city developments. In particular, we assume that the participatory governance is required to be smart to generate democracy of participatory governance.

Most of the times social and collective information are used for research works interested in forecasting or modeling urban factors and natural phenomena, considering the geographic features of tweets and their time stamp. Twitter has shown to be a useful tool for data analytics in different science disciplines. Tweets are a new way to have information about what happens in the real world. Many factors motivate people to tweet, these are related to the kind of gratification people get after doing it. Tweets have important features such as metadata and text that can be used to georeference the tweet and to identify the time of the day it was posted. The technological advances in mobile devices such as smartphones with GPS device integrated let users keep in touch with the social media all the time and even to add their geographic coordinates to the tweet metadata; unfortunately, for scientific analysis based on tweets, few of them have geographic coordinates.

Summing up, this chapter presented a framework to manage data from civic participation applied for supporting the urban analysis. In particular, this approach is oriented toward sensing and evaluating an urban phenomenon to detect emergent behaviors (Giovannella et al., 2016). The use of this kind of approaches is focused on improving the quality of life of inhabitants and providing services that incrementing the smartness of a city because data are sensed and analyzed in near real time. The framework contains the required elements to support the use of data to better operate the civic participation to support the urban analysis.

Acknowledgments

This work was partially sponsored by the Instituto Politécnico Nacional (IPN), Consejo Nacional de Ciencia y Tecnología (CONACYT), and the Secretaría de Investigación y Posgrado (SIP) under grants 20181568 and 20182159. Additionally, we are thankful to the reviewers for their invaluable and constructive feedback that helped improve the quality of the chapter.

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CHAPTER

Citizen participation in the design of smart cities: methods and management framework

4

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Chapter outline

1. Introduction

In the last few years, smart cities have been more popular than ever because they provide new solutions in the domains of mobility, environment, economy, governance, quality of life, and education, thanks to the innovative use of information and communication technology (ICT) as shown in Fig. 4.1 (Caragliu et al., 2011). Generally, the interest in smart cities is strongly linked with the rise of new information technologies such as mobile devices, semantic web, cloud computing, and the Internet of things (Schaffers et al., 2011; Lytras and Visvizi, 2018). The term "smart city" was adopted in 2005 by a number of technology companies as they offered complex information systems to integrate the operations of an urban infrastructure (Harrison and Donnelly, 2011). A number of other nontechnological factors led to the larger adoption of a smart city strategy: the increasing size of cities, the need to safeguard the environment from pollution

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00004-1

FIGURE 4.1

Smart city dimensions.

and energy consumption, or the higher requirements of citizens regarding the delivery of public services (Cocchia, 2014).

Although the technological aspects of smart cities have been well covered by the literature, the essential role of citizens in these cities has often been neglected (Visvizi et al., 2017). Too often, smart cities have not reached their objectives because citizens were not properly involved in their definition or the impact on their daily life was not taken into account (Dameri and Rosenthal-Sabroux, 2014; Lytras and Visvizi, 2018). In the smart city research area, many authors have underlined the importance to discuss citizen participation in a smart city. However, so far, very little has been written on the different enablers of citizen participation in a smart city context. In this chapter, smart cities are considered as sociotechnical systems with citizens as their end users. The goal of this chapter is thus to find out which methods can be used to foster citizen participation in the smart city design and to provide a framework that help in the management of this participation.

This chapter is structured as follows. Section 2 presents the concept of citizen participation and its relevance for designing smart cities. In Section 3, we describe the different methods of citizen participation. In Section 4, we present the different uses of the CitiVoice Framework, thanks to its application to the cases of three Belgian smart cities (Mons, Namur, and Brussels). Finally, Section 5 provides some closing comments and summarizes the contributions of the chapter.

2. Background: role of citizens in smart cities

The concept of citizen participation is not exclusive to smart cities, but smart cities have shed a new light on this concept and provide new means to enable this participation. This section positions citizen participation and its impact in different research fields.

Smart cities are currently benefiting from a positive buzz from supporting organizations and thus from a lot of economic support. Taking advantage of this support and the multitude of technological possibilities, cities must devise smart city projects, decide how they will use and advance their ICT infrastructure, and optimally exploit their assets. A key challenge is to carry out these actions in coordination with the citizens because the ultimate goal of building a smart city is to improve their quality of life. Hollands (2008) underlines the importance of citizens and critiques the technological focus of smart cities. He also claims that smart cities must be based on something more than the use of ICT if they want to enable social, environmental, economic, and cultural development. The real smart city, according to Hollands, should start from the people and human capital of the city and use IT to favor democratic debates about the kind of city people want to live in. This radical critique led to a new stream in the scientific literature. A new definition of a smart city integrated the various dimensions of a smart city and the critique (Caragliu et al., 2011, p. 70): *A city can be defined as* "smart" *when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory governance.* This definition is widely accepted and used in scientific literature and in practice (e.g., smart cities such as Amsterdam used this definition as a basis for their strategy). Fig. 4.2 represents these

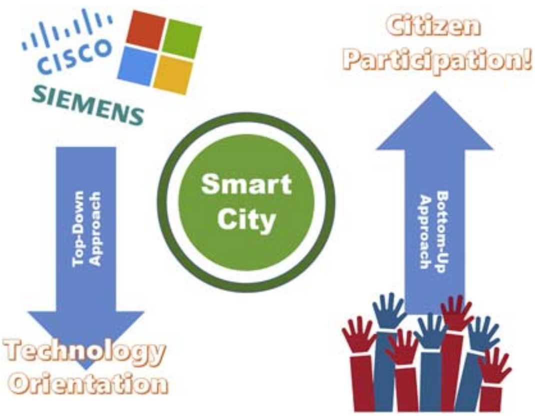

FIGURE 4.2

Smart city approaches.

two conflicting views between top-down (with the focus on technology) and bottom-up (with the focus on citizen participation) approaches.

Even though the traditional definitions of smart cities take the specific role of citizens in a smart city into account through the "participatory governance" or the "human capital" dimension (Albino et al., 2015), the input they can provide and how it can be gathered need further research. In their integrative framework, Gil-Garcia et al., n.d. attempt to conceptualize smartness in government. They state that fostering collaboration between citizens and governments is an essential dimension of smart government. Scientific literature acknowledges the essential role of citizens in smart cities and argues that the notion of empowerment of citizens and "democratization" of innovation should be added to this definition (Perera et al., 2014; Schaffers et al., 2011). The citizens must be able to identify priorities, strategies, and goals for the smart city strategy and should be considered as actors at the center of the implementation and benefits of smart city projects (Albino et al., 2015; Nam and Pardo, 2011).

However, despite this crucial role for citizens, a holistic view on the different participation methods with concrete examples is still rare in scientific literature. Based on our observation in practical cases, this leads to the risk that "citizen participation" remains an abstract buzzword instead of an essential element of the strategy of a city aiming for the label "smart." In this context, this chapter aims at identifying the different methods of citizen participation in a smart city. Furthermore, it builds on previous research on the matter to present a framework to manage this participation (Simonofski et al., 2017).

3. Participation methods

The section presents the different methods of citizen participation with concrete examples. Building on previous literature and an analysis of some of the most well-known and successful smart cities (i.e., Ghent or Santander), we formalize citizen participation in three main categories as shown in Fig. 4.3 (Berntzen and Johannessen, 2016; Callahan, 2007; Simonofski et al., 2017). Firstly, citizens can be democratic participants in the decision-making process of the city. Secondly, citizens can be cocreators to propose better solutions and ideas and to decrease the risk of failure early in the process. Finally, in the postimplementation phase, the citizens can also participate as ICT users by proactively using the smart city infrastructure to make them feel surrounded by technology and to enable them to participate more easily.

3.1 Citizens as democratic participants

Seeing citizens as direct democratic participants in a smart city has several advantages (Irvin and Stansbury, 2004). By being involved in the decision process, the citizens can learn about difficult technical problems and become experts in matters

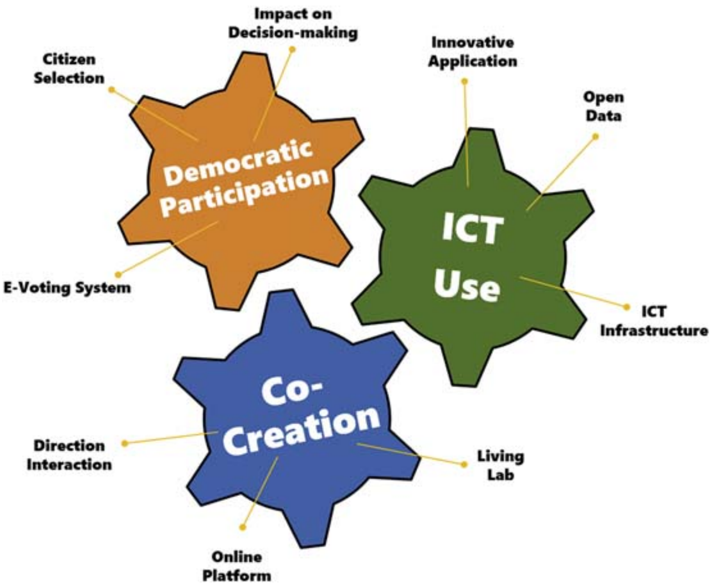

FIGURE 4.3

Citizen participation categories.

of public relevancy. Moreover, the public servants are also learning from the citizens about the reasons why a policy might be unpopular and how to avoid this. Democratic participation of citizens is also cost effective as it reduces the chance for litigation or, in a smart city, useless investments that will not be helpful or used by the public.

In practice, the implementation of democratic participation of citizens faces numerous challenges. Firstly, the group of citizens involved in the process must be sufficiently representative for the population. For instance, the selected group could be biased toward people whose life is more heavily influenced by the decisions about the smart city strategy. This representation could be obtained through basic statistics about the population to ensure the representativeness of each subgroup. Secondly, the participation process can be costly in terms of resources, money, and time (Irvin and Stansbury, 2004). These challenges can lead to an overrepresentation of a certain social group having the time and money to participate (Weber, 2000). To reduce the time and money consuming nature of the decision-making process, this support can reward the citizens through financial but also other kinds of social benefits ("Citizen of the week" awards, free training courses, etc.). The time-consuming nature of the decision-making process and, thus, the challenge of underrepresentation of people lacking time can also be tackled through to the introduction of *e-voting systems*. As citizens may not be used to participate in this kind of meetings, facilitators should also ensure each voice is heard through the use of facilitating techniques such as described by Mahaux and Maiden, 2008.

➢ Example e-voting system: E-voting systems differ and can be decomposed in two main categories (Zissis and Lekkas, 2011). First, voting systems that are physically supervised by electoral authorities such as the electronic voting machines located at polling stations. Second, remote voting systems where the citizens can vote at home or without going to a polling station. In its most developed conception, e-voting enables the Electronic Direct Democracy paradigm where citizens can directly influence all matters of public life from a distance (ongoing legislation, new legislation, representatives, etc.).

3.2 Citizens as Cocreators

The traditional approach to innovation in cities consisted in urban planners making centralized decisions based on their own ideas, but in recent years, and in the smart city context, a new model that takes advantage of the citizens' input and ideas has emerged (Schaffers et al., 2011). Hence, citizens should not be considered as passive consumers but as crucial stakeholders that can generate valuable ideas that can meet social needs. This section explores how this cocreation can be applied in a smart city context.

There exist some *direct interaction techniques* to collect citizens' ideas such as conducting focus groups or interviews with experts and users, town hall meetings, testing usability, functionality, and accessibility, encouraging real-time comments and suggestions, and developing and adhering to measures and standards of service quality (Johannessen, 2010). Other means to gather citizens' ideas and needs for the smart city can be found in the area of requirements engineering for e-government services. Requirements engineering increasingly tries to reflect as accurately as possible the goals, needs, and expectations of the users who are, in this case, the citizens.

➢ Example direct interaction technique: A citizen-oriented approach (van Velsen, van der Geest, ter Hedde and Derks, 2009) advises to conduct semidirective interviews to explore the critical needs of the citizens for the potential system. Other approaches such as the application of the agile paradigm (Schön et al., 2016) and the crowdsourcing paradigm (Adepetu et al., 2012) to the traditional requirements engineering method also provide new methods to collect citizens' needs in a more optimal way.

Another popular technique resides in the *living labs*, defined as "user-driven open innovation ecosystem based on business-citizens-government partnership which enables users to take active part in the research, development and innovation process" (European Commission, 2009, p. 7). The living lab methodology implies that the user is involved early in the development process when analyzing the needs and brainstorming about solutions. The panel of users can also be involved in the concrete development of ideas and finally in testing of prototypes. The goal is to get as close as possible to the citizens to connect with their expectations and to test how this innovation relates to the everyday environment of the users.

The applications of the living lab methodology are very diverse and often relevant in the smart city domain: eHealth, ambient assisted living, e-governance, ICT for energy or environment (Pallot et al., 2010; Chui et al., 2018), and so on. The motivation to engage in a living lab methodology not only originates from the willingness to improve user participation. It also ensures market evaluation, the exploration of a large range of ideas, and the reduction of business risks for companies (Pallot et al., 2010). However, the application of the living lab methodology for the public sector drives away these market-related motivations and increases the potential for citizen participation. Thanks to these labs, the needs, expectations, and ideas of citizens about the smart city projects can be explored.

➢ Example living lab: The Ghent Living Lab is a collaborative platform that includes key stakeholders such as the local government, colleges and university, local developer networks, entrepreneurs, and citizens (Gent City, 2014). The focus of this living lab is on the smart cities and the Future Internet evolutions that could support smart cities. It is also a Learning platform and a test environment. For instance, they organized the "Citadel on the Move" European project that aims at facilitating the use of Open Data for citizens so that they are able to build relevant mobile applications. In this philosophy, the Ghent Living Lab organizes "Apps for Dummies" sessions for citizens who are not used to the program.

In the presence of time or space constraints, citizen participation can be enhanced by two means: centralized *platforms* and social media analysis (Berntzen and Johannessen, 2016). As centralized platforms can be expensive to develop and hard to maintain, social media can be used to reach a larger number of citizens in different contexts: crowdsourcing platforms, collaboration tools, social networking, questioning tools, etc. (Criado et al., 2013). However, the gathering and analysis of social media data might require the support of proprietary platforms. Solutions to this challenge are hybrid systems where a social media interface is included in the proprietary platforms to favor the interaction between citizens and government (Dolson and Young, 2012). This kind of system could be applied in a smart city context to stimulate the citizen input.

➢ Example online platform: There exist a number of other platforms that are able to collect citizens' opinion and experience on certain public matters. For instance, "Civocracy" (Canteneur, 2015) is an online platform that aims at involving citizens and other actors (companies, NGO's, political authorities, etc.) in issues by offering information and discussion support about problems that go from very large subjects such as poverty to more concrete matters such as the opening of a commercial center or the closing of a school. The developers of this platform are currently working on an algorithm that is able to identify the reputation of the users in function of their past interventions. This platform could stimulate citizens to engage into public life and make them provide their own insight and experience problems that the city finds hard to solve.

3.3 Citizens as Information and Communication Technology users

The presence of ICT as "the" defining element in smart cities does not suffice, and the excessive emphasis on ICT has even been reported as the principal defect of a number of smart cities (Merli and Bonollo, 2014). The integration of ICT in a city can nevertheless offer a new range of opportunities and can change the landscape of the city.

Technological advances enable a "ubiquitous computing" infrastructure (Friedewald and Raabe, 2011), a term that is closely related to the concepts of sensors and Internet of things. It refers to the embeddedness of wireless, intercommunicating microprocessors, etc., in objects of the everyday life such that these objects can record and modify the environment. The critical factor is to put these technological developments at the service of the citizens. These developments still remain too abstract for most citizens who are most interested in applicable solutions (Schaffers et al., 2011; Visvizi et al., 2018). New citizen-oriented applications can be mapped to the infrastructure. These *innovative applications* range from Augmented Reality systems (Gutierrez et al., 2013, p. 174), through Citizen Science platforms (Khan and Kiani, 2012) and Public Displays (Du et al., 2017) to any innovative application that makes the citizens feel surrounded and supported by technology and motivated to engage in other applications.

➢ Example innovative application: The City of Santander developed a "Pace of the city" application that has three functionalities. The first one consists in the sampling of values sensed by the smartphones such as GPS location, acceleration, temperature, luminosity, humidity, etc. The second one allows the citizens to create and share events. For instance, a user can make a photo of a hole in the road and send this event via the application. As the city council is connected to the platform of the application, it can be notified of this event and sends someone to fix it. The third functionality results from the fact that a local newspaper "El Diario Montañes" is also connected to the application (Santander City, 2014).

Open Data refers to all publicly produced data that are diffused without restrictions (Janssen et al., 2012). It stimulates the government to act as an open system and interacts with its environment, thus to welcome opposite views and ask for feedback. Open data focuses on several domains such as traffic, weather, public sector budgeting, tourist information, etc. However, the publication of open data will not automatically lead to citizen participation because it demands considerable transformations of the public sector and skills for the citizens to use this data. Even so, more active citizens can create open source platforms or applications to make use of Open Data, to ease collaboration among citizens to solve issues at any scale (neighborhood, city, or even country).

➢ Example open data: Numerous Open Data platforms and strategies are implemented throughout the world. Previous research has already performed an international comparison of Open Data strategies (Huijboom and Broek, 2011).

The particular case of the Open Government initiative launched by Obama in 2009 is interested to examine as it constitutes a repository of interesting data about regulations, IT investments, records, etc. (US Government, 2018).

4. Evaluation of participation

Fig. 4.4 summarizes the CitiVoice Framework, with the proposed criteria organized hierarchically into categories and subcategories. It builds on the participation methods identified in Section 3 and constitutes a useful tool to manage citizen participation in the context of smart cities. We improved CitiVoice by applying it to the smart city designs of three Belgian smart cities (Mons, Namur, and Brussels). These three uses allowed use to demonstrate the three uses of the framework: evaluation tool, governance tool, and comparison and creativity tool.

CitiVoice can be of interest for several stakeholders as it allows them to make better decisions about participation. Indeed, citizen participation is in fact not only about citizens but also impacts a multistakeholders ecosystem that includes

- Public servants: The integration of citizens' input is a challenge that has to be integrated by the public servants to rethink their internal processes. Administrations tend to have a hierarchical functioning that can be incompatible with the networking approach of working with citizens. Therefore, it is not surprising to see failure of participatory projects if the internal functioning of the cities is not ready to integrate this additional layer of complexity.
- Political representatives: The political representatives show two contradictory attitudes regarding citizen participation in smart cities. On the one hand, they sometimes push the administration to engage in such projects due to the visibility of smart city projects. On the other hand, they are sometimes not completely committed to take the voice of the citizens into account because they fear that the participation of citizens will be limited to negative complaints and personal comments. There is thus a need to convince representatives about the usefulness of citizens' comments.
- ICT managers: A strong tendency in Belgian smart cities is to assign the responsibility to implement the smart city strategy to the ICT managers of the administration. This constitutes an opportunity and a threat. The opportunity exists that it allows reusing the best practices from e-government strategies and not to disconnect the two areas. The threat exists in falling back on the technology-oriented conception of smart cities.

4.1 Evaluation tool

It can be used ex-post as an evaluation tool to assess a smart city strategy. This evaluation refers to the analysis of one city along all the criteria of the framework. This evaluation is essential as the concept of participation has been theorized by Arnstein (1969) who suggests that participation is a spectrum that consists of three

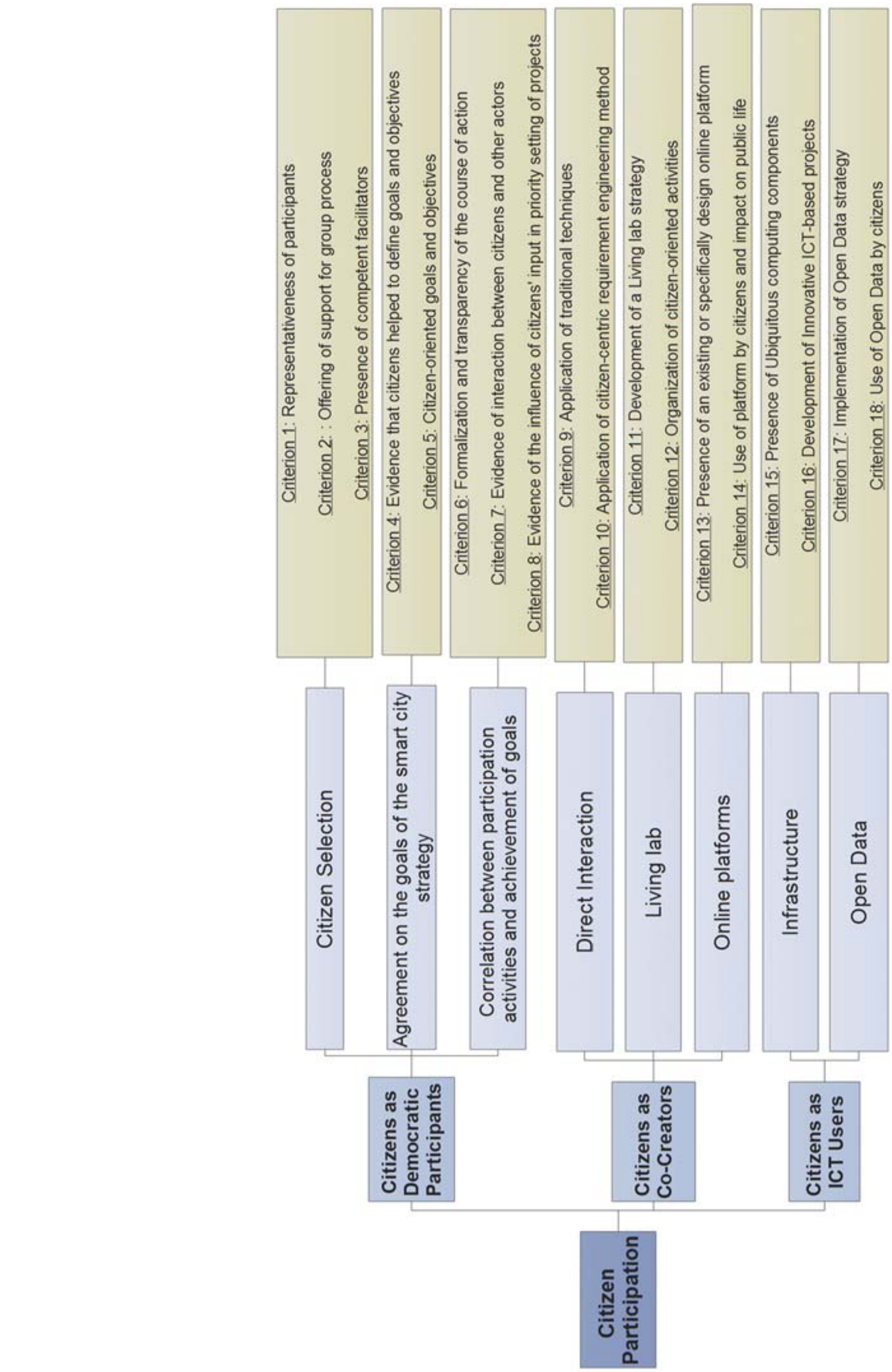

FIGURE 4.4
CItiVoice framework.

main steps: nonparticipation, consultation (gathering of ideas but no impact on decision-making), and codecision (with decision-making shared between officials and citizens). The criteria in this category aim at verifying that citizens' opinions indeed have an impact in decision-making. The main pitfall when including citizens in the decision process is to perform this in a purely instrumental manner. Governments might include citizens in the process only to obtain a more cooperative public hoping to face less resistance when the discussed project is implemented (Irvin and Stansbury, 2004). Similarly, administrations may revert to democratic participation to take decisions that they could never have taken unilaterally. This conception may lead to "routinized" democratic participation that serves only marketing purposes. This risk is considerable for smart cities because citizen participation is considered a matter on which cities want to capitalize to be labeled as "smart." Some strategies attempt to minimize this risk and aim to enable efficient democratic participation, e.g., through the evaluation of citizen participation (Rosener, 1978) To avoid the instrumental participation of citizens, there must be an established cause/effect relationship between the activities of the participation program and the achievement of the agreed-upon goals (Rosener, 1978).

CitiVoice takes as input all information that demonstrates the fulfillment of a criterion. The evidence for criteria can be gathered through, e.g., reviewing textual materials, interviews, excerpt from minutes, etc. For each criterion, a score of 0/0.5/1 can be attributed to quantify the state of advancement for each smart city. This scoring is not criterion-specific and is generic enough to be applied to all criteria. The general scoring rules are as follows: "0" means that the city has not considered this criterion or has rejected it. This criterion has no effect on the participation of citizens. "0.5" means that the city has considered this dimension but has not fully implemented it yet (for example, a project is budgeted and planned or at the beginning of its lifecycle without concrete effects yet). In this state of implementation, the criterion holds the possibility of improving the participation of citizens or already influence it at a minor level. "1" means that the criterion is fully implemented and has a clear effect on citizen participation. For more information about this use, we kindly refer the interested reader to the previous work and the application of the framework to the case of Namur (Simonofski, Serral Asensio et al., 2017).

When used as an evaluation tool, stakeholders can use the framework as lens to analyze the strategy ex-post. Such analysis will reveal missing elements (for instance, no facilitators in group discussion) and provide stakeholders with a clear view on the orientation of participation of their current smart city. Furthermore, thanks to the potential automation of the criteria, it will provide practitioners with easy-to-read status reports of their participation strategy.

4.2 Governance tool

CitiVoice can be used ex-ante as a governance tool for government officials that want to invest in a citizen-oriented smart city strategy. In that respect, the criteria can be considered as guidelines for implementation. To make smart cities as citizen-oriented as possible, the guidance of CitiVoice allows to issue more concrete recommendations for a specific city. Indeed, the different criteria could also be used as a checklist beforehand by any interested stakeholder (e.g., the smart city manager) to guide his actions about citizen participation.

CitiVoice provides practical guidelines for all the precited stakeholders. By establishing a "dashboard" overview of citizen participation categories, we help stakeholders to think about their participatory strategies in a holistic way. For instance, the Democratic Participation category leads the interested stakeholder to think about the ideal organization of participation activities (representativeness, facilitators, etc.) and to truly implement activities that will have an impact on decision-making to avoid manipulation or simple consultation. As far as cocreation goes, CitiVoice provides an inventory of cocreation methods to guide the interested stakeholder. This inventory enablers the stakeholders to develop a multichannel strategy to reach the whole population. Finally, for ICT use, the framework enables stakeholders to invest or redirect ICT infrastructure investments to really think about the potential value they have for citizens.

Using CitiVoice as a governance tool ex-ante allows to guide stakeholders for specific projects. For instance, the city of Brussels used this framework in a participatory budget activity: they used the guidelines of the democratic participation category (presence of facilitator, impact in decision-making, representativeness of participants) to improve their strategy. Ultimately, they decided to use a multichannel approach to enable the cocreation of projects with citizens (by using online platform and workshops).

4.3 Comparison and creativity tool

CitiVoice can be used as a comparison and creativity tool by enabling comparative analyses of best practices for one criterion or category across different smart cities. These comparisons allow differentiating by which means different smart city strategies can ensure citizens' participation and to design new means based on this comparison. For facilitating the visualization of citizen participation in smart cities, we have made use of a radar graph (see Fig. 4.5). This form allows comparing in a straightforward manner in which forms of citizen participation the smart cities have decided to invest. The framework provides the dimensions to establish a "Dashboard" to monitor citizen participation strategies within smart cities. This Dashboard would allow to monitor in which directions (democratic, cocreation, or ICT) investments are made to stimulate participation.

The comparative analysis of different cities could also help generating new methods for citizen participation, thanks to the identification of different best practices within one specific category. In this chapter, we will not reflect extensively on that potential use as it would require the analysis of a higher number of smart cities to truly generate value. However, the comparison of three cities along one particular dimension is already promising. For instance, the specific case of the use of Online Platforms by the researched smart cities yielded interesting insights.

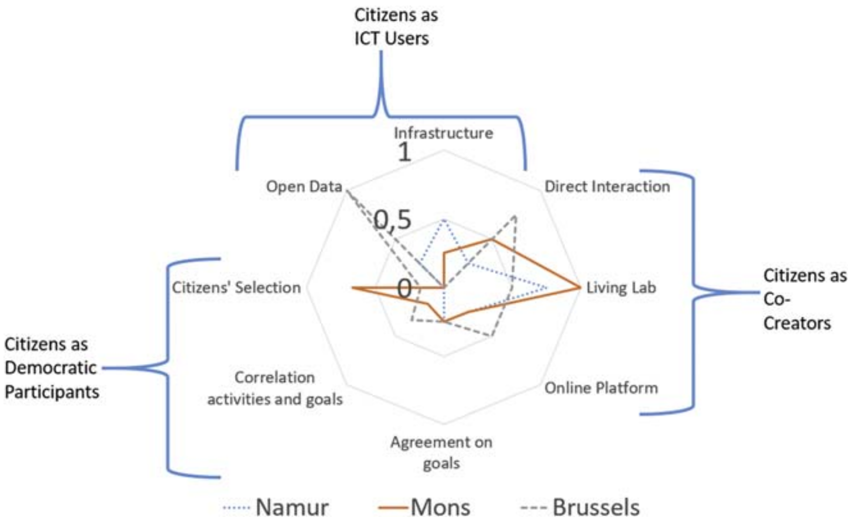

FIGURE 4.5

Participation dashboard of Namur, Mons, and Brussels.

In the three cities reviewed, two categories of online participation platforms were present: large scope participation platforms that enable to collect an important number of ideas from citizens on the one hand and more focused platforms that only enable participation on a specific issue (e.g., mobility, culture) on the other hand. Next to this difference in scope, there was also a difference in the degree of influence that the citizens truly have in the decision-making process. With focused scope platforms, the administration will thoroughly process the ideas of the citizens and even provide some additional participation opportunities (such as crowdfunding to invest in the projects). However, with the large-scope platforms, this processing will be more challenging depending on the resources of the administration. Furthermore, no real mechanism of feedback or additional participation opportunities are provided by the city.

Thanks to the analysis of three different cities, the framework allowed us to describe two relevant dimensions to consider when investing in an online platform: the scope of participation and the degree of influence in decision-making. In that regard, cities must find a balance between the scope of the "Citizens as Cocreators" and the impact of "Citizens as Democratic Participants." Currently, the citizens are generating ideas that do not always have a concrete impact on the city's strategy.

5. Conclusion

This chapter contributes on several levels. Firstly, a state of the art was performed to summarize participation methods to enable citizen participation in the smart city. The participation methods were grouped into three main participation categories: citizens as democratic participants, citizens as cocreators, and citizens as ICT users. This state of the art will provide a solid theoretical basis stimulate research to determine new means for participation. Secondly, a framework to manage citizen participation in smart cities was presented based on the aforementioned state of the art. This framework can be helpful in different ways. For instance, CitiVoice can be applied as an evaluation tool, thanks to defined criteria. Furthermore, this framework can also be used as a governance tool to provide governance recommendations to make smart cities more citizen-oriented. A last interesting use that has been demonstrated was the comparison of several smart cities according to the main categories of the framework. Thanks to the guidance of the framework, a structured comparative tool was suggested to compare best practices among different smart cities. Finally, we expect this chapter to have relevant implications for research as it provides a structuring tool to analyze citizen participation in smart cities. We also expect the chapter to have implication for practices as the framework constitutes an interesting evaluation, governance, and creativity tool that help manage citizen participation in ongoing and future smart city strategies.

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CHAPTER

5

Smart city as a platform economy: civic engagement and self-employment in focus

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Chapter outline

1. Introduction

Thinking and projecting a smart city is a reflective and critical exercise in which different elements act as an intelligent system, full of interactions and transitions, and technology plays a preponderant role in the development and promotion of productive processes, both environmental and social, that affect practically all the services that are provided in a city: medicine, education, public and private services, roads, security, urban infrastructures, etc.

The rapid growth and extension of technological communication nodes facilitate the massification of functions related to virtual reality, artificial intelligence, robotics, nanotechnology, the Internet of things, and big data. Until the present, the citizen could hardly have appreciated the usefulness of these innovations in his daily life, but now he will be able to think that with the smart city concept, he will be able to benefit directly from them. But thinking about smart cities is thinking about communication, which comprises interactions between citizens and governments, between citizens and companies, and between citizens themselves. In the construction of the platforms that support a modern smart city, new relationship frameworks must be designed, starting with the flow of information and the

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00005-3

development of competences. Ultimately, it is about building a complex and dynamic system with multiple interactions in which autonomous employment occupies the focus of our reflection.

We must first of all avoid thinking that the technological element is the only determining factor in the construction of this model and focus more on those skills and competencies of each sector that can be efficiently integrated into these intelligent systems. It is necessary that the political will in decision-making and negotiation can encourage greater citizen participation in the creation of smart cities, having a favorable impact on the quality of life of citizens (Telos Review, 2017).

The European 2020 strategy for the promotion of smart cities proposes investment in information and communication technology (ICT) infrastructure, developing human capital and new technologies to improve the sustainability, quality of life, and work of citizens and companies. This will also increase the efficiency and accessibility of services by reducing poverty, unemployment, social exclusion, pollution, and environmental degradation. In the Venice Declaration for a Digital Europe (2014), smart cities were considered places of experimentation for measures capable of generating growth and employment because in them digital technologies can converge with innovative infrastructures and new services.

2. Smart cities concept

The definition that we will use as a basis to define the concept of smart city is the one included in the Spanish National Smart Cities Plan (PNR, 2014), which is within the objectives pursued in the 20/20 strategy. This has been proposed by the AENOR Technical Standardization Group (AEN/CTN178/SC2/GT1 N 003), so that the smart city (Smart city) is considered to be "the holistic vision of a city that applies ICT for the improvement of the quality of life and the accessibility of its inhabitants and ensures a sustainable economic, social, and environmental development in permanent improvement" An intelligent city allows citizens to interact with it in a multidisciplinary way and adapts in real time to their needs, efficiently both in quality and costs. It can do this by offering open data, solutions, and services aimed at citizens as people, with the purpose of solving the effects of the growth of cities, in public and private spheres, through the innovative integration of infrastructures with intelligent management systems (cf. Visvizi and Lytras, 2018).

We can also define smart city as a city in constant search for new urban solutions, focused on the quality of not only the life of its inhabitants but also of its companies, tourists, researchers, and entrepreneurs. As established by the European Union (EU) in the document "Mapping Smart Cities in the EU" (2014), a smart city should be the one that contemplates mobility solutions, energy efficiency, environmental aspects, government, economy, culture, leisure, sports, and technological solutions that cover the ICT needs of the citizen to develop their smart city plan.

Similarly, the opinion of the European Economic and Social Committee on "smart cities as the driving force of the new European industrial policy" (2015/C383/05) considers smart cities to be those that are destined to become engines for the development of a new European industrial policy capable of influencing the development of specific productive sectors, extending the advantages of the digital economy on a large scale. Among other things, the Vice President of the Commission, Maroš Šefčovič, on the occasion of his speech in the plenary session of the committee on April 22, 2015, declared that smart cities are a development priority for the EU. To obtain the desired results, the Commission proposed to the other European institutions and national governments to connect the concept of "intelligence" to a sustainable and integrated model of development applicable to a city, island, territory, or industrial district, based on the coherence and integration of six fundamental pillars: (a) technology and instruments for energy efficiency and integration of renewable sources; (b) dissemination of technology and connectivity platforms to create the new digital service systems; (c) new digital services to improve the quality of life and work of citizens and companies; (d) modernization of urban infrastructures and urban redesign; (e) education and training of citizens, businesses, and the public sector in digital skills; (f) a model of economic and financial sustainability for investments. The simultaneous presence of these six pillars should be considered a standard and essential component of the strategic smart city project. Equally important is that the application of this model is accompanied by policies that guarantee the highest levels of security in the networks, computer systems, applications, and devices, which form the basis of the ecosystems of digital services (cf. Lytras and Visvizi, 2018). And it proposes, as a means to achieve this, the translation of these proposals into concrete actions—considering as fundamental the participation of civil society—and that the EU and the Member States harmonize their policies by providing them with the corresponding public financial resources and opening them structurally to the association between the public and private sectors.

A city would be a smart city from the perspective of its economic structure if the economic activities that take place in it have a significant presence of ICT, either because the industry of the ICT sector itself is predominant or because other sectors make intensive use of ICT in their activities. From the demographic point of view, the smart city is the one that has a trained and capable population, especially in the field of ICT. In addition, a city will be a smart city in the field of governance if ICTs are widely used in city government and also serve as a channel of communication and development of transparency policies between the administration and citizens.

The companies and their workers who live and work in smart cities are none other than their citizens. The concept of intelligent cities must also be defined for companies that have gone through many phases and stages since the industrial revolution. Today industrial advances are in the area of digitization, information, and transparency, which are basically fundamental instruments for corporations. This allows us to define intelligent companies as those which, using innovative principles, pursue the social welfare of their human resources and integrate themselves in a sustainable way into the society for which they work. At present in Spain, the Industry Connected 4.0 initiative has been launched by the Ministry of Industry, Energy, and Tourism, led by the Secretary General of Industry and Small- and Medium-sized Enterprises in collaboration with the Secretary of State for Telecommunications and the Information Society whose mission is the definition of the strategy for industry digitalization. The Industry Connected 4.0 initiative is defined as a public-private initiative, in which, although promoted by Public Administration, the involvement of the private sector, participants from the educational and research fields, and social agents is essential. Therefore, the management model will consider the inclusion of the different actors that make up the industry in general.

Social reality considers that the economic and financial viability pace of smart investments could be increased by encouraging large companies, small companies (SMEs), and start-ups to propose advanced solutions for intervention programs, both in Spain and in Europe. This would generate effects such as promotion and integration with regard to strategic projects, systems of creating new companies (start-ups), innovative companies, and investigations that could generate important positive effects relating to the technology, social organizational models, and their repercussions for the employment.

3. Platform economy

Technologies have made new forms of socialization possible, the main exponent of which are the digital social networks that form the basis for the launching and development of new consumption modalities. The rapid penetration of new telecommunication technologies in homes, together with an increasing access to devices connected to the network and the growth of social media, has led to structural changes in consumer behavior and habits of consumption.

In recent years, we are witnessing an important growth of this new reality that is revolutionizing the whole industry, radically transforming the way in which consumers and users relate to industries. This has been the basis for the launch of a countless number of new business models based on services and products that already existed but are now offered in a more affordable and efficient way.

Platforms create value through contact between suppliers and demanders of a product or service based always on a technological support that would not have been possible without the concurrence of several technological developments that facilitated its architecture. These include cloud storage, virtual servers, virtual reality, artificial intelligence, the development of big data, and above all, the rise of connectivity, which has allowed the so-called “Internet of things” This connectivity would not be possible without the development of a broad and effective telecommunication infrastructure in urban areas.

The superiority of the platform economy over the traditional economy is based on a series of factors that make a company succeed in building an innovative platform with a common characteristic: they are all structured as networks, connecting individuals, companies, information, and goods among themselves.

Take Google for example: Google connects pieces of information through its indexing engine, connects users with information through its search engine, then connects users to each other through Gmail and connects businesses with Adwords. Any other exercise with any technological actor will agree that everyone is in the business of connecting things. Airbnb and Netflix are examples. Even Apple, with its apparent focus on physical products, actually connects us with information, business, and digital products through its App Store. For these actors, connections have become the most valuable assets that a company might want to own. Layered over classical economics, the network economy has its own rules and its own market mechanisms.

This network structure provides companies with four superpowers, the cornerstones of their competitiveness. First is the power of **magnetism** (to detect, organize, and animate very small value units, creating value for the user). Second is an extraordinary capacity to operate in **real time** (they use real-time data to instantly optimize market adjustment and improve the value of products). Third is an **infinite** capacity for growth. (Thanks to network effects and zero marginal costs, they can grow indefinitely in revenues with minimal impact on costs. Its competitive advantage is the speed of scale and profitability.) And fourth is a capacity never seen before, to **personalize** the products or services (using the knowledge of the client, such as Amazon or Netflix, to adjust and customize the experiences delivered to each client. Large-scale personalization is the heart of their products. Directing and personalizing their products to each individual user, they create intimate and hard relationships) (Fabernovel Innovate, 2015).

Companies wishing to compete in this new economy should aspire to become networks (at least in part). By multiplying connections, they can acquire these four superpowers and benefit from externally produced value, exponential growth, instant market adjustment, and tailored customer relationships.

APIs (Application Programming Interfaces) offer an easy way for companies to establish these almost essential connections, allowing any company to connect with other companies to access information, customers, or products.

Through the multiplication of connections, they can acquire these four superpowers and benefit from externally produced value, exponential growth, instantaneous adjustment to the market, and personalized customer relationships.

The model developed by "start-ups" is the one that best takes the advantage of the scalability and flexibility of this environment offered by technological platforms for the rapid development of businesses with little infrastructure.

Ronald Coase, in 1937, in his article "The Nature of the Firm" argued that companies exist to be, sometimes, more efficient than the market as a form of organization because of their lower transaction costs. A pure market economy would require the continual renegotiation of agreements to carry out the production of goods or services, which would generate considerable uncertainty. In return, the company generates a series of rigidities inherent to its status as a stable organization, such as its lower flexibility in labor and production costs. The platforms constitute an intermediate stage between the market and the company, taking elements of both to develop their activity.

The great virtue of platforms consists not only in their scalability but also in their unlimited capacity to generate services or resources between suppliers and demanders. In this manner, in almost all sectors, demand is met with the greatest efficiency and lowest cost because it takes advantage of and optimizes the returns to scale in each sector.

We are, therefore, facing a scenario of great potential, which puts in check the large multinationals and the traditional operating structures of the industry. There are many entrepreneurs who no longer consider the idea of establishing a new company in the traditional style, with stable physical infrastructures, staffing, organizational resources, etc. Rather, as soon as they design the idea or project, they seek its rapid implementation through any of the platforms that are already available in the Internet ecosystem or also by creating their own platform, something that is more complex to carry out but that allows them to lead that platform.

At this point they have developed to the point that they compete directly with traditional companies established in the sector, such as, for example, the hospitality or transport sectors, which are currently the most affected by the competition of these large platforms. Their great capacity for growth and scalability makes it possible to reach very quickly significant quotas of activity in their respective sectors, seriously damaging the competition and preventing the participation of new agents. This occurs because, once they have reached rapid growth due to their economies of scale, they can offer services at a more competitive cost than any rival that wishes to enter the market again.

The traditional regulation created in the framework of the development of classic business models in the capitalist economy is incapable of regulating these new players efficiently.

The platform economy allows the generation of micro entrepreneurs or “workers per project” in a very fast way and with hardly any costs. The opportunities generated by the platforms, combined with relocation, and even, in many cases, with the virtualization of work, make this possible.

It is, therefore, reasonable to expect a large growth of “freelance” workers under the shelter of the development of many of these platforms. The possibility of notably increasing the cost efficiency in this type of systems also affects the labor factor. But despite the fact that they can generate quick and flexible employment options, they do not guarantee that minimum remuneration can be achieved. In many cases, they may require workers to be able to do more than one job to adapt to the evolution of market demands.

4. The collaborative economy in smart cities

The collaborative economy is the sale, exchange, or transfer of products or services, mainly by individuals, through online technological platforms that allow the connection and management of the relationship between suppliers and consumers (Bulchand Giudumal and Meilan Gonzalez, 2016).

According to these authors, with a collaborative economy, we could arrive at a society in which the property of the goods is increasingly less relevant. In the vast majority of cases, we will use services when we need them. Companies will become less and less relevant as individuals or small groups of individuals are those that manufacture goods and produce services, using technology as a connector.

Think and project the smart city is a reflexive and critical exercise in which different elements act as an intelligent system, loaded with interactions and transitions, technology has a preponderant role, but it is not exclusive. The risk of thinking that the technological element is the only determining factor can lead us to organize its administration in an excessively mechanistic way. It is therefore necessary to think in terms of intelligent systems that efficiently integrate the capacities and competencies of each sector, adapting technology to them.

For the creation of smart cities, political will, decision-making, negotiation, and the power of governmental decisions are required. Citizen participation can have a favorable impact on the quality of life of citizens, covering options as broad as e-commerce forums, online work, telemedicine, open government operations, and democratic exercises. Having a city as a platform full of options only has value if its citizens know how to integrate into it. A smart city is the sum of diverse efforts from multiple sectors, forming an intelligent system.

The connectivity in cities that has been deployed in recent years, mainly in the industrial and technological field, has focused principally on the business use of new connectivity solutions, closely linked to their digital transformation processes. However, in addition to the work or collective scopes, there is already a continued presence of the "Internet of things" in the other aspects of personal life. The confluence between the sustained growth of the solutions market and its daily uses on a personal level is what highlights the need to carry out a study with attention specifically focused on employment within the smart city.

Certainly the collaborative economy has its beginnings in this capacity developed by the connectivity of things and people. However, the development of the collaborative economy can create many market inefficiencies such as those of labor quality, unfair competition, lack of security in the transactions, distrust, asymmetric information, and so on. But once control mechanisms are created, the market can do the rest of the work by drastically reducing transaction costs and increasing market efficiency and optimization for all participating agents.

According to Professor Arun Sundararajan ("*The Sharing Economy: The End of Employment and the Rise of Crowd-Based Capitalism*"), there are five key characteristics that favor the development of the collaborative economy in cities:

1. The collaborative economy creates markets for goods or services.
2. The collaborative economy opens opportunities for the efficient use of possibilities and capacities not used in housing, time, or money.
3. Networks based on crowds are created instead of centralized institutions or hierarchical hierarchies.

4. In these platforms, the personal and professional level of the workers diffuse.
5. In the new economy, the limits between full-time work and occasional work, between employment and self-employment, and between what is work and what is leisure, are blurred.

We can distinguish two forms of transactional exchange called the B2C (Business to Consumer) and the C2C (Consumer to Consumer), depending on whether the exchange is between individuals or between companies and individuals. From there, the types differ depending on the economic sector in which they operate.

Thus, we have, in the transport sector, cases of car-sharing platforms such as Uber, Zipcar, Lyft, or BlaBlaCar, which connect drivers and their cars of any type with passengers.

In the tourism sector, the Airbnb platform has been very strong, providing a solution for sharing the available space of real estate resources. Both Uber and Airbnb were born as an asset exchange platform in which people discovered that they had many unused or barely used assets, including their time. Besides, these platforms provide them additional income in the same manner as the traditional economy. But we also have examples of services in finance, public services, goods, food, education, etc.

Think of the example of renting bicycles by city councils. The users are responsible for the property that the community puts at their disposal, favoring a responsible use of these bicycles. This responsible use is thanks above all to the control carried out by the use of cards with identification chips that allows tracking who the user is and how he or she uses the bicycle. These control measures make it easier for this system to work in practically every city in Europe.

That technology allows creating and multiplying an offer of scale for that experience and establishes a market in which almost no disagreements exist. Of course, this market may attract other users, some of them with opportunistic behaviors. Some companies may use these platforms to reach a niche market that was trying to escape them in search of a more personalized and more cost-effective attention, or there may be companies that perceive these platforms as unfair competition. Therefore, it is essential to accompany the creation of these platforms that generate employment and services or that help to liberalize the market with regulations, while maintaining a minimum quality standard for both users and suppliers.

An interesting example is provided by platforms such as Airbnb and Uber, where the market has generated both a surplus of consumers and suppliers, creating an exchange value in which the platform makes sure to capture a part of that value. In these cases, the platforms can cause damage to traditional legally constituted companies. Another risk is the tendency of these platforms to create monopolies and therefore potentially monopolistic charges. This proliferation of sharing services has a profound and relevant impact at the city level, generating many external factors, some positive and others negative.

Take the case of Airbnb: among the positive ones, we expect that the additional income from tourism is distributed among less touristy areas of the city, but among the negative externalities, we have the opposite: saturation of tourism, where areas are created with very concentrated gentrification of entire neighborhoods and where the increase in rental prices is displacing the native inhabitants toward areas bordering the center (Bulchand et al., 2016).

New platform-based sharing businesses can transform cities and can help increase the efficiency of the city and solve some of the great urban challenges of this century. The smart city should study how to incorporate these new business models into the particular context of each city or could also consider the creation of its own service platform. As noted by Ricart and Berrone (2017), regulation should not be considered in isolation but should be the result of incorporating these new sharing platforms as part of the city's strategic plan and, therefore, studying them in the context of the city model.

Technological platforms of intermediation reduce information asymmetry and do not have other references that, in some cases, can be found in the traditional economy (for example, the company's facilities or the physical appearance of the workers). The supplier's online reputation helps new customers choose between the products and services offered and becomes a key element in the exchange process. Thus, "the recommendation of the clients becomes one of the main engines of expansion of the collaborative economy" (Bulchand Giudumal and Meilan Gonzalez, 2016).

The reality is that today the collaborative economy is not a full-time occupation but is often chosen as a source of complementary income. Botsman and Rogers (2010) affirm that people share their goods, avoiding in this way an excess of consumption and the unnecessary purchase of products that will not be used later. This generates a more responsible and reasonable consumption, more sustainable and less demanding of the planet's resources.

Regarding the fiscal impact of the economic figures generated by the collaborative economy, PwC (PricewaterhouseCoopers) estimates a total market size of 15 million dollars in 2015, noting that in 2025, it could reach 335 billion dollars. In Europe, the European Commission mentions 28 billion euros as the total economic figure caused by the collaborative economy in 2015.

The premise is made that independent professionals, in comparison with salaried workers, should be free to decide with whom, when, and how to perform their services (Nieto, 2010).

5. Self-employment in smart city

From the analysis of the investigations examined, it can be deduced that the work generated by the "collaborative" economy is, generally, a sporadic and part-time job that provides insufficient income, which provides an obviously insufficient means of living to satisfy the minimum requirements of quality of life in cities.

An example is shown in the research work carried out by De Groen et al. (2016) on gross hourly earnings per hour in a collaborative economy platform and in the traditional labor market in Belgium (Fig. 5.1).

From this table, which compares income through the ListMinut jobs platform versus the average income of the same offline jobs, the finding is that workers in

category	Online agency	Offline labour market	Diference
wellness	26	10,29	15,71
animals	26	10,82	15,18
tutoring	15	8,2	6,8
transport	17,5	10,94	6,56
home repair	17,5	12,7	4,8
gardening	13	11,35	1,65
computer science	14	12,51	1,49
events	13	12,12	0,88
households	10,5	13,06	-2,56
babysitting	7,67	10,78	-3,11

FIGURE 5.1

Earnings per hour in an online platform versus the offline platform, in the Belgian labor market.

Source: Elaboration of authors based on data indicated by De Groen, W.P., Maselli, I., Fabo, B., 2016. The Digital Market for Local Services: A One-Night Stand for Workers? An Example from the On-Demand Economy. CEPS Special Report, No. 133. Available at: SSRN: http://ssrn.com/abstract=2766220.

the digital labor market are not necessarily worse paid than in those in the offline market. Remuneration is comparable in sectors such as event management and information technology. Home repairs, animals, household services, tutoring, gardening, transportation, and welfare are best paid through the online agency, while the average hourly rates for child care are below payments in standard forms of work (De Groen et al., 2016).

The Spanish Association of the Digital Economy (Adigital) has recently reported (in "Work on Digital Platforms, Analysis and Proposals for Regulation" 2017) on the adaptation of the labor regulatory framework to digital platforms. This was done with the aim of promoting a normative framework appropriate for work activities that are developed within digital platforms and which provides companies and users with greater legal security and competitiveness.

The report proposes an "adequate delimitation of the type of relationships between platforms and their users" and defends the existence of a mercantile relationship represented by the figure of the self-employed person as the regime that best adapts to this reality in most cases, with some nuances. At present, the platforms operate according to an established regulatory framework that seems insufficient to meet the expectations and needs of all parties; hence, there is need to promote frameworks that better adjusted to the new realities.

Among the proposals presented is the recommendation of how to define minimum forms of social protection and insurance, minimum wages, measures to guarantee the protection of users' privacy and to avoid discrimination based on gender, ethnicity, race, or age, and including the creation of information mechanisms for users about their work obligations.

However, in Spain as in most European countries, the collaborative economy does not have specific regulation, but rather its activity is discussed within the framework of the application of a series of already existing standards. According to data from the European Commission referring to March 2016, 17% of the European population would have used the services offered by the collaborative platforms.

As the report of the Economic and Social Council of Spain (04/2016) points out, in many collaborative economy platforms, it is not well established as to when a service is provided by a professional as a commercial activity, and when not. This creates doubts as to what legislation to apply when determining whether or not they have any responsibility for the transactions that take place in their digital environment.

As a consequence of the aforementioned gaps in the regulation of collaborative economy platforms (especially in tax, labor, and competition matters), traditional operators (in the transport and accommodation sectors) have interposed in recent years various demands (mainly due to unfair competition) against collaborative economy platforms.

6. Conclusions

The European Commission affirms that platforms can make an important contribution to the employment and growth of the EU if they are promoted and developed responsibly. However, at the same time, it points out the issues and concerns that surround them and the uncertainty about the rights and obligations in these business forms. Among those concerns, it has called attention to the most ambiguous limits that are noted between self-employed and employed persons. ("An agenda for the collaborative economy", European Commission, p. 356 final, 2016).

This new form of employment has implications for working conditions and the social protection of crowdworkers and for the dynamics of the labor market, generating a high degree of uncertainty about the income of service providers on the platform. This is because access to work is neither continuous nor does it offer a guarantee of regularity, causing low levels of remuneration, especially in certain services that offer low-skilled work tasks. In turn, this situation can cause a spiral of outsourcing of work in companies, causing losses of stable employment and labor market conditions.

The spread of this system of work threatens to dismantle traditional labor markets because they do not seem to guarantee a fair protection of workers' rights (Aloisi, 2016).

Therefore, our proposal for a more sustainable development of the smart city is that the city should assume, in an institutionalized way, the role played by all the service platforms within the community. As Aloisi points out in his paper "Commoditized Workers, 2016," the role of these platforms is none other than to facilitate transaction costs with consumers by serving as a simple virtual "bulletin board."

Given that, in many European cities, service platforms designed to inform citizens about public transport have already been developed by city councils, the next step in the progress toward a smart city would be to incorporate more platform services, in which the workers that provide their service in private platforms can connect with the city's client through the city's virtual platform. The registration of these workers in an institutional platform would require keeping an official record in which professional qualifications are recorded, thus guaranteeing a more reliable service for the citizen. On the other hand, these workers would also have their labor rights covered and their fiscal obligations more transparent.

Providing citizens with a wider and more transverse portfolio of services would imply the assumption of the role currently developed by private platforms, which, in a chaotic and unregulated way, offer intermediation services that cities could perfectly assume, but respecting the rights of workers and regulating their fiscal commitments, providing a more efficient and higher quality service to the citizen of the smart city.

The urban platform of work services would provide workers with an efficient means to reach customers by obtaining remuneration commensurate with the market.

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CHAPTER

6 Understanding sentiments and activities in green spaces using a social data–driven approach

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Chapter outline

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00006-5

1. Introduction

Half of the world's people are living in cities today, and the proportion of urban residents is forecasted to increase to two-thirds of the world's population by 2050 (United Nations, 2014). With this rapid urbanization throughout the world, there is an increased emphasis on understanding and enhancing the overall well-being of residents in cities and urban areas (Hartig and Kahn, 2016; Lytras et al., 2019). Toward this objective, city planners have sought to incorporate green spaces in their urban development plans, as green spaces are believed to improve the physical and mental health of people residing in these urban areas. The emphasis on incorporating green spaces is also reflected in the United Nations Sustainable Development Goals, which include a specific target to provide accessible green space for all urban residents (United Nations, 2017). This topic has also garnered the interest of researchers in recent years (Hartig and Kahn, 2016; Schetke et al., 2016; Wang et al., 2017; Dadvand et al., 2017), and the importance of green spaces has also been highlighted with a recent perspectives article in Science (Hartig and Kahn, 2016).

Existing research has explored the emotional benefits of green spaces in urban areas (Lee and Maheswaran, 2011; Hartig et al., 2014), typically employing the use of user surveys, questionnaires, and case studies. Although these works have generated interesting findings on green spaces, they are often small in scale and involve the explicit participation of users. Moreover, these traditional methods are often intrusive, time intensive, and costly for researchers to perform a longitudinal study or fine-grained analysis involving participants. For example, to track users with a fine-grained resolution, personal tracking devices have to be used and worn by the participants. Similarly, to study the changes in sentiments or activities across the different days or months, surveys would need to be regularly administered over the course of the study, which is time consuming for both researchers and participants. To overcome these challenges of traditional methods, we apply sentiment analysis and topic modeling techniques on geotagged tweets posted by Twitter users, which serves as a nonintrusive way of exploring sentiment expressed in user-generated content and is also easily available on a large scale. Although we focus on green spaces in this work, our approach is easily generalizable and can be extended to examine other research questions (RQs).

Research objectives and contributions: In this empirical study, we aim to examine the effects that visits to green spaces have on people's sentiments and the implications of these findings for urban planning.[1] The novelty is the combination of psychological theory and analysis of digital traces left by Twitter users, which, as we will demonstrate, addresses some of the constraints of traditional methods. In particular, we will answer the following RQs.

- RQ1: How do sentiments and emotions differ in green spaces compared to urban areas?
- RQ2: How does the time of day and season of visit to green spaces affect these sentiments and emotions?
- RQ3: How does the proximity of green spaces affect these sentiments and emotions?
- RQ4: How are green spaces utilized in terms of activity types, and how can these findings be used to improve recommendations?

We apply this proposed methodology on a large set of 21.2 million tweets (2.2 million geotagged) to better understand the relationship between green space and user sentiments, and our main findings are as following:

- Tweets in green spaces exhibit higher levels of joy, anticipation, and trust (positive emotions), and lower levels of anger and fear (negative emotions), compared to tweets in urban areas.
- Although tweets in green spaces are generally more positive than tweets in urban areas, the season (spring, summer, autumn, winter) when a tweet was posted affects the various emotion levels differently in green space and urban areas.
- In addition, we observe interesting changes in sentiments based on the hour, day, and month that a tweet was posted, which reflect trends in real life.
- We also find a positive correlation between the sentiment polarity, i.e., degree of positivity or negativity, of tweets in urban areas and their proximity to green spaces.

Structure and organization: This chapter is structured as follows. Section 2 provides an overview of literature on Twitter-related analytics and green space studies. Section 3 describes our data set collection and analysis framework. Sections 4–7 highlight the results from our experiments using Twitter, while Section 8 discusses the implications of our main findings. Finally, Section 9 concludes and summarizes the chapter.

2. Related work

There are two streams of research that are related to our work, namely research on general Twitter-related analytics and research that examines the emotional benefits of green spaces.

[1] This chapter is an extended version of an earlier conference paper (Lim et al., 2018).

General Twitter-related analytics: As our work aims to understand the effects of green spaces on user sentiment using Twitter, we first discuss key works that are related to general Twitter analytics. Twitter is a popular microblogging social networking site that allows users to post short messages of 280 characters and share these tweets with their followers. In recent years, researchers have made extensive use of Twitter to understand many social phenomena and behaviors. As a form of location-based study, researchers have used Twitter to understand correlations between user mobility patterns and happiness levels (Frank et al., 2013), identify popular topics (Lansley and Longley, 2016) or witness accounts (Truelove et al., 2014) associated with various places, determine visitation rates to parks (Hamstead et al., 2018), and study travel trends across different areas (Ferrara et al., 2013). Another group of work focuses on prediction and recommendation tasks, such as predicting levels of happiness, food preferences, and physical activities (Nguyen et al., 2016), predicting flu outbreaks (Achrekar et al., 2011), recommending friends (Barbieri et al., 2014), and constructing interest profiles (Besel et al., 2016) and topical expertise (Wagner et al., 2012; Xu et al., 2016) of Twitter users. Other researchers focus on general applications of Twitter data in areas such as politics (Conover et al., 2011; D'Avanzo et al., 2017; Karunasekera et al., 2018; Visvizi et al., 2019), academic conferences (Wen et al., 2014), community detection (Lim and Datta, 2016), crisis management (Kavanaugh et al., 2012), crowd sensing (Roitman et al., 2012), event detection (Cui et al., 2012; Popescu and Pennacchiotti, 2010; Xie et al., 2016), among others.

Analysis of psychosocial response to green spaces: We now discuss key works related to the various aspects of understanding green spaces in urban areas. The study of green spaces in urban areas have garnered strong interest in recent years (Hartig and Kahn, 2016; Schetke et al., 2016; Wang et al., 2017; Dadvand et al., 2017), ranging from determining the appropriate levels of green spaces (Wolch et al., 2014) to understanding the usage patterns of urban green spaces (Schetke et al., 2016). Among these works, we are most interested in works that study the effects of green spaces on people in urban areas. Many of these works utilized surveys or questionnaires to understand how green spaces affect a range of different outcomes related to personal well-being (Chiesura, 2004), thermal comfort (Wang et al., 2017), life expectancy of residents (Takano et al., 2002), and prevalence of myopia (Dadvand et al., 2017). Researchers (Roe et al., 2013; Tyrvainen et al., 2014) augmented these surveys with clinical measurements to study the correlations between green spaces and stress level, via measurements of blood pressure and salivary cortisol levels. Others (Al-Husain et al., 2013) have also used wearable biosensors to study the physiological response of users to different types of environments. However, green space research typically relies on traditional methods based on surveys, questionnaires, case studies, or wearable sensors and has not previously used twitter data analytics to explore user sentiment. This observation is supported by recent comprehensive literature surveys of existing work on the benefits of green spaces (Lee and Maheswaran, 2011; Hartig et al., 2014).

Discussion: While previous research has examined interesting aspects of Twitter and green spaces separately, we note two key differences with our study, namely, (1) while the works using Twitter-related analytics present interesting and useful understanding of some social phenomena, our work examines the relationship between green spaces and people's sentiments in multiple aspects, such as time, proximity, and activity types, and demonstrates how these findings help to improve recommendations and (2) many early studies on green spaces and their associated health and well-being outcomes are based on surveys, questionnaires, or case studies, which are typically small in scale, intrusive, time intensive, costly, and difficult to replicate. In contrast, our study utilizes a big data-driven framework based on implicit digital traces left by Twitter users, which is large in scale and nonintrusive, to study how green spaces affect user sentiments across different time periods and spatial areas. In addition, our proposed framework can be easily extended to study other RQs, e.g., understanding general sentiments about the "La La Land" movie by analyzing tweets with the "#LaLaLand" hashtag or sentiments regarding specific areas by examining geotagged tweets posted in those areas.

3. Experimental design

Fig. 6.1 illustrates our data-driven approach to studying green space, which comprises the main steps of data collection, tweet preprocessing, sentiment analysis, and topic/activity detection that are described in Sections 3.1–3.4, respectively.

3.1 Data set and data collection

Our data set comprises a set of 21.2 million tweets (2.2 million geotagged) generated by 10,510 users in Melbourne, Australia. We also have access to a green space data set, comprising the locations and coverage of 482 green spaces (e.g., parks, gardens, green fields, and other open areas) in this city.

Twitter data set: We first describe our data collection methodology for the Twitter data set, which was collected from Nov 2016 to Jan 2017 using the Twitter REST API. For this data set, we employed a two-stage collection as follows:

1. **Stage 1 collection**: This initial stage involves collecting all geotagged tweets (i.e., tagged with latitude/longitude coordinates) that are posted within a 5×5 km grid in central Melbourne, Australia. This 5×5 km grid is centered on approximately the Melbourne General Post Office building. Fig. 6.2 illustrates this data collection process, where a series of overlapping circle-based Tweet searches ensures comprehensive coverage of the whole 5×5 km grid. We experimented with various other approaches and found this approach, i.e., using overlapping circle-based Tweet searches with a radius of 400 m, performs the best in terms of retrieving a high proportion of geotagged tweets.

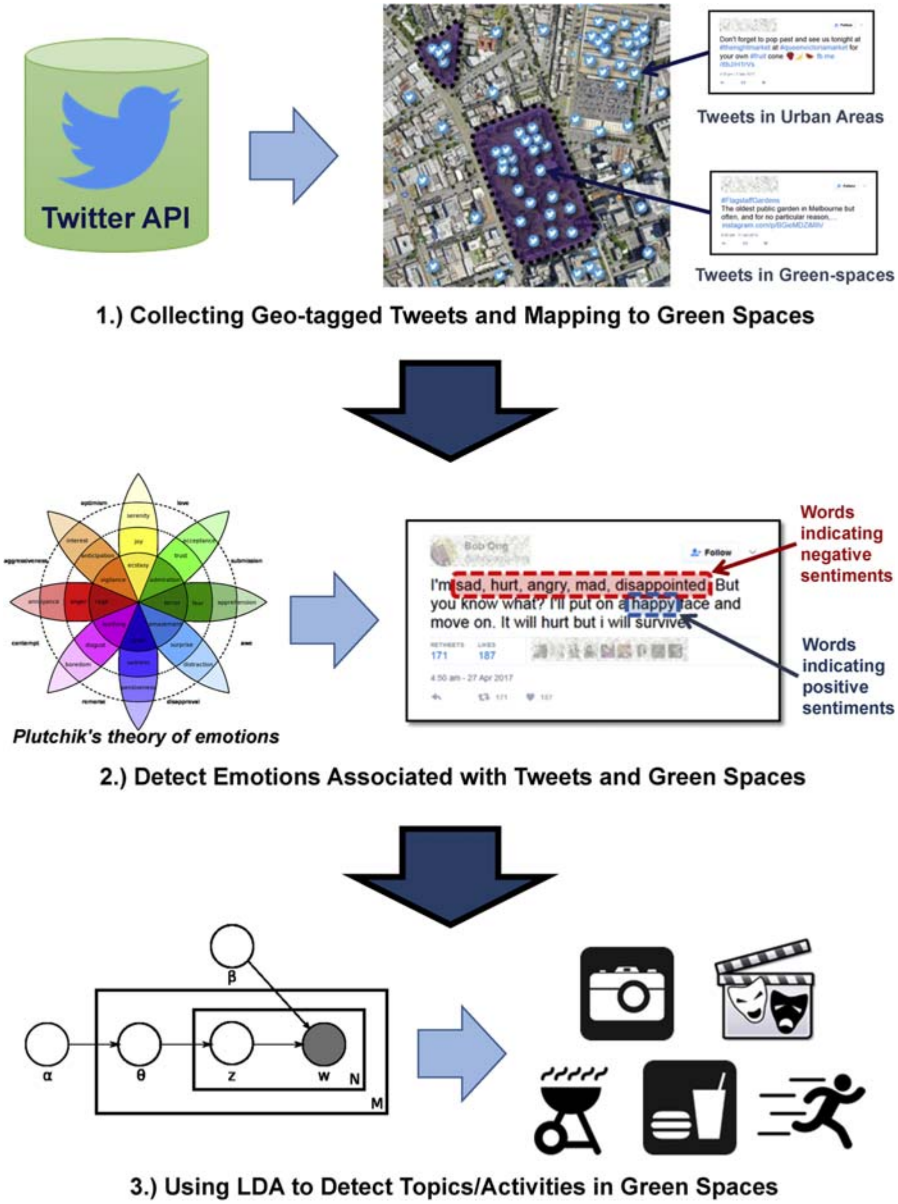

FIGURE 6.1

Overview of our approach to green space analysis. *LDA*, Latent Dirichlet Allocation.

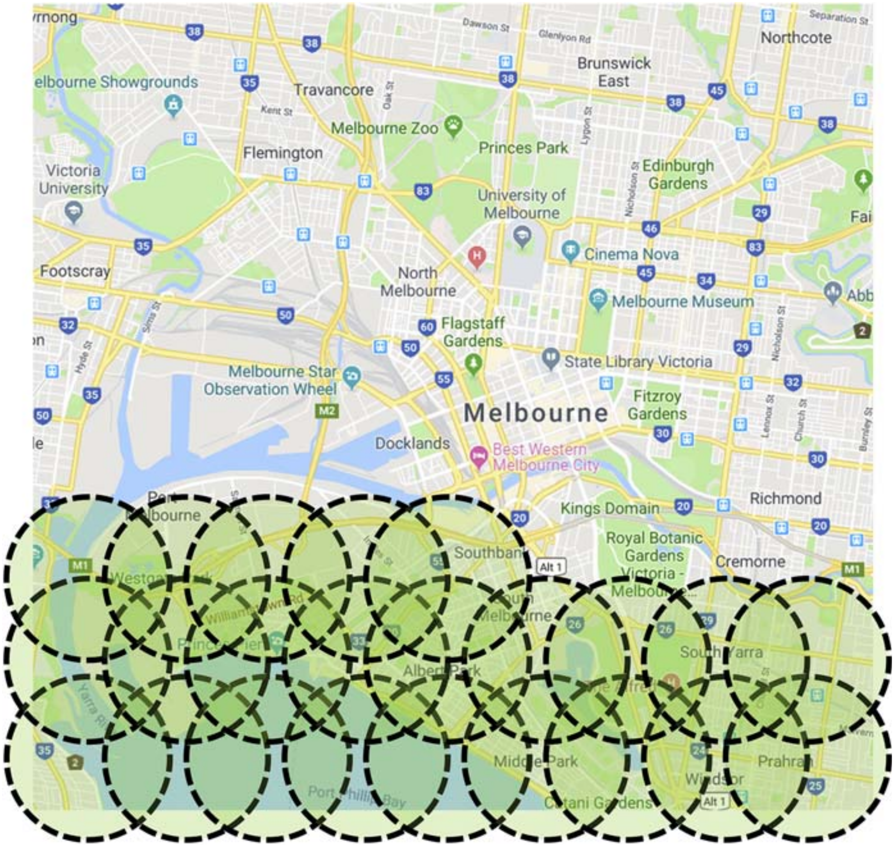

FIGURE 6.2

Tweet collection using overlapping circle-based searches. A single iteration of this collection starts from the bottom left and continues until the entire area is covered, before repeating itself for the entire duration of data collection.

Table 6.1 Description of data set.

Number of users	10,510
Total tweets	21.2 million
Geotagged tweets	2.2 million

2. **Stage 2 collection**: Based on the set of retrieved geotagged tweets (from Stage 1), we then proceed to extract the list of unique Twitter users who have posted these tweets, i.e., a set of seed users who have posted tweets in Melbourne, Australia. Thereafter, we retrieve the most recent 3200 tweets of these users, as per Twitter API constraints, to build a tweeting profile for these users. Table 6.1 shows the statistics of this collected data set, while Fig. 6.3 illustrates the geographical distribution of these tweets.

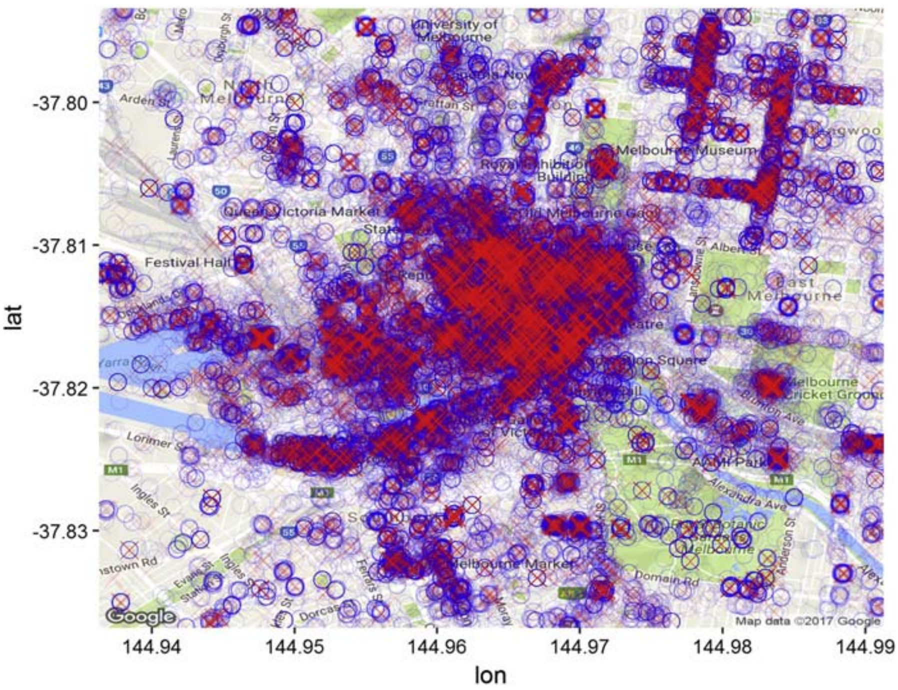

FIGURE 6.3

Geographical distribution of tweets in our data set.

3. **Green space data set**: We also have access to a green space data set, provided by the City of Melbourne, which is the local government authority in charge of urban planning and regulations for the central Melbourne area. This data set is in the form of a GeoJSON file that comprises 482 green spaces in Melbourne. These green spaces are represented by polygons, which encompasses the entire and exact area of each green space.

Mapping tweets to green spaces: We also identified the following: (1) if a tweet was posted in a green space, which park was it posted from and (2) if this tweet was not posted in a green space, how far was it from the nearest green space. Using our collected tweets and green space data set, we then labeled each tweet with the ID of the green space that these tweets were posted from. For tweets that were not posted from a green space (i.e., posted from an urban area), the distance to the nearest green space and the ID of this green space was identified.

3.2 Data preprocessing

Before performing our sentiment analysis on the tweets, we perform a number of preprocessing steps on the collected tweets. We restrict our work to using tweets that are explicitly geotagged as such tweets allow us to determine where they are posted from. These steps include the following:

- Filtering tweets that are explicitly geotagged with latitude and longitude coordinates and within the 5×5 km grid in Melbourne, Australia.
- Selecting tweets that are written in English, based on the "language" field provided by the Twitter API. We chose to only consider English tweets as English is the main language spoken in the Australia, and more importantly, focusing on one language allows us to abstract away the nuances associated with sentiment analysis based on different languages.[2]
- Tokenizing each tweet into individual words based on separation by white spaces.
- Converting all tweets and tokenized words into lowercase.

3.3 Sentiment analysis

We utilize a commonly used sentiment analysis technique (Bollen et al., 2011; Le et al., 2017), which involves first splitting each tweet into a series of tokens/words and then comparing each token/word to determine the sentiment category in which they belong to. Similar to these earlier works, we calculate sentiment score $Senti_t^S$ of a tweet t based on the word usage frequency of each sentiment category S. To account for different tweet lengths, we normalize each sentiment score $Senti_t^S$ by the number of words in each tweet. More formally, given a list of words $w \in t$ and a specific sentiment type S, the sentiment level of a tweet t is calculated by

$$Senti_t^S = \frac{|w \in t \cap S|}{|t|} \tag{6.1}$$

Based on this definition, the calculated sentiment level will take on a value in the range of [0,1], with 0 and 1 representing the weakest and strongest levels of the sentiment, respectively. For these sentiment categories, we utilize the NRC Word-Emotion Association Lexicon (EmoLex) (Mohammad and Turney, 2013, 2010), which is a widely used emotion word lexicon due to its rich vocabulary. EmoLex has also been used in numerous research for sentiment analysis purposes (Aiello et al., 2016; Quercia et al., 2016; Orellana–Rodriguez et al., 2015). EmoLex comprises 10,170 words that are associated with the emotions of anger, anticipation, disgust, fear, joy, sadness, surprise, and trust, introduced in Plutchik's theory of emotions (Plutchik, 1980). Fig. 6.4 illustrates Plutchik's theory of emotions, where each leaf indicates an emotion category (terror, fear, apprehension) with the inner

[2] Although we focus on English tweets in this work, this work can also be easily extended to any text-based social media written in other languages by using a sentiment dictionary of that language. Furthermore, this work focuses on the text/words used in tweets, and future work can also consider the embedded links, photos, and videos using image recognition techniques.

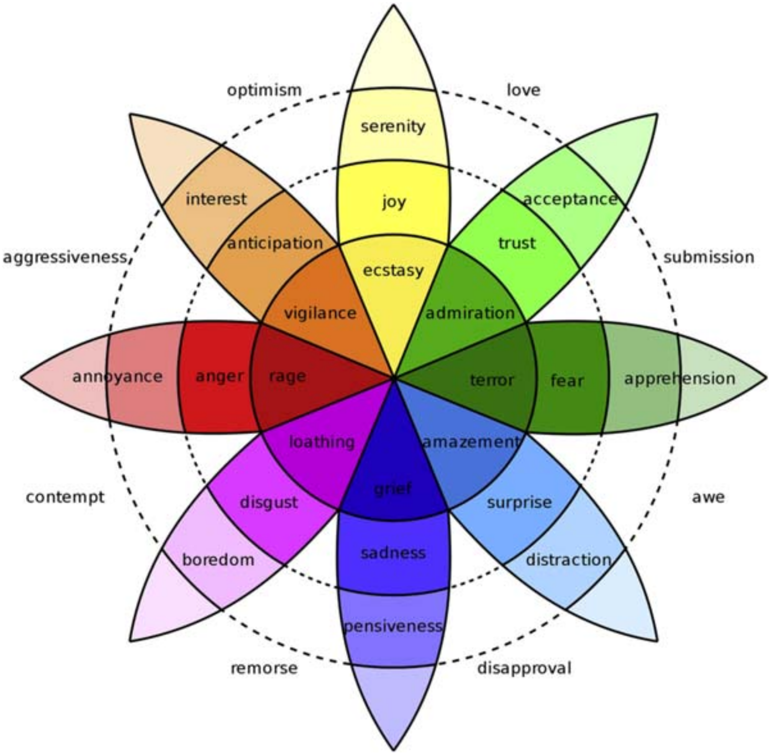

FIGURE 6.4

Plutchik's wheel of emotions (Plutchik, 1980).

Retrieved from Wikipedia, 2017. Plutchik's Wheel of Emotions. Internet. https://en.wikipedia.org/wiki/Contrasting and categorization emotions#Plutchik.27s_wheel_of_emotions.

and outer most quadrants showing the highest and lowest intensity of that emotion category, respectively.

As pointed out by Mohammad and Turney, 2013, the emotions of anger, disgust, fear, and sadness are generally associated with negative sentiments, whereas the emotions of anticipation, joy, and trust are generally associated with positive sentiments. The emotion of surprise is neutral, i.e., can belong to either category, and hence is used independently but not for the calculation of positive or negative sentiments. Thus, we define another two sentiment categories of positive (comprising the emotions of anger, disgust, fear, and sadness) and negative (comprising the emotions of anticipation, joy, and trust). We define the positivity and negativity level of a tweet t as follows:

$$Senti_t^{Neg} = \frac{|w \in t \cap S^{Neg}|}{|t|} \tag{6.2}$$

$$Senti_t^{Pos} = \frac{|w\in t \cap S^{Pos}|}{|t|} \tag{6.3}$$

where sentiment type $S^{Neg} = \{anger, disgust, fear, sadness\}$ and sentiment type $S^{Pos} = \{anticipation, joy, trust\}$.

It should be noted that a tweet can be both positive and negative based on the words used. For example, consider the tweet "A wonderful day for a picnic! The heat is horrible but it's great that the weather cooled down"! This tweet has both positive and negative sentiments based on the words, "wonderful" (positive), "horrible" (negative), and "great" (positive).

To address the issue of tweets with both positive and negative sentiments, we adopt a similar approach as Le et al. (2017) and determine the polarity of a tweet based on the difference between the positive and negative sentiment scores of a tweet. Thus, the polarity of a tweet t is defined as

$$Senti_{pol}^{t} = Senti_{Pos}^{t} - Senti_{Neg}^{t} \tag{6.4}$$

To verify this sentiment analysis approach, we also compared this method with various algorithms, namely those proposed by Goodrich et al. (2016), Liu et al. (2005), Hu and Liu (2004), and Nielsen (2011). The results show a similar trend in terms of the derived tweet sentiments regardless of the algorithm used, thus validating the general performance of our sentiment analysis approach against other similar algorithms.

3.4 Identifying topics/activities in parks

Next, we describe our approach for understanding the main topics/activities in parks. Similar to Lim et al. (2017), we apply a topic modeling algorithm, Latent Dirichlet Allocation (LDA) (Blei et al., 2003), on all tweets in each park to determine the main topics and activities that take place in these parks.

Given that each tweet t is represented by a sequence of words $w \in t$ and w_n denotes the nth word in the tweet, LDA applies a generative process for each tweet t, as follows (Blei et al., 2003):

1. Choose $N \sim$ Poisson(ξ).
2. Choose $\theta \sim$ Dir(α).
3. For each of the N words w_n,
   a. Choose a topic $z_n \sim$ multinomial(θ).
   b. Choose a word w_n from $P(w_n|z_n,\beta)$, a multinomial probability conditioned on the topic z_n.

The general idea behind the LDA algorithm is that it represents each topic/activity as a bag of words (i.e., a set of individual words), and each tweet is represented by a set of topics with varying probabilities.

4. RQ1: green space effects

In this section, we aim to address RQ1 on the effects that green spaces have on the sentiments and emotions in such green spaces, compared with tweets posted in urban areas.

4.1 Comparison of tweet sentiments in green spaces versus urban areas

We first examine the presence of any significant difference in mean sentiment (positive, negative, polarity) between tweets posted in green spaces and those posted in urban areas. Table 6.2 shows the average sentiment level of tweets posted in green space and urban area and the associated *P*-values. In particular, the column "difference" indicates the increase in a specific sentiment level of tweets in green space over that of urban areas, the reported *P*-values are based on a two-sided Student's t-test.[3]

Table 6.2 shows that there is a statistically significant increase ($P < 0.0001$) of more than 15% in the polarity of tweets posted in green spaces, compared with those in urban areas. Similarly, there is a statistically significant decrease ($P < 0.0001$) of more than 5% in the negativity of tweets posted in green spaces and also an increase of more than 6% in the positivity of tweets. These results show that green spaces generally benefit from higher positivity and lower negativity, compared with urban areas, and we examine more specific emotions in the next section.

4.2 Comparison of tweet emotions in green spaces versus urban areas

Similar to Section 4.1, we performed a two-sided Student's t-test to compare if there is any difference in each emotion level between tweets posted in green spaces and those in urban areas. The results are shown in Table 6.3, and the columns are

Table 6.2 Comparison of tweet sentiments in green spaces and urban areas.

Sentiment type	Green space	Urban area	Difference	*P*-value
Negative	0.0300	0.0318	**−5.60%**	<0.0001
Positive	0.0815	0.0764	**6.79%**	<0.0001
Polarity	0.0515	0.0446	**15.62%**	<0.0001

The bold numbers indicate a statistically significant difference.

[3] This "difference" is calculated by dividing the mean sentiment levels in green spaces over that of urban areas, and the reported values are based on the exact (nonrounded) sentiment levels for a higher precision, whereas the values reported in the tables are rounded to the nearest 4 decimal points for brevity.

Table 6.3 Comparison of tweet-level emotions in green spaces and urban areas.

Sentiment type	Green space	Urban area	Difference	*P*-value
Anger	0.0071	0.0079	**−9.75%**	<0.0001
Anticipation	0.0264	0.0256	**2.95%**	<0.0001
Disgust	0.0051	0.0053	−3.13%	0.05689
Fear	0.0085	0.0095	**−10.27%**	<0.0001
Joy	0.0300	0.0271	**10.62%**	<0.0001
Sadness	0.0093	0.0092	1.39%	0.24705
Surprise	0.0129	0.0122	**5.60%**	<0.0001
Trust	0.0252	0.0236	**6.54%**	<0.0001

The bold numbers indicate a statistically significant difference.

similarly defined as those in Section 4.1. In contrast to Section 4.1 that examines how positive or negative the tweets are, this section examines a more detailed breakdown of the sentiments into specific emotions, which are discussed later.

Based on our analysis, we find that there is an increase of more than 10% in joy and decrease of approximately 10% in both the fear and anger emotions, for tweets posted in green spaces compared with their counterpart in urban areas. There is also an increase of 6.5%, 5.6%, and 2.95% for the trust, surprise, and anticipation emotions, respectively. The reported difference in the emotions of joy, fear, anger, trust, surprise, and anticipation are also statistically significant, with *P*-values of less than 0.0001. Although there are differences in the emotions of disgust and sadness, these differences are not statistically significant with *P*-values of more than 0.05.

Section 4.1 shows that green spaces generally display higher positivity and lower negativity than urban areas, and there are higher levels of positive emotions of joy, trust, and anticipation and lower levels of negative emotions of fear and anger in green spaces than urban areas. For the negative emotions of disgust and sadness, there is insufficient evidence to indicate any differences between green spaces and urban areas. We now explore how these sentiments and emotions change over various time periods.

5. RQ2: impact of time

In this section, we perform a longitudinal study of sentiments and emotions across time periods of different seasons and, in fine-grained time steps, of time of day and month.

5.1 Comparison of sentiments and emotions across seasons

For our analysis of sentiments and emotions across the four seasons, we label a tweet as belonging to a particular season if this tweet was posted within the 3 months of the season, as widely used in Melbourne, Australia: Spring (Sep—Nov), Summer (Dec—Feb), Autumn (Mar—May), Winter (June—Aug).

5.1.1 Comparison of sentiments across seasons

We start our longitudinal study on tweet sentiments by first examining the level of positive, negative, and polarity of tweets posted across the four seasons in green spaces and urban areas, as shown in Fig. 6.5. When examining levels of positive (Fig. 6.5A) and negative sentiments (Fig. 6.5B), we note that positive sentiments are higher and negative sentiments are lower in green spaces compared with urban areas, across all seasons of spring, summer, autumn, and winter. For both tweets in green spaces and urban areas, we also observe that negative sentiments are the highest in autumn and winter, a trend that resembles the seasonal affective disorder where "depressive symptoms occur during the winter months"[4] (Rastad et al., 2006; Rosenthal et al., 1986).

Recall that a tweet can contain both positive and negative sentiments (as described in Section 3.3), hence we use the polarity of a tweet to better measure the positivity or negativity of a tweet on its own. Fig. 6.5C shows that the polarity levels of tweets posted in green spaces are higher (more positive) compared with those in urban areas, regardless of the season when a tweet is posted. In particular, we observe that tweets posted in green spaces are the most positive in summer, followed by spring, autumn, and winter, in an order corresponding to the temperatures associated with each season. The polarity of these tweets gives us an overview of the positivity and negativity of tweets, and we examine the emotions associated with these tweets in the following sections.

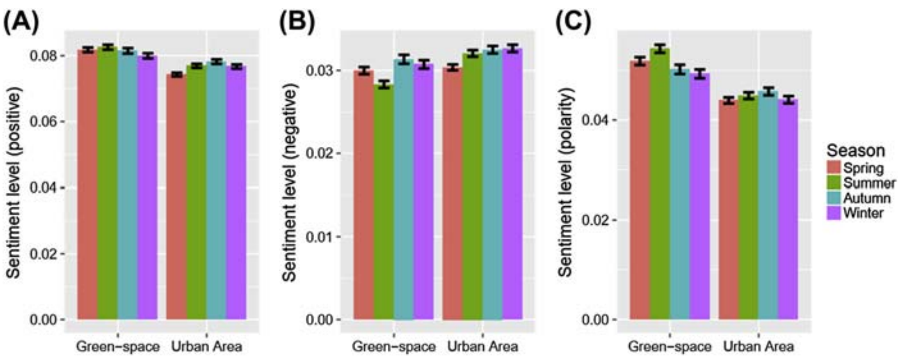

FIGURE 6.5

Longitudinal study of tweet sentiments across the four seasons, in terms of positive (A), negative (B), and polarity (C) sentiment levels.

[4] In the study by Rastad et al. (Rastad et al., 2006), they consider that "winter was defined as the combination of autumn and winter seasons".

5.1.2 Comparison of emotions across seasons

Fig. 6.6 shows the average level of emotions for anticipation, joy, surprise, and trust for tweets posted across the four seasons in green spaces and urban areas. The results for these positive emotions are similar to that in Section 5.1.1, as tweets in green spaces show higher levels of anticipation, joy, surprise, and trust, compared with those in urban areas in the same season. Fig. 6.6B shows that the emotion of joy is most prevalent out of all four emotions, with the highest levels for tweets in both green spaces and urban areas. In general, the results show that tweets in green spaces evoke more positive emotions of anticipation, joy, surprise, and trust.

Next, we examine the average levels of emotions for anger, disgust, fear, and sadness, as shown in Fig. 6.7. In terms of the emotions of anger (Fig. 6.7A) and fear (Fig. 6.7C), tweets in green spaces show lower levels of these negative emotions, compared with its counterparts in urban areas in the same season. In terms of the emotions of disgust (Fig. 6.7B) and sadness (Fig. 6.7D), we observed mixed results where there are no clear "winners" between tweets posted in green spaces and urban areas, i.e., green spaces exhibit lower levels of these emotions in some seasons but not others. In all cases for tweets in green spaces, we note that the lowest levels of anger, disgust, fear, and sadness are found during summer, an observation similar to that of the seasonal affective disorder where depressive symptoms are less likely during summer months (Rastad et al., 2006; Rosenthal et al., 1986).

5.2 Comparison of sentiments across hours, days, and months

After examining how sentiments change across the seasons, we now examine how these sentiments change across finer time periods of hours, days, and months, as shown in Fig. 6.8.

In terms of sentiment changes across the hours of the day (Fig. 6.8A), e.g., 12 a.m., 1 a.m., 2 a.m., etc., we notice that the sentiment polarity of tweets becomes lower (more negative) from approximately 12−1 p.m. onward until reaching a trough at 4−5 p.m., before increasing drastically thereafter. Although this trend applies to both green spaces and urban areas, the change during this time period is more pronounced for tweets in green spaces. We attribute this due to the fact that most people are either at work (or school) from 8 a.m. to 5 p.m., and they become more negative toward the end of this work cycle, i.e., 12 p.m. to 4 p.m. However, the recovery period (work detachment and relaxation) takes place at the end of this work cycle (Sonnentag et al., 2008), and sentiment of the person improves through the evening, i.e., 5 p.m. onwards. Similarly, social scientists have also noted that "positive emotion runs high in the morning, declines throughout the day, and rebounds in the evening" (Miller, 2011).

Fig. 6.8B shows the change in sentiment based on the day of the week. Psychological studies have shown that people tend to be happier during weekends (Stone et al., 1985), and our Twitter-driven study shows the same observation, as indicated by higher levels of sentiment polarity during Saturday and Sunday for both green spaces and urban areas. Although there is a trend of more positivity during

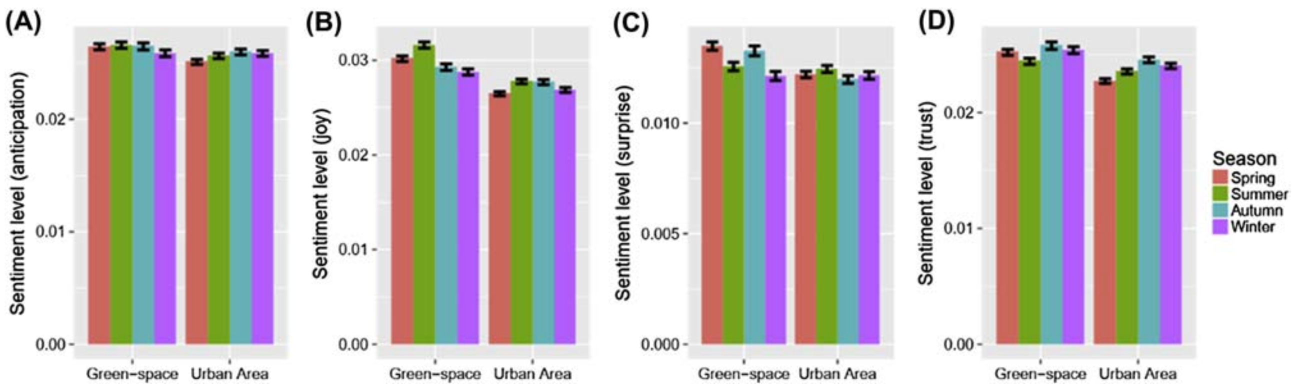

FIGURE 6.6

Longitudinal study of tweet emotions (positive only) across the four seasons, in terms of anticipation (A), joy (B), surprise (C), and trust (D) sentiment levels.

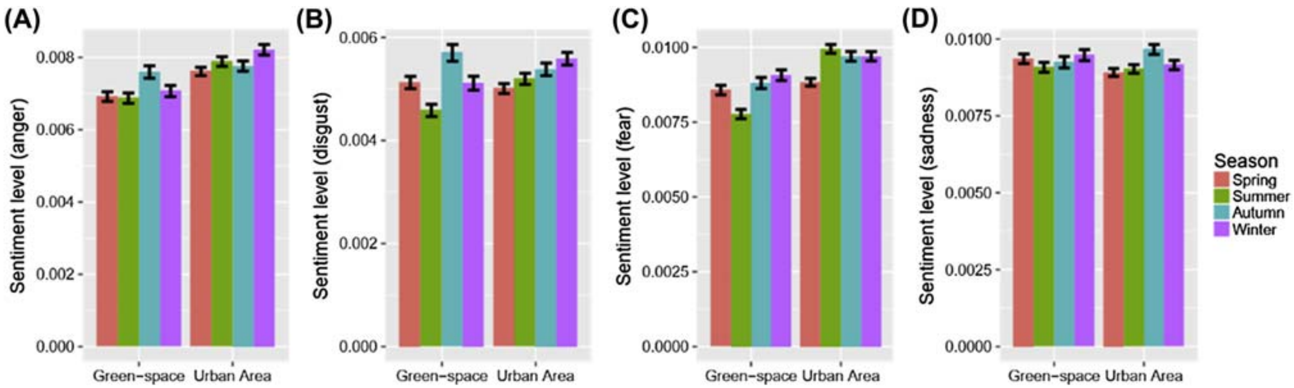

FIGURE 6.7

Longitudinal study of tweet emotions (negative only) across the four seasons, in terms of anger (A), disgust (B), fear (C), and sadness (D) sentiment levels.

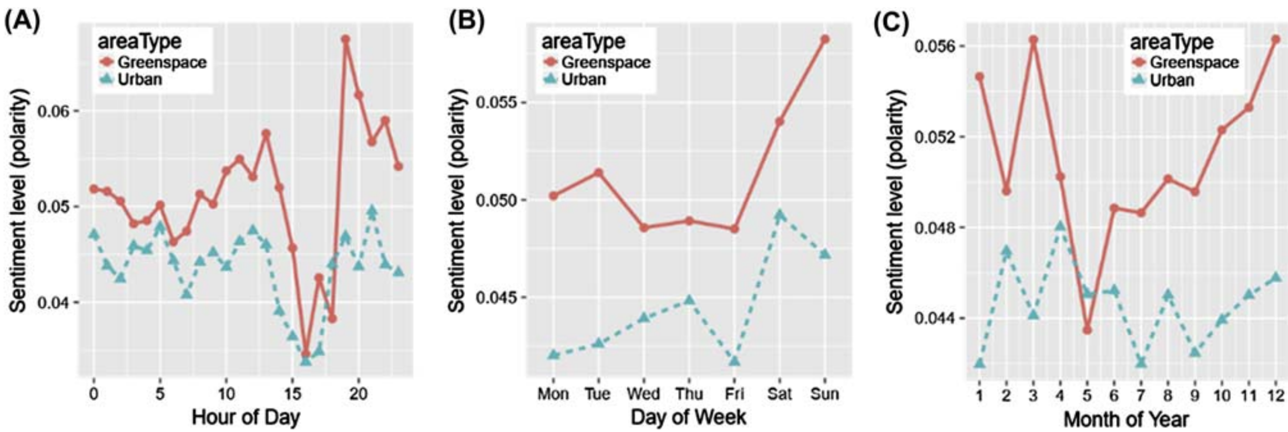

FIGURE 6.8

Longitudinal study of tweet sentiments based on the hour of day (A), day of week (B), and month of year (C) that a tweet was posted. Scales do not start from zero for a clearer comparison.

weekends, we also observe that tweets are consistently more positive in green spaces compared with urban areas, regardless of the day a tweet was posted.

The sentiment changes across the months (Fig. 6.8C) show that sentiments in green spaces are the lowest (most negative) in May, i.e., the end of autumn, before gradually increasing to a peak in December, i.e., the start of summer. Although there are some variations in tweet sentiments in urban areas, we note that there are no obvious trends in sentiment change for urban areas. These results show a fine-grained analysis of how sentiments change across the months, while displaying the same general trends of how sentiments change across the broader seasons (as discussed in Section 5.1.2).

6. RQ3: green space proximity effect

In this section, we investigate the effects of green space proximity by performing a high-level study of sentiments in broad city grids and studying the correlation between sentiments in urban areas and their proximity to green spaces.

6.1 Grid-based analysis

For a broader-scale understanding of sentiments in Melbourne, we perform a grid-based analysis of sentiment polarity within the same city, where each 250 m grid comprises the aggregated sentiment polarity of all tweets within that grid. Fig. 6.9 shows the result of this analysis where blue grids indicate positive sentiments and

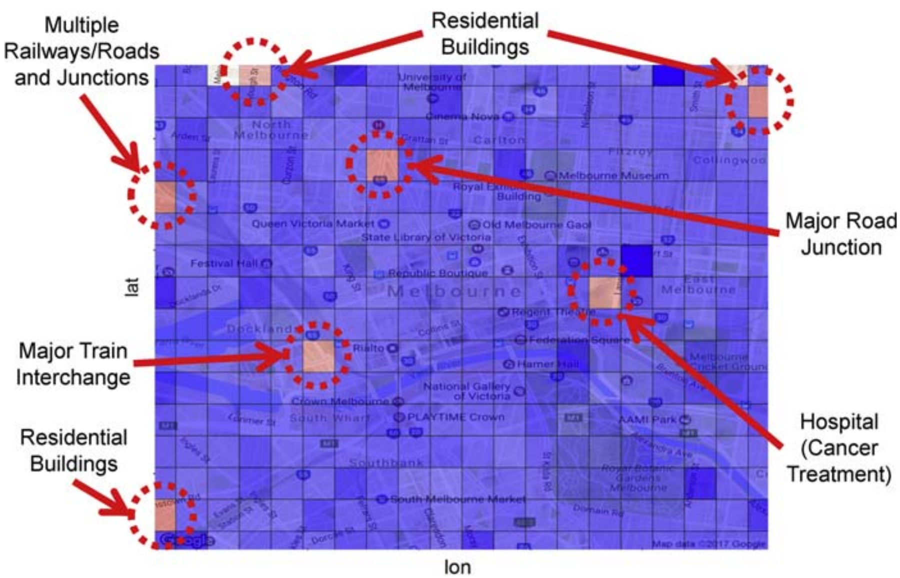

FIGURE 6.9

Grid-based sentiment analysis.

red grids indicate negative sentiments, while deeper colors indicate a higher level of that sentiment.

Fig. 6.9 shows that most of the grids with negative sentiments are relating to areas that contain large transport infrastructures (train stations, road junctions, railway tracks) or residential areas. Most of the grids containing green spaces exhibit positive sentiments with the exception of one grid that contains a hospital (which has since shifted), where most tweets mention about visiting patients or going for their cancer treatments.

6.2 Proximity of green spaces and urban sentiments

To understand how the proximity of green spaces affects user sentiments in urban areas, we calculate the Pearson correlation coefficients between the sentiment levels of urban tweets and their distance to the nearest green space. Tables 6.4 and 6.5 show the results of this correlation test in terms of sentiments (positive, negative, polarity) and emotions (anger, anticipation, disgust, fear, joy, sadness, surprise, and trust), respectively.

The results (Table 6.4) show a significant negative correlation between negative sentiments and green space proximity ($P < 0.0001$) and a significant positive correlation between sentiment polarity and green space proximity ($P = 0.00,017$),

Table 6.4 Pearson correlation of sentiments and distance to nearest green space.

Sentiment	Correlation	*P*-value
Negative	**−0.0150**	<0.0001
Positive	0.0003	0.90918
Polarity	**0.0091**	0.00017

The bold numbers indicate a statistically significant correlation.

Table 6.5 Pearson correlation of emotions and distance to nearest green space.

Sentiment	Correlation	*P*-value
Anger	**−0.0111**	<0.0001
Anticipation	**−0.0103**	<0.0001
Disgust	−0.0011	0.64589
Fear	**−0.0244**	<0.0001
Joy	**0.0191**	<0.0001
Sadness	−0.0066	0.00655
Surprise	0.0031	0.19721
Trust	**−0.0094**	<0.0001

The bold numbers indicate a statistically significant correlation.

but none for positive sentiments. Table 6.5 shows that anger, anticipation, fear, sadness, and trust are negatively correlated with green space proximity ($P < 0.0001$ for all, $P = 0.00655$ for sadness), while joy is positively correlated ($P < 0.0001$). These results show that while green spaces have an effect on urban areas, this effect is significant in terms of a reduced negative sentiment, but not significant in terms of an increase in positive sentiments.

7. RQ4: activities, sentiments, and recommendations

In this section, we focus on nine popular parks (Table 6.6) within inner Melbourne and study the different activities and sentiments associated with these parks. We also discuss how these findings can be used to improve recommendations of green spaces.

7.1 Activities and sentiments

Consistent with our earlier results, we found that none of the studied parks evoke an overall negative sentiment, i.e., polarity < 0. Although all parks generate positive sentiments, they evoke different levels of emotions based on the types of activities that take place in each park. For example, Yarra Park evokes high levels of trust likely due to the confidence of supporters in their sporting teams during the respective matches. Fig. 6.10 and Table 6.7 show that both the #hashtag wordcloud and activity/topic analysis are able to pick up the two main sports of Cricket and Football. For example, hashtags and words such as gopies, gotiges, and gostars are frequently used in support of the various sporting teams.

In the interest of space, we summarize our two main findings in terms of the activities and sentiments observed in these parks, which are as following: (1) the most common activities that occur in larger parks are food, drinks, and events, with

Table 6.6 Parks and tweets.

Green space	Description	# Tweets
Batman park	Small park located north of crown casino	727
Birrarung marr	Park located along Yarra river	1322
Carlton Gardens	Large park that is listed as a World heritage Site	4565
Domain parklands	Network of various connected parks and reserves	5026
Enterprize Park	Very small park ($\sim$60 × 40m) along Yarra river	1112
Flagstaff Gardens	Large park in the office district	1197
Parliament reserve	Small triangular park in the city	827
State library forecourt	Small green patch at the state library of Victoria	6623
Yarra Park	Large park that includes the melbourne Cricket ground	5963

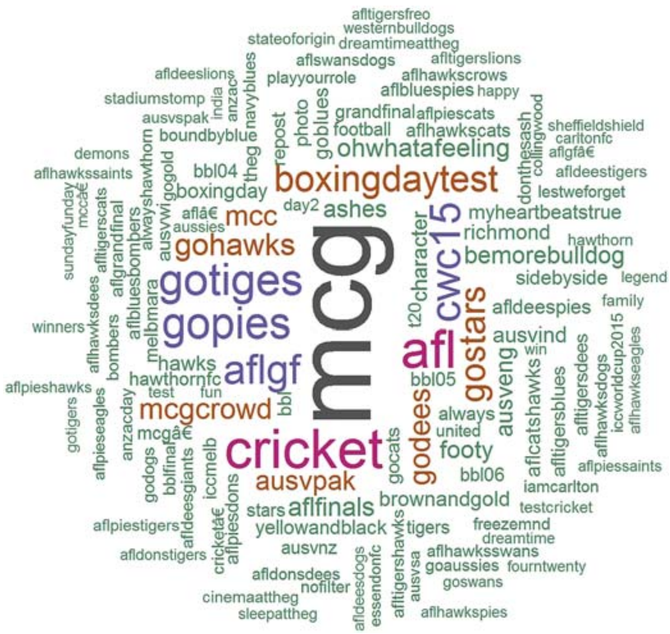

FIGURE 6.10

Wordcloud of twitter hashtags used in Yarra Park.

Table 6.7 Activities/topics in Yarra Park.

Activity	Words used	Polarity
Cricket	mcg, ground, cricket, game, mcc, night, happy, cwc, carlton	0.1211
Sports	mcg, cricket, mcc, afl, football, gopies, win, team, footy, gotiges	0.0995
Sports	cricket, ground, mcg, east, today, just, others, mcc, members	0.0405

all activities being associated with positive sentiments. The only exception is Flagstaff Gardens, where the education activity shows a slight negative sentiment, while other activities in the same park are positive and (2) another observation is that parks with a rich historical background or containing prominent landmarks show #photo as the most popular hashtag (Fig. 6.11), e.g., Carlton Gardens and Flagstaff Gardens, indicating that photography is another popular activity in those places.

7.2 Sentiment-aware activity recommendations

Building on our previous finding that different green spaces are associated with different types of activities, we now examine how these results can be used to improve recommendation systems. We extended on these results in (Wang et al., 2018) and grouped activities into three main categories of workout (e.g., jog, run), relaxation

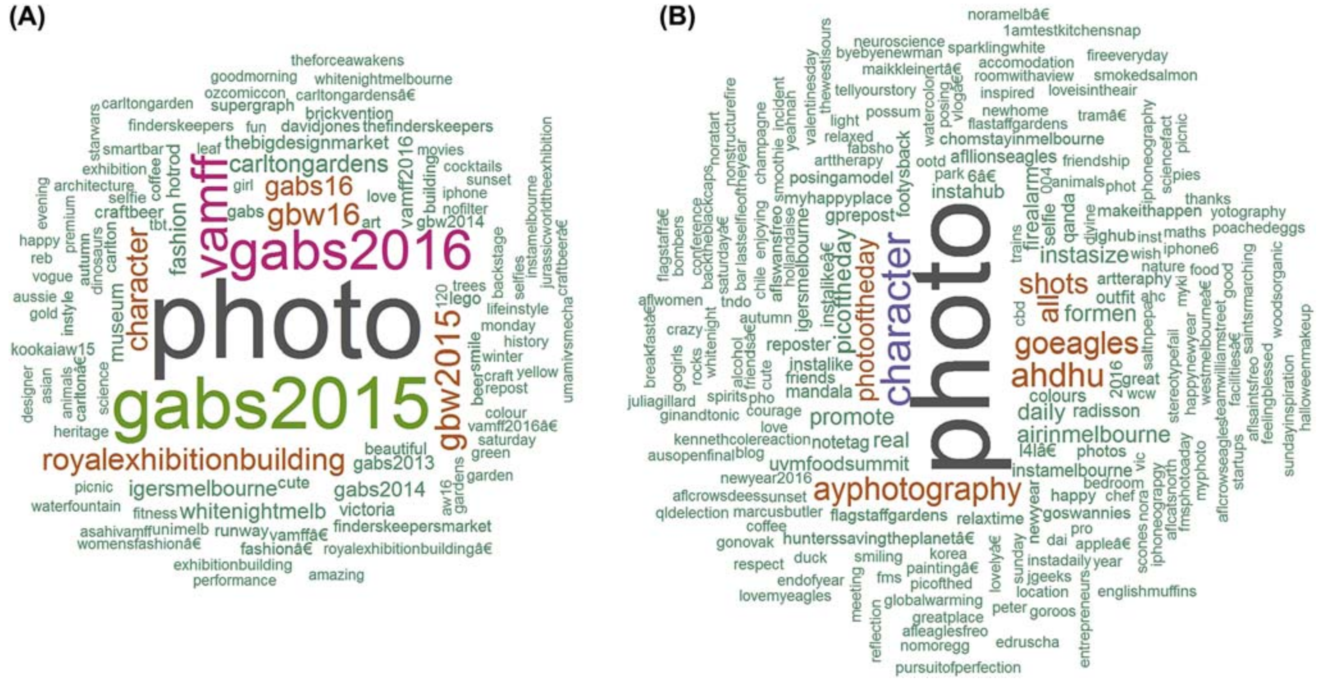

FIGURE 6.11

Wordcloud of twitter hashtags used in Carlton gardens (A) and Flagstaff gardens (B).

(e.g., meditation, chill), and social (e.g., hangout, party) using a supervised approach. Our main finding is that the sentiments and popularity of different activities vary widely throughout the year and in different green spaces, i.e., no single green space is consistently popular for the same activity through the year.

Based on this earlier observation, we developed a sentiment and activity-aware recommendation system for green spaces, as shown in Fig. 6.12. This system considers the preferences and context of the user to recommend green spaces that

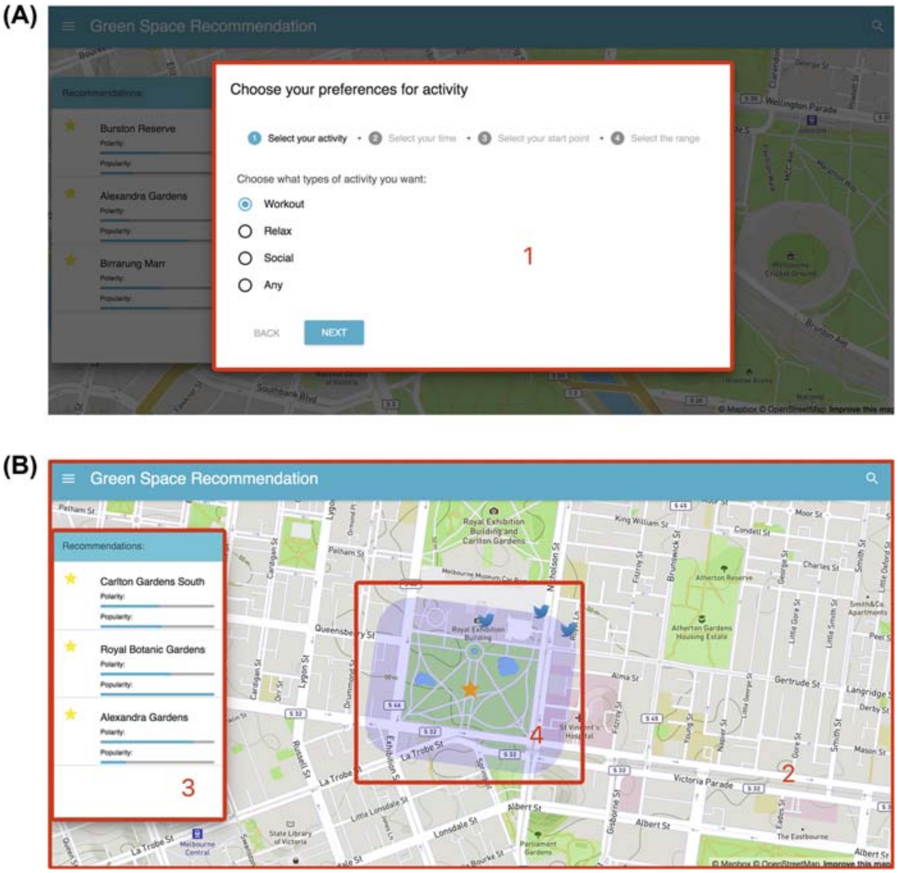

FIGURE 6.12

Our sentiment-/activity-aware recommendation system, comprising (A) user preference solicitation; (B) general map layout; (C) top three recommended green space; and (D) outline of recommended green space.

Retrieved from Wang, J., Feng, Y., Naghizade, E., Rashidi, L., Lim, K.H., Lee, K.E., April 2008. Happiness is a choice: sentiment and activity-aware location recommendation. In: Proceedings of the 2018 Web Conference Companion (WWW'18), Workshop on Online Recommender Systems and User Modeling (ORSUM'18). pp. 1401–1405.

are popular for specific activities based on this context. This system first solicits user input (context) based on the preferred visit time, current location, travel distance, and desired activities (Fig. 6.12, top half), before recommending the top three green spaces (Fig. 6.12, bottom half) based on a combined popularity and sentiment score.

8. General discussion

In this section, we first highlight the main findings of our study, discuss some implications of these findings, and describe future research directions.

8.1 Summary of main findings

Our main findings of how green spaces affect user sentiment are

- RQ1: In general, tweets in green spaces are more positive and less negative than those in urban areas. When we examine these changes in terms of specific emotions, green spaces exhibit higher levels of joy, anticipation, and trust (positive emotions) and lower levels of anger and fear (negative emotions), compared with urban areas.
- RQ2: Although green spaces are generally more positive than urban areas, this varies by the season the tweet was posted. We observe that green spaces display higher polarity (more positive) than urban areas across the four seasons, with the size of this effect greater in warmer seasons (spring and summer) and smaller in colder seasons.
- RQ2: Breaking down our analysis in terms of hours and days, the results show sentiment changes that likely reflect the general lifestyle of users. For example, sentiment polarity is the lowest at the end of a work day (early evening) before gradually increasing through the evening after work. Similarly, sentiments are more positive during weekends than weekdays, with green spaces being more positive than urban areas across all days.
- RQ3: Our grid-based analysis shows that areas containing major transport-related infrastructures and residential areas are more likely to show negative sentiments, while almost all areas with green spaces exhibit positive sentiments (with the exception of an area that contained both a green space and a hospital).
- RQ3: Examining urban tweets, we find a correlation between the sentiment polarity of urban tweets and its distance to the nearest green space. The results show a significant negative correlation between negative tweets in urban areas and distance to green spaces, but no significant correlation for positive tweets.
- RQ4: Our activity analysis shows that popular activities in larger parks are food, drinks, and events, and all park-related activities evoke positive sentiments, except the education activity that is slightly negative.

8.2 Implications and future directions

These findings have some important implications for urban planning authorities (Zeile et al., 2015; Hartig and Kahn, 2016; Schetke et al., 2016) and smart city applications (Ahlers et al., 2016; Lytras and Visvizi, 2018). They add to the body of research on the benefits of green spaces, relevant for policies aiming to improve well-being outcomes through urban greening interventions; people express more positive emotions and less negative emotions in green spaces or in close proximity to one. In Melbourne (a large city in the Southern hemisphere), this effect is particularly notable in warmer months and on weekends. At some times of the year, e.g., autumn, more negative sentiment is expressed in parks than in urban areas. Further research could explore whether these seasonal changes can be mitigated (e.g., negative sentiment could be related to mess from falling leaves, which could be mitigated through additional maintenance) or whether park use can be promoted at optimal times.

In addition to implications for urban planning, our findings also have implications for the general recommendation of tour itineraries or points of interest (POIs) (Taylor et al., 2018; Wang et al., 2016; Becker et al., 2015; Lim et al., 2019), particularly those that emphasize on the enjoyability and happiness of such tours (Quercia et al., 2014). To increase the enjoyability of tours, existing tour recommendation systems can incorporate a preference for POIs that are located in or near green spaces, as our findings show that these areas benefit from more positive and less negative sentiments. In addition, our observation of how different time periods affect user sentiments can be used to make context-aware tour recommendations that also consider the time or season when a tour itinerary is scheduled to commence.

This work can also be extended in several directions. One research direction is to examine the green space and urban effects in terms of other aspects, such as more specific categorization of green spaces (amount and types of foliage cover, species of trees and flowers), different types of urban areas (industrial, commercial, residential, entertainment), and user demographics (gender, age group, occupation) (Markevych et al., 2017). Although our work focuses mainly on the text used in tweets, future work can utilize other media types, such as pictures and videos, and employ image recognition techniques alongside sentiment analysis on photosharing sites, similar to the studies on pet ownership and alcohol consumption using Instagram (Wu et al., 2016; Pang et al., 2015).

9. Conclusion

In this chapter, we studied the effects of green spaces on user sentiments based on digital traces left by Twitter users in the form of geotagged tweets and presented our main findings in Section 8. We utilized a big data-driven approach to understand how green spaces are related to user sentiments across different time periods and spatial areas. In contrast to earlier works that utilizes surveys, questionnaires, and case studies, our approach utilizes a large amount of Twitter data, which can be easily collected and is neither intrusive nor time consuming for the users (as the tweets are publicly available). These properties allow an unprecedented capacity for fine-grained analysis, such as capturing all green spaces at once, studying local effects, size effects, time effects, and proximity effects, thus also allowing to identify gaps. Moreover, our study methodology can be easily extended to examine other RQs, and thus this type of analysis is relevant for social researchers and psychologists who are currently using independent studies and traditional methods. For example, instead of administering surveys to understand how a specific crisis or natural disaster affects people's emotional well-being, we can perform sentiment analysis on a large number of tweets that are posted in close proximity to the natural disaster or by users residing near the natural disaster.

Acknowledgments

This work was funded by the Melbourne Networked Society Institute. Kate Lee is supported by the Clean Air and Urban Landscapes hub of the National Environmental Science Program. Kwan Hui Lim is supported by a Defence Science and Technology Group Postdoctoral Fellowship. The authors thank IBM Research, Australia and the City of Melbourne and the anonymous reviewers for their useful comments.

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PART

2

Safety, security, resilience

CHAPTER

7

Smart city is a safe city: information and communication technology—enhanced urban space monitoring and surveillance systems: the promise and limitations

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Chapter outline

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00007-7

1. Introduction

There have been more and more successful stories of information and communication technology (ICT) and Internet of things (IoT) for smart city applications (Bifulco et al., 2016; Nitti et al., 2017). It brings services to human beings with an improved living environment and increases their overall quality of life. A survey has concluded that human beings would like to have ICT-based services if the services are useful and innovative (but not related to city engagement) while maintaining the security and privacy of them (Visvizi et al., 2017; Yeh, 2017). In other words, the services can benefit human beings without any side effect.

Surveillance devices such as closed-circuit television (CCTV), camera, and smartphone play an important role in monitoring human activities, behavior, and any varying information. In other words, we can say surveillance devices are sensing devices for monitoring purpose. It is estimated that the world collects 566 petabytes of video data every day (Data, 2016), which has already putting challenges in data transmission and storage and even more complicated when it comes to data analytics. Certainly, it belongs to the knowledge era of big data technologies (Wu et al., 2018; Xu et al., 2016; Yan et al., 2017).

The global surveillance cameras market is estimated to reach 30 billion USD and 62 billion USD by 2020 (MCP-1459, 2018) and 2023 (Global, 2018), respectively. In the past, it is desired to monitor and secure infrastructure, assets, resources, and human beings using surveillance systems. In recent years, in-depth analysis becomes a hot topic and vision by adopting business intelligence and artificial intelligence as a leading opportunities to escalate the market growth of surveillance systems. We may call it video surveillance as a service or video content analytics. Extensive case studies and research (full-scale deployment by government has not yet come true) have been carried out on the leading, in addition to developing, regions in the video surveillance market such as Latin America, Middle East, North America, and APAC. Various case and pilot studies have been carried out in literature. For instance, studies have conducted in Italy (Cocca et al., 2016), United States (Piza et al., 2017), Turkey (Abanoz et al., 2016), Brazil (Heukelbach, and Werneck, 2016), China (Xu et al., 2016), and Canada (Lett et al., 2012).

Table 7.1 summarizes the comparison between traditional surveillance systems and near-future smart surveillance systems. Here, smart can refer to any surveillance

Table 7.1 Comparison between traditional surveillance systems and smart surveillance systems.

	Traditional surveillance systems	Smart surveillance systems
1	Lower video quality	Better video quality
2	Without surveillance analytics	With surveillance analytics
3	Convention network	IoT enabled
4	Traditional data architecture	Big data architecture

IoT, *Internet of things.*

system that embeds with artificial intelligence, business intelligence, machine learning algorithm, image processing techniques, etc., as long as it can provide automation (not necessary complete) and intelligent applications. Because the cost for high-quality surveillance system and storage has been reduced, the newly implemented smart surveillance systems often possess better video quality. The growing number of such systems requires a migration of traditional data architecture to big data architecture for big data storage and management. Another key aspect in smart surveillance systems is IoT-enabled network because interconnected devices will enhance the functionality of the system. When high-quality surveillance cameras are deployed in the IoT and big data environment, it is an achievable goal to analyze the data by advanced algorithms in real-time manner.

The objective of this chapter is to make a study on urban space monitoring and surveillance systems for a safe smart city, by mapping and discussing the ways in which smart applications may in fact increase the real and perceived safety in cities and urban areas, that is, by proper use. Also, it highlights the experienced challenges such as government support, data quality, security, and privacy for the deployment. Some ideas are presented to further research to eliminate all of these.

The remainder of the chapter is organized as follows. Section 2 presents the architecture of ICT-based urban space monitoring and surveillance system. It is followed by selected applications of the system. In Section 4, the key limitations of its deployment will be discussed. Finally, authors have shared the vision, which is followed by conclusion in Section 5.

2. Architecture of information and communication technology—based urban space monitoring and surveillance system

Fig. 7.1 illustrates the architecture of ICT-based urban space monitoring and surveillance system. The Mongo operations (ops) manager handles the web-based browser console to control, display, manage, and configure surveillance cameras in the customers' Internet Protocol (IP) network. Such interface is able to link more and one servers, for continuous surveillance monitoring.

Camera feeds originate from both analog and IP-based surveillance cameras attached to analog gateways or encoders. Consider IP-based surveillance analog video gateway module installed in the branch router as an example. This router consists of network and storage management, which support both media server and ops manager. To deploy the remote branch, the adoption of virtual machine scale set offers high efficiency, where the data traffic is required in the surveillance network only if request is made by users. In other words, the video stays localized when there is no call.

The advantage of this topology allows different users, such as (1) remote workers; (2) third party; and (3) physical security staffs, to display, manage, and configure the

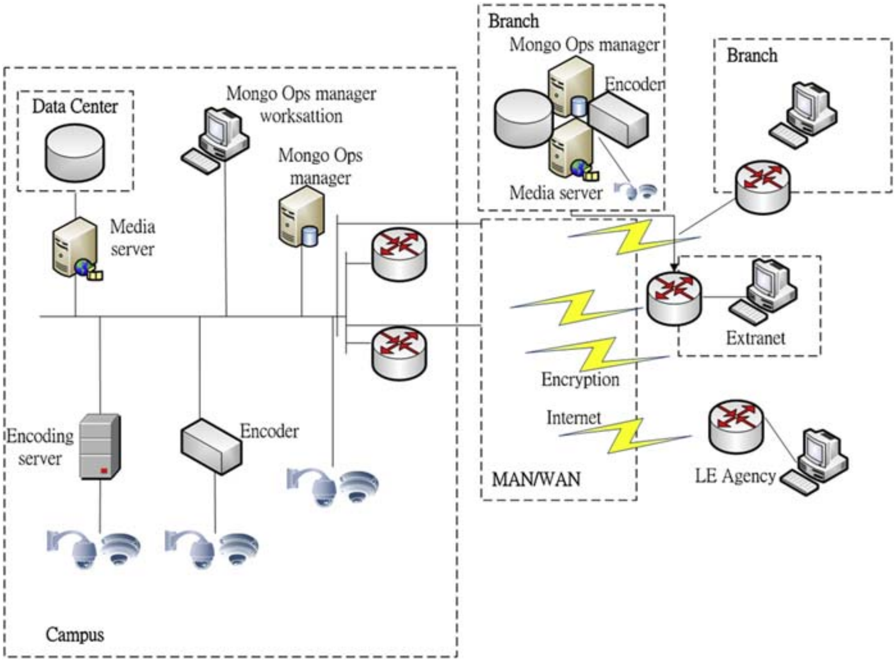

FIGURE 7.1

Information and communication technology—based architecture for urban space monitoring and surveillance systems.

Source: The authors.

virtual machine scale set at the branch location. Once data request is sent, the stream is transferred to the users via HTTP traffic. It is noted that if the data have to be shared to a third party, the privacy must be protected based on the laws in both sides.

The surveillance cameras are generally operated in the form of motion joint photographic experts group or moving picture experts group 4 (MPEG-4). The video quality and file size depend on the format of the video. It may create the question that how long does the systems store. The former format is usually transported through transmission control protocol (TCP). The TCP guarantees successful delivery of data via receiving acknowledgment, and retransmission will be made if there is no acknowledgment. Because every image is stand alone, the quality of image is high. The latter MPEG-4 is generally adopting real-time transport protocol, real-time streaming protocol, or user datagram protocol (UDP). Compared to TCP, the data packet transmission through UDP is not guaranteed because retransmission is not available. Nevertheless, UDP transport is most appropriate protocol for data transmission in network that takes the advantages in small bandwidth and little packet loss. Also, the data stream produced by the surveillance cameras can be sent to multiple destinations (such as media servers) using IP multicast delivery.

To enable IP network for surveillance cameras in public, it is crucial to provide quick access to users at any location. Attributed to pros and cons of UDP and TCP, both protocols should be employed as all round solution.

There are some key issues that have to come over for the design of branches with area network (metropolitan and wide). Authenticity, integrity, and privacy of IP surveillance cameras as well as rerouting, optimization, path selection, and quality of service by routing protocols are foundation elements to robust surveillance systems. Thanks to the nature of networks, the existing networks are capable for surveillance systems deployment. Latest camera design supports power over Ethernet, network management protocol, and discovery protocol that use to reduce the level of difficulty for device and provisioning management. In Fig. 7.1, it is worth mentioning that the encoders, media servers, and surveillance cameras can work well in a virtual local area network for isolation.

The big data storage is another issue that normal smart city applications experience (Shao et al., 2018). Because the amount of surveillance data is continuously increasing, the big data solution must be scalable and interoperable (someone will add more and more noncoherent surveillance cameras to the existing systems). MongoDB, Hadoop Distributed File System , Hadoop, MapReduce, and Spark are some of the famous tools that contribute to the big data solutions (Liang et al., 2018).

3. Applications

Surveillance cameras have been widely adopted in most industries attributable to their applications ranging from remote video monitoring, employee safety, public safety, and traffic monitoring. In addition, nonintrusive load monitoring (NILM) is deduced to be another surveillance system. At last, health surveillance is discussed as one of the key focus in 21st Century.

3.1 Surveillance cameras applications

3.1.1 Remote video monitoring, employee safety, and public safety

One of the most important surveillance cameras' applications is to detect and prevent crimes (e.g., violent crime, theft from auto, and auto theft). A recent study has conducted to examine the efficacy of crime prevention via CCTV (Piza, 2018). Results showed that it works well for auto theft. Someone who suffers from street-level crimes is partially benefited from CCTV and thus the deployment of CCTV alongside other evidence-based strategies but not simply a stand-alone tactic. However, regarding the cost benefit from CCTV, the cumulative criminal and societal justice results revealed some evidence of a modest cost savings, and the strategy is highly cost prohibitive for each of the individual criminal justice system components when CCTV system costs are included (Piza et al., 2016).

In general, video data are used only after the fact as a forensic tool, thus losing their primary benefit as real-time and active medium. Therefore, it is desired that surveillance cameras can serve as virtual security guard because they can analyze the real-time streaming data for human behavior analytics, provided that machine learning algorithms are embedded into the sensing system (Debes et al., 2016). Considering a high-rise building with many floors, normally the company will hire a few security guards for the safety of property and employee. However, they cannot oversee every place continuously because there are limited people. Surveillance cameras can serve as 24/7 continuous monitoring for all places at the same time (the adjacent cameras should set up properly to avoid having any blink spot).

3.1.2 Traffic monitoring

Video surveillance systems have been widely adopted for traffic monitoring. Traffic accidents have caused more than 1 million deaths and 50 million injuries every year (Chui et al., 2016). Generally, cameras are installed near the traffic lights, crossroad, and busy road. Applications include monitoring traffic, detecting over speed driving, encouraging safe driving habit, and supporting road management. Generally, traffic flows vary day to day in high-density cities. It is important to monitor the traffic so that early and timely alerts can send to drivers to have better time management to drive from one place to another.

The massive amount of daily road traffic data provides hints to government to design the possibilities of restructuring existing road map and constructing new road paths. If the probability of traffic in a particular road is statistically high, it has higher priority to be focused and thus improved. On the other hand, the data can be utilized as the evidence for decisions of lawmakers from enforcing the laws in red light and speed. When high traffic is found in a road, consideration to increase the duration of red light (in contrast the duration of green light will be decreased) can be proceeded. It is worth mentioning that before implementing the new decision, traffic simulation tools such as SUMO, TRANSIMS, MATSIM, VISSIM, and AnyLogic are typically used in simulation and analytics.

The life cycle of the surveillance cameras is much lowered compared with indoor cameras. Cameras can be damaged by weather change in place and time with respect to rain, wind, sunshine, dryness, cloudiness, and heat. The potential damage of cameras may create challenge of missing data handling and even fail to provide crucial evidence in case of road traffic accidents.

3.2 Nonintrusive load monitoring

Advanced metering infrastructure, as of key element in smart grid, provides two-way communications between smart meters and utilities (Tung et al., 2014; Xu et al., 2017). Based on the reading of smart meters, meter data such as power, voltage, and current will be analyzed by signal processing and machine learning techniques to deduce the type of appliances (along with its energy consumption) using in each of the apartment (Chui et al., 2013; Hosseini et al., 2017). This is called NILM. This is the reason why NILM can be interpreted as surveillance system. Based on the energy consumption of the user, one can know the activities of users (privacy concern) and potentially guess whether the apartment is emptied (security concern).

The applications of NILM include the following: (1) cost-effective appliance recognition (Rossier et al., 2017): the ultimate goal of NILM is to use only one current transformer for every apartment of lower hardware and installation cost. This is an extremely difficult task because the algorithm should be able to disaggregate the consumption pattern from several dozens of appliances. The difficulty of NILM decreases with the increase in current transformers within the apartment because the problem is reduced to load disaggregation from single to a few appliances. Besides, it is more challenging if only less granular data (lower sampling frequency) is provided by the smart meter. The real-time high frequency current waveform can serve as important characteristic to determine the type and operation mode of the appliances, and predictive and preventive maintenance can be achieved as well; (2) appliances consumption pattern and user behavior analysis (Leung et al., 2012): the user consumption pattern can be utilized to summarize the statistic and trend of the users' behavior. In addition, for the same type (different brand) of appliances, the energy consumption and efficiency can be compared so that government can force the manufacturers to produce more environmental friendly products; and (3) demand response (Kong et al., 2016): electric energy cannot be easily stored and thus power plants have normally fulfilled the support and demand via throttling the production rate and taking generating units online and offline alternatively, or it is possible to share (or buy) power from other power plants. The energy consumption by every user can be accurately predicted especially during the peak hours so that the power plant can generate less reserved electricity.

3.3 Health surveillance

According to the World Health Organization, health surveillance is defined as the ongoing, systematic collection, analysis, and interpretation of health-related data essential to evaluation, implementation, and planning of human health practice (Outbreak Surveillance, 2012). This becomes more popular as population aging is worsening and the shortage of medical professionals has remained unsolved. It is unaffordable to most of the human beings to hire private medical professionals to pay attention to their health and provide 24/7 monitoring. In general, many related works are focusing on disease diagnosis (Chui et al., 2017). Traditionally, we are always relied on the examination and advice from medical professionals (doctors and nurses). However, we are moving toward the ultimate goal of smart city, it is sought for smart health surveillance systems embedding computational algorithms that provide professional decision as same as doctors and nurses.

Because the range is too broad for health surveillance owning to huge kinds of disease around the world, authors are provided only some common diseases and are not intended to explain each of the case in details. Readers are recommended to refer to the following literature: (1) headache (Burch et al., 2015); (2) end-stage renal disease and chronic kidney disease (Collins et al., 2015); (3) arthritis (Murphy et al., 2017); (4) asthma (Fishwick, and Forman, 2018); (5) cardiovascular diseases (Chui et al., 2015); and (6) tuberculosis (Alkhalawi et al., 2016).

Also, health surveillance can be referred to health checks in high-risk employees who usually expose to hazardous substances, biological agents, dusts, fumes, solvents, ionizing radiation, vibration, and noise (Carty et al., 2017; Chellini et al., 2018; Trachtman et al., 2014). Unfortunately, less research has been focused on this area (small group of people) compared to those diseases in last paragraph. However, with the ICT-based surveillance system, many sensing devices can be utilized to monitor the user so that the disease monitoring and diagnosis will be an all-in-one solution.

4. Limitations

In this section, government support data quality, privacy, and security support are discussed as the challenges in deploying the surveillance system for smart city and some factors that limited the development and advancement of the technologies.

4.1 Government and industries support

Authors would like to discuss the government and industries support as the foundation of surveillance system for smart city. It is trivial that the outdoor installation of surveillance cameras in road and public areas is managed by government. Others are by no means contributing on this even if someone is willing to give a hand in financial support. Industries are usually the contributors of surveillance systems in indoor and private areas. The penetration rate depends on how the management team vision on the safety and security of property and human beings.

It is suggested that the deployment and promotion of the surveillance system is bidirectional. If government has announced planning on large-/full-scale deployment as the next city vision, it is easier to facilitate the adoption in industries. In vice versa, the extensive use of surveillance system in industries imply the general population acceptance of the system and thus it remains one-step forward to complete the whole picture of surveillance system for smart city.

Universities, industries, and government (mainly R&D and innovation departments) carry out research works and share the innovative idea and technologies. In general, commercial product and system aims at quick deployment (acceptable performance) because the market is highly competitive. It is not always necessary to achieve optimal functions in their first or second versions. As a result, the existing service and new service of the surveillance system can be improved and launched, respectively.

4.2 Data quality

The data quality of the surveillance data can be broadly categorized into (1) inaccuracy type; (2) low level with weak semantics type; (3) huge scale dynamic type; and (4) multisource high heterogeneity type (Cai et al., 2017; Mohammadi, and Al-Fuqaha, 2018; Storey, and Song, 2017).

It is difficult to guarantee that the video frames are accurately captured without blurring (especially in indoor environment) and in high resolution (high cost). It brings difficulties into direct usage because some images are masked by noise and lack of sufficient information. Shockproof camera is useful if it is not mounted in a stable location. In addition, after collecting the surveillance images or video, image and video signal processing techniques can be utilized for noise removal and data recovery.

Surveillance data from sensors are with low-level weak semantics with respect to sound recording before analysis by semantic technologies (Shi et al., 2018). It is desired to examine not only the movement of the humans but also what they are talking about, as a full understanding of the human behaviors. It is a challenging application because there are too many languages in the world and if researchers firstly focus on world common and famous languages like English, Spanish, and Mandarin Chinese, the accents of various groups of people increase the difficulty of the problem.

The surveillance systems capture massive amounts of data that need robust network to provide a continuous monitoring in high data rate and low latency. Hence, scalable big data storage is crucial for sustainable development. It is noted that the scalable storage is not unlimited, and it is referred to a basic fulfillment to support many years deployment without upgrading the platform. Practically, the data may not be stored in third-party cloud platform for many years, so the old (depend on applications) data could be deleted, moved to another low-cost platform, or transformed into less granular data (e.g., daily electricity consumption to monthly consumption).

In addition, the data are originated from various sensors. Heterogeneity of data is challenging because the format of data, quality of data, and granularity of data may not be coherent. The integration of these data can be achieved by various machine learning techniques (Tang and Song, 2016). When the data heterogeneity is solved, more data can bring together to form a more detailed picture of the application.

4.3 Privacy

Civil liberties activists and groups are usually opposing the full-scale deployment of surveillance system that cannot guarantee perfect privacy. There are more and more surveillance cameras around the world. In 2016, it was estimated to have 62 million and 172 million surveillance cameras in the United States and China, respectively (Denyer, 2018). It seems that the activities of human beings are hard to avoid being captured by any of the surveillance sensor. However, we can be protected by the guidelines of privacy policy. Someone may argue that privacy policy is effective because it is difficult to know whether the owners of surveillance systems follow strictly the rules and laws.

One of the approaches for privacy protection is by denaturing of the video frames of surveillance systems by digital signal processing techniques (Cheng et al., 2017; Jotsov et al., 2017; Wang et al., 2017). Fundamentally, it is a compromise between data quality and privacy. The extreme case for denatured method is to black a video, and the outcome is trivial: all zero values for the video stream and perfect privacy. Oppositely, the source video stream offers highest quality for data analytics, nevertheless has highest prone to privacy exposure.

4.4 Security

The surveillance data must be protected from any unwanted action by unauthorized users. A security breach can lead to severe consequences and affect large amounts of people. Cyberattack is not an uncommon offensive maneuver in computer systems (Jenab, and Moslehpour, 2016). There are two international standards named ISO/IEC 27001:2013 and ISO/IEC 27002:2013, which covers data security within the category of information security. The former involves the specifications for establishment, implementation, maintenance, and improvement of organizational data security. The latter sets up the rules for information security management and standards: selecting, implementing, and managing the control of the security in any risk environment.

Besides policy approach, data encryption and access control are essential to ensure data security (Lafuente, 2015). For example, attribute-based encryption aims at providing fine-grained access control of encrypted data (Jung et al., 2015). However, this solution may not be appropriate when it comes to cloud architecture, which is becoming more and more popular in daily life applications. Fully homomorphic encryption supports surveillance data storage in the cloud to perform operations over the encrypted data, and thus new encrypted data will be generated (Roy et al., 2017).

Besides software-based security, the data can be secured in hardware perspective. Normally, users can access (log in/out) and change settings on the device manually. To embed the biotechnology into the device could challenge the users from both access and setting adjustment. Hard disks as the controllers in peripheral devices are commonly used to read the current status of the user. Any illegal access will be interrupted, making it not possible. Operation systems are vulnerable to malicious attacks by hackers and viruses so that the hardware-based access control is more reliable than that of operating systems. The hardware protects the operating system image, and file system privileges from being tampered. As a result, a completely secure system can be obtained via a combination of secure system administration policies and hardware-based security.

5. Vision and conclusion

The idea of urbanization across countries implies cities need to be more efficient and managed. Improved management of every aspect, from socioeconomic issues to the provision of ICT infrastructure, the delivery of public surveillance services, and ensuring of public safety, privacy, and security, is essential. The smart city is centralized by smart governments, which make a footstep to outline the plan and direction of the city/country that tells industries to grasp the opportunities on certain projects (easy to receive benefit with the support of government). The ICT forms the architecture for data collection as a prerequisite. Most of the focuses are believed to be on the data analytics and applications of the surveillance data. Comparing the data size and the computational power, the amount of data is infinite and the computation speed of the computer is limited. Chances are one may first use less granular data (lower cost) for some services and if possible move forward to the raw and high frequency and quality data.

Anyway, it is believed that surveillance systems will be all around citizens in the near future, no matter whether the artificial intelligence and advanced technologies are mature. The surveillance data are useful for polices and security guards to keep the public safe. The upcoming 5G deployment in 2020 should be able to support high-quality video data streaming; however, it may severely lead to worsening in the big data storage (the data set is more massive).

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CHAPTER

8

Risks, hazards, and disasters: can a smart city be resilient?

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Chapter outline

1. Introduction

The world urban population in 2050 will be approximately 63% of the global population (Estevez et al., 2016). This anticipated urban growth will be in cities of developing countries that face fiscal and economic challenges, social ills, and environmental degradation. Cities occupy approximately 2% of the surface of the globe. However, they contribute to about 70% of the gross domestic product of the world and consume more than 60% of the world energy. Accordingly, cities are

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00008-9

responsible for around 70% of the produced greenhouse gases and generating about 70% of the global waste (UN-HABITAT, 2017). This situation requires a new urban planning process and management modalities that employ the latest technologies, such as the "Internet of things (IoT)" and using "big data" (Batty, 2012, 2013, 2016). In short, the situation necessitates transforming these traditional cities into smart cities that can generate and integrate data to produce information for informed decision-making mechanism, using gadgets, such as sensors, video, and voice.

A smart city can respond to near-term predictions by providing detailed and action-oriented plans and maintaining a synchronized process across city stakeholders (Brech et al., 2011). A smart city is capable of effectively integrating physical, digital, and human systems of the built environment to avail the residents a sustainable, prosperous, and inclusive future (Brech et al., 2011; Paul et al., 2011; Visvizi et al., 2017).

Natural disasters are among the issues that cities of the world, particularly those of developing countries, encounter. According to the Oxford Dictionary, a disaster is an incident or circumstance that has unfortunate consequences. It is an unexpected fate or a natural catastrophe that results in significant losses or death. Meanwhile, the Dictionary defines risk as a condition involving exposure to hazard, which is a possible source of danger (Anon, 2018).

In 2011, natural disasters caused economic losses, valued at US$370,000 million worldwide. Since the 1980s, the sum of disasters around the globe has almost doubled (Bousquet et al., 2013, 2014). Most of these disasters inflicted on cities of both developed and developing countries. In 2005, for example, Hurricane Katrina hit the southeastern United States, claiming more than 1,800 lives. It is among the most expensive natural disaster in US history (The Editors of Encyclopedia Britannica, 2018a).

On December 26, 2004, an undersea earthquake with a magnitude of 9.1 struck off the coast of the Indonesian island of Sumatra. Over the next 7 h, a tsunami was out across the Indian Ocean, shocking coastal areas as far away as East Africa. When the waves hit the shoreline of some locations, they had reached a height of 30 ft (9 m) or more. The tsunami killed at least 225,000 people across 12 countries, including Indonesia, Sri Lanka, India, Maldives, and Thailand. In Sri Lanka and India, tens of thousands were reported dead or missing. In the Maldives, there were more than a 100 victims and enormous economic damage. Casualties included both natives and tourists. Environmental damage was severe. The disaster demolished or inundated villages, tourist resorts, farmland, and fishing grounds with debris, bodies, and plant-killing salt water (The Editors of Encyclopedia Britannica, 2018b; United Nations Environment Program, 2005).

Anything perceived to cause harm or be a source of danger is a hazard. Hazards come in various forms. They can be physical, such as fires. They can be chemicals, such as emissions degrading air quality or leak of toxins in a water body. They can be radiation, such as harmful rays reaching Earth as a result of depleted ozone layer thus causing skin cancer. Hazards can be biological, such as the outbreak of a virus and bacteria causing human mortality and morbidity. Hazards can be ergonomic in the form of poorly designed built environment, as well as psychological resulting from stress brought by constant levels of noise. The risk is the probability whether high or low that any hazard will inflict hurt on somebody and cause damage.

Disaster risk reduction (DRR) is a process that systematically evaluates potential risks. Natural hazards are the cause of the disasters. The effect of a hazard to society and the environment determines the severity of the disaster. Decisions and choices regarding the city and its hinterlands decide the scale of the impact of a disaster. Decisions and choice govern multiple issues, such as how to grow our food, where to build our homes, the kind of government, the financial organization, and extend to both the education and health-care systems (UNISDR, n.d., 2015). Decisions and choices are responsible for the resilience or vulnerability of the city.

To assure the sustainability of a city, it is of utmost importance to mainstream DRR within its day-to-day routine of decision-making, planning, and management. Risk assessment is central to DRR. It depends on data essential for careful calculation needed for prevention and preparedness, such as establishing early warning systems (EWSs) and shelters. DRR depends on data for disaster management, such as logistics for evacuation during the unfortunate event. Finally, DRR cannot be complete without a recovery, rebuilding, and rehabilitation after a disaster, which requires enabling people to overcome the psychological trauma.

A smart city depends on data flows and computer models on the one hand and an economy and governance rooted in innovation, knowledge creation, and entrepreneurship that smart people enact on the other (Kitchin, 2014). Transforming traditional cities into smart cities can enable better planning and management as a result of the influx flow of data and the growing computing capacities to model urban realities and elaborate scenarios, develop alternatives, and assess impacts of planned interventions.

The chapter attempts to argue that transforming the traditional city into a smart one will improve its resilience, thus assuring its sustainability. Following this introduction, the chapter conceptually examines risk assessment and specifically spatial risk assessment. Next, it reviews the literature on the smart city. The final section of discussion is a confluence of the former two subsections. Conclusion, recommendations, and policy implications end the chapter.

2. Risk assessment

Risk assessment is a continuous process of monitoring and reviewing, as well as consulting and communicating with various stakeholders. Risk management is a four-stage process. The first is problem definition, where the team responsible for the entire process establishes the context. The second step is risk assessment, which requires the application of statistical models, such as the Monte Carlo simulation, Bayesian statistic, and so forth. In this step, the team identifies the risk, analyzes it, and evaluates it. The third step of risk management is treating it, i.e., to act and address the risk. In all three stages, the group of experts has to work closely with the community. The team and their counterparts representing stakeholders have to consider both the temporal and spatial dimension and assure the flow of data to generate and disseminate information.

3. Literature review

Spatial risk assessment is a process that combines geospatial analysis with decision-making processes. It is a procedure that combines statistical and numerical analyses concerning a specific issue, such as public health or environmental issue, in a particular geographic location by producing maps that exhibit the spatial distribution of risks plus the spatial allocation of resources. A spatial decision support system (SDSS), Fig. 8.1, is the basis for these analyses. Platz et al. (2014) introduced an SDSS using a fuzzy spatial logic on topological spaces, which enables early warning systems (EWSs) and avails support to both current and future spatial distribution of disease.

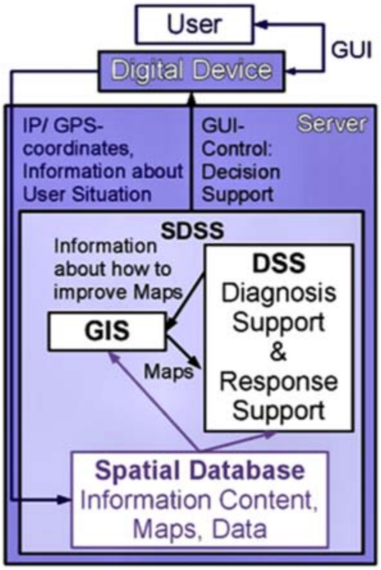

FIGURE 8.1

General structure of a spatial decision support system (SDSS). *GIS*, geographic information system.

From Platz, M., Rapp, J., Groessler, M., Niehaus, E., Babu, A., Soman, B., 2014. Mathematical modeling of spatial disease variables by spatial fuzzy logic for spatial decision support systems. In: ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. XL-8, pp. 213–220. Hyderabad, India. https://doi.org/10.5194/isprsarchives-XL-8-213-2014.

Many studies used spatial risk assessment to determine the causes of danger. For example, following the Hurricane Mitch in 1998, there was a need for modeling the slope stability in Honduras. Zaitchik et al. (2003) were able to develop a digital elevation model (DEM) from digitized elevation contours. They combined with the DEM the results of surveys to collect samples and geological attributes, to determine soil characteristics, and to produce a set of simulations to elaborate a distributed probability map for slope failure, which supports identifying the spatial scale of variability that the model captures (Zaitchik et al., 2003). In 2014, Allison used the available data on PM10 from the Scottish Air Quality website to model an annual mean log PM10 on a 1 km by 1 km grid over Glasgow and incorporated background measures, traffic, and point sources, Fig. 8.2 (Allison, 2014).

Spatial risk assessment can determine environmental hotspots, i.e., a biogeographic area of significant levels of ecological importance that is subject to risks. Craigmile et al. (2016) examined the Arsenic (As) concentration in topsoil across the States of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. They used US Soils dataset, which encompasses measurements of over 46 compounds.

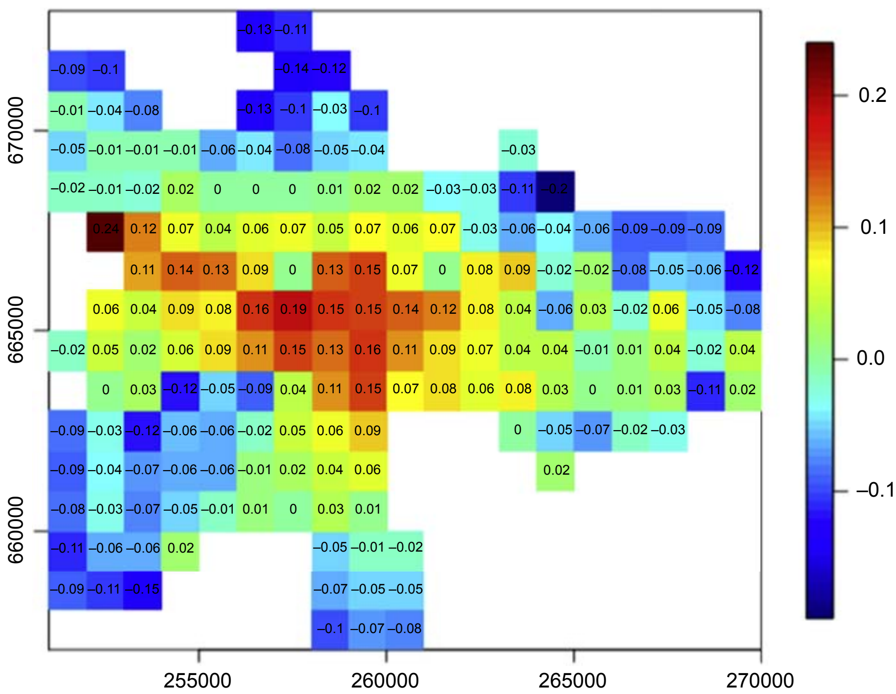

FIGURE 8.2

Displayed PM10 data, Glasgow (2010).

From Allison, K.J., 2014. Statistical Methods for Constructing an Air Pollution Indicator for Glasgow. University of Glasgow. Retrieved from: http://theses.gla.ac.uk/5558/2/2014AllisonMSc.pdf.

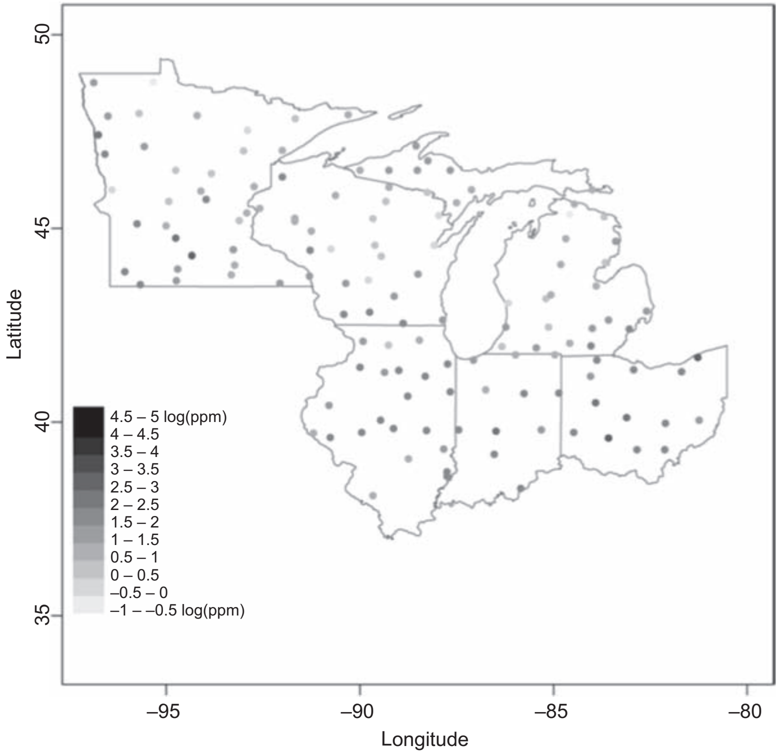

FIGURE 8.3

Location and level of 135 topsoil arsenic concentration measurements.

From Craigmile, P.F., 2016. An Introduction to Spatial Risk Assessment. Quantifying Environmental Risk and Resilience Workshop, Glasgow, Scotland.

Units of measure are µg/m3 or parts per million (ppm), Fig. 8.3. Craigmile and his colleagues restricted their analysis to the surface layer, i.e., 20 cm depth. Next, they mapped the location and level of 135 topsoil arsenic concentration measurements (Craigmile, 2016).

Experts use spatial risk assessment as a tool for decision-making. Climate change is a significant risk. Urban heat islands associate with major metropolitan areas. Mitigating and adapting to climate change are at the crux of urban planning activities. In 2007, using spatial risk assessment, Lindley et al., examined how a spatial risk assessment framework can aid adaptation planning by availing pertinent information to support efforts for elaborating adaptation strategies related to land use and spatial planning. Using adaptation to heat stress in Greater Manchester, as an example, they illustrated how socioeconomic and climate scenarios could assist in shaping future patterns of risk. Accordingly, the researchers propose measures for effectively tackling heat stress risk (Lindley et al., 2007).

4. Disaster risk management: the process

The process of risk management is similar to that of environmental management. It involves the following four stages that Fig. 8.4 portrays:

1. **Plan:** The first stage is to define the risk accurately. A risk defined clearly is a risk that is well managed and handled as it helps in selecting levels of investigation, methods and tools used, assign responsibilities, and so forth. This step has to be participatory. All stakeholder groups have to participate. It is recommended to conduct a stakeholder analysis before inviting them to the discussion.
2. **Do:** Now it is time for assessing risks. This stage requires first to analyze the risks and then to establish criteria for evaluation and prioritization. Next is to build stochastic models using advanced multivariate statistical techniques. Risks are the product of exposure and vulnerability. These models have to integrate both exposure and vulnerabilities, including their subcategories, such as adaptive capacities, coping capacities, and so forth.
3. **Check:** Based on the results of monitoring and feedback from tabletop exercises and simulations, it is time for the team of experts and their counterparts from various stakeholders to introduce necessary intervention modifications to the plans suggested in the first step as a result of the risk profile. It is the stage of appraising options.
4. **Act:** It is time to address risk. The team and its counterpart have to act according to what they have learned. If the proposed intervention did not work, then they have to go through the cycle again with a different plan. If they are successful, then they have to incorporate what they have learned from the test into more comprehensive changes, i.e., to scale up. In this stage, the team has to use what they have learned to plan new improvements and iterate the cycle again.

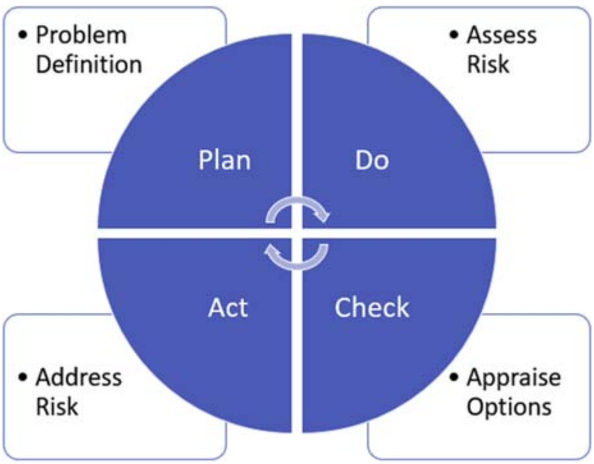

FIGURE 8.4

Plan—do—check—act.

Source: Anon.

4.1 Stage 1: problem definition

Formulating a problem requires checking the regulatory framework that governs the processes of environmental risk assessment and management. The team, therefore, has to compile past unfortunate events and analyze them. It is the stage of preparing a risk profile. The team has to ask questions concerning the risk, such as what? whom? which part of the environment? where? which location? and when?

4.1.1 Data gathering

Present municipalities are complex institutions that deal with both central authorities and nongovernment entities, including private sector companies, community organizations, labor syndicates and unions, research institutions, and so forth. Municipalities deal with several diverse sectors, such as health, education, drinking water and sanitation, solid waste management, and so on. Together, these bodies have their information and data regarding the environmental issues that fall under their jurisdiction. Accordingly, any cross-hazard analysis is not possible because of the dispersed, isolated data, which are not conducive to ordering priorities for a synchronized, planned action. If there is no, or little, georeferencing of the available data, the situation then will be complicated further.

The municipality has to find a process for assembling a risk profile to overcome the above problem. As a beginning measure, the city administration has to collect simple actuarial data on the number and magnitude of different risks that have taken place in the city using both official and private records held in various organizations, paper stories, private diaries, and logbooks, and even folk records.

For these organizations, the city administration can synthesize a risk profile for the city. The profile will include, but not limited to, how many times a disaster took place; its scale, size, extent, and impacts; when and where did the disaster take place; who were the victims, and so forth. Gathering these data over time offers statistics on trends over time in their various features.

Geospatial maps are essential at this stage. They are digital data and information of an implicit or explicit relationship with a location. Experts generate these digital maps using a series of standards to produce a custom map to fulfill particular needs. These maps portray elements such as slope, faults, and so forth, and include land uses and land cover, as well as sources of hazards and pathway of pollution to inflicted areas.

One of the outcomes of this step is identifying information gaps in knowledge as some necessary information on any risks might not be available, complete, valid, or reliable. The recommended action, then, is to plan activities for research and monitoring that might require institutional transformation to assure that someone is responsible for closing this gap.

Setting each entity, whether governmental or nongovernmental, to establish the risk profile within their area of specialization is the first step toward gathering the data and building the risk profile of the city. Sectoral profiles and priorities are the expected outcome. Next is to synthesize these data sets in both qualitative and quantitative forms, as well as spatial and georeferenced, into a single database on risks in addition to priorities for intervention via interdepartmental structures, such as working groups according to a predetermined procedure to embark on risk assessment.

4.1.2 Institutional framework

Formulating a problem requires checking the regulatory framework that governs the processes of environmental risk assessment and management. Environmental issues are often multifaceted and necessitate the collaboration of all actors. For example, municipal solid wastes include organic matter that starts to decompose thus emitting harmful gases, such as methane, and effluents, such as leachate that pollute soil and both ground- and surface water. Harmful elements will enter the human food chain through plants grown in polluted soil and irrigated with contaminated water. Emitted methane can be the cause of municipal solid waste self-ignition.

Environmental degradation is a sign of market failures. It is the condition where the free market does not allocate goods and services efficiently. The outcome is a net loss in social welfare. Imperfectly competitive markets can result in environmental degradation (Panayotou, 1992). Among the functions of the government is to regulate markets and provide public goods that the private sector does not avail. It is a good or service that is jointly consumed and cannot exclude any person from it. Examples of public goods include air quality, disaster risk management, and so forth.

The organizational structure of many public institutions is not conducive to handle environmental problems. Most of these structures are rigid and closed. They often are after maintaining the status quo. Unlike private sector companies, most public sector organizations do not face serious competition, and for that reason, they are seldom innovative. Usually, models to develop public institutions, such as strategic planning, evolved from the business sector. There is a need to open current organizational structures of public entities to assure sustainable development.

Institutional coordination is a requirement for information flow. It is possible, once the institutional framework is structured to exchange data as well as to generate and disseminate information, both within and between public institutions on the one hand and the public on the other.

4.1.3 Framing the problem

Here, the team and their collaborators have to formulate the question that the assessment addresses. For example, what is the probability of impacts of genetically modified organisms on the consumers, the economy, and the environment? What is the possibility of a disruptive flood on coastal areas? Experts often use the source—pathway—receptor (S—P—R) framework, Fig. 8.5, thus linking pressures on the environment as an outcome of anthropogenic activities, transforming the present situation (Gormley et al., 2011).

Allen et al. (2006) used this framework and applied spatial risk assessment to define and exhibit a spatially explicit risk assessment that allows a wide range of

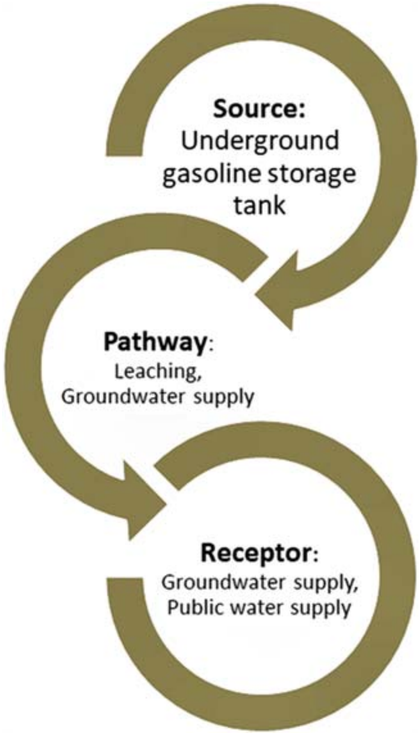

FIGURE 8.5

Example of the use of source—pathway—receptor framework.

Adapted from Gormley, A., Polland, S., Rocks, S., Black, E., 2011. Guidelines for Environmental Risk Assessment and Management— Green Leaves III. In: Risk Management, vol. 2008. London, UK. Retrieved from: http://www.defra.gov.uk/publications/files/pb13670-green-leaves-iii-1111071.pdf.

information regarding the distribution of invasive species, toxicants, or other stressors, integrated with landscape variables that affect the spread of a species or substances. They elaborated models and quantified spatial overlap between the stressor and target organisms. Risk, then, is assessed as a product of spatial overlapping and a hazard index based on the vulnerability of target species (Allen et al., 2006).

When defining a problem, it is essential to be aware of engineered, natural, and human events and processes that affect the risk. If the team of experts and their counterparts do not consider the influencing factors at an early stage, difficulties may arise in conducting meaningful assessments and selecting feasible options (Gormley et al., 2011).

4.2 Stage 2: risk analysis and assessment

The risk is the probability of an unfortunate event to take place in the future. It is the likelihood that a hazardous incident will take place in a location of exposed and susceptible elements. A model that analyzes risks consists of (1) hazard, (2) exposure, (3) vulnerability, and (4) losses (Brecht et al., n.d.).

A hazard is a situation or a biological, chemical, or physical agent that may, under specific conditions, lead to harm or cause adverse effects. Identifying the hazard will have a significant bearing on the scope of the overall assessment. One common pitfall is to overlook secondary hazards that may also arise. The possible outcomes that may result from any given hazard are intrinsic to it.

Based on the risk profile that the S—P—R analysis resulted, the team can quantitatively assess exposures, the magnitude of impacts associated with identified hazards, Fig. 8.6. It is possible by conducting a fault tree analysis, for example, and simple deterministic risk estimation and Monte Carlo Simulation techniques.

The repercussions of a specific hazard may be actual or potential harm to human health, property, the natural environment, or dependent valued services. The team of experts and the community has to determine the magnitude of these consequences, which is an integral part of a risk screening process, i.e., risk quantification

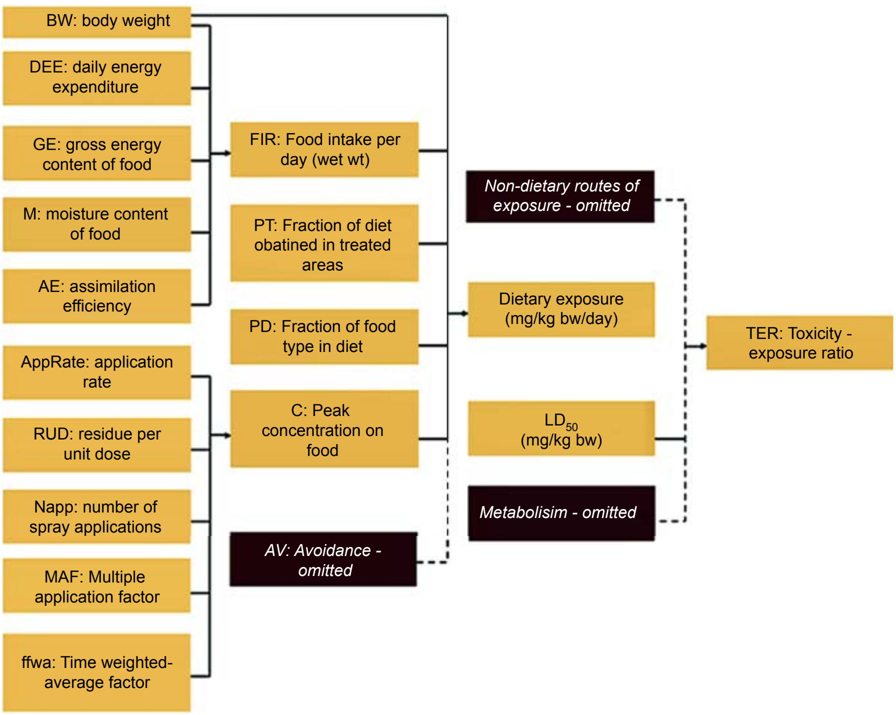

FIGURE 8.6

Model for assessing the consequences of acute risks of pesticides to birds.

From Gormley, A., Polland, S., Rocks, S., Black, E., 2011. Guidelines for Environmental Risk Assessment and Management — Green Leaves III. In: Risk Management, vol. 2008. London, UK. Retrieved from: http://www.defra.gov.uk/publications/files/pb13670-green-leaves-iii-1111071.pdf.

procedure. It is of utmost importance to consider both the spatial and temporal scale of the consequences and the time to onset of the results.

Now it is time for the team to answer the following question: What is the probability of the initiating event occurring? They have to check the source of the threat, such as the location of susceptible species or the site from which the hazard originates, such as a spill that contaminated the water reservoir. If the information indicates the vulnerable species is infected or the reservoir is contaminated then do these species or levels of contamination constitute a hazard to human health? If the response is yes, then the team, in collaboration with the local community, has to explore the available range of options. List of alternatives include controlling the spread of a pathogen or the contamination all the way to evacuating the metropolitan area. Gormley et al. (2011) presented a case of assessing risks of using anaerobic digestion residue to illustrate the process of risk assessment, Fig. 8.7.

To spatially analyze risk, Craigmile (2016) recommends building a spatial model for the data, producing predictions of the process at the different locations in the area

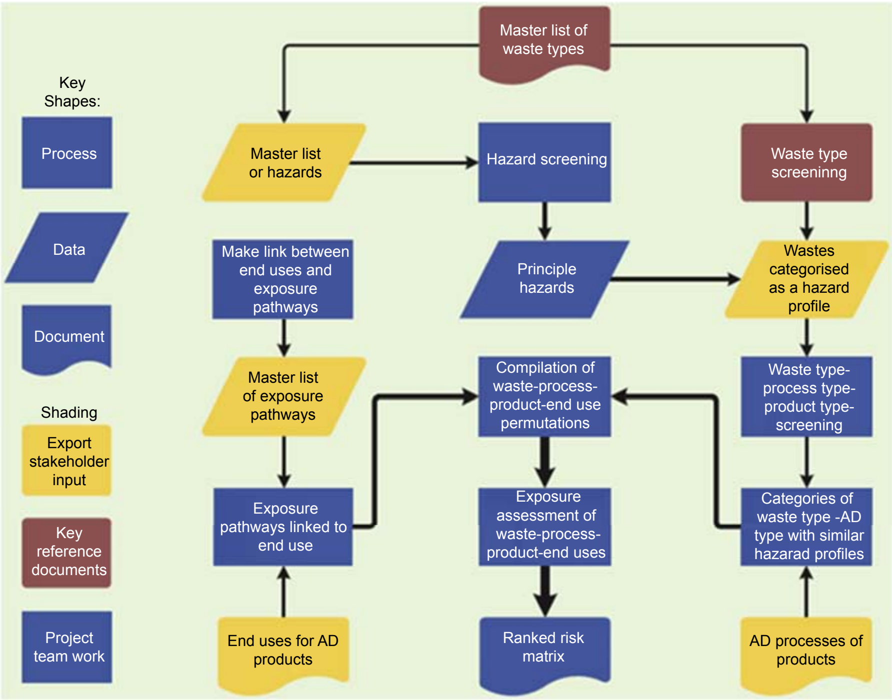

FIGURE 8.7

Risk assessment method for the safe use of anaerobic digestion residue.

From Gormley, A., Polland, S., Rocks, S., Black, E., 2011. Guidelines for Environmental Risk Assessment and Management — Green Leaves III. In: Risk Management, vol. 2008. London, UK. Retrieved from: http://www.defra.gov.uk/publications/files/pb13670-green-leaves-iii-1111071.pdf.

of interest, forming an exceedance region using these predictions. The team has to identify areas that exceed a given threshold value. The geostatistical method that solves the problem of expecting the realized value of a linear function of a Gaussian spatial stochastic process Y(s) based on observations $Z(s_i) = Y(s_i) + \in(s_i)$ at sampling locations s_i, where the $\in(s_i)$ are mutually independent zero-mean Gaussian random variables (Craigmile, 2016).

If the information is not enough, valid, or reliable, then the team and their counterpart can provide rank, score, and index to the risks using causal criteria and logic-based systems. These methods often offer a consistent and systematic approach when risk prioritization is required; however, these might be subjective (Gormley et al., 2011). The team can use the Analytical Hierarchy Process (AHP) or Delphi technique linked to geographic information system (GIS) system to integrate the spatial dimension into the risk assessment process.

A risk matrix is the expected outcome of this stage, Fig. 8.8. The matrix is a simple presentation of the likelihood of an unfortunate event to occur and its expected impacts. The measures on both access of the form are on an ordinal scale, i.e., rank order according to the probability and severity of the consequence. The team in collaboration with the local community has to decide on the breaking points to enable the prioritization of the risk according to their probability and consequences.

One of the approaches recommended in risk assessment and analysis is the use of Multi-Criteria Decision Analysis (MCDA). It is a useful approach when there are two or more different considerations when evaluating available alternatives, such as cost and quality. MCDA in conjuncture with GIS can be used in resolving conflicts in land use planning (Zhang et al., 2012). In 2017, Akay and Erdoğan produced a forest fire risk map using variables such as forest vegetation structures, topographic features, and climatic parameters depending on GIS-based MCDA method. They used "extAhp 2.0" plug-in when running AHP in ArcGIS 10.4.1 to categorize study

Likelihood ↑ / Impact →	Negligible	Minor	Moderate	Significant	Severe
Very Likely	Low Med	Medium	Med Hi	High	High
Likely	Low	Low Med	Medium	Med Hi	High
Possible	Low	Low Med	Medium	Med Hi	Med Hi
Unlikely	Low	Low Med	Low Med	Medium	Med Hi
Very Unlikely	Low	Low	Low Med	Medium	Medium

FIGURE 8.8

Example of a risk matrix.

From Boers, D., 2017. Beyond the Risk Matrix - Making Value Based Risk Informed Decisions. Retrieved from: https://www.thereliabilityblog.com/2017/09/13/beyond-the-risk-matrix/.

area under four fire risk classes: extreme risk, high risk, moderate risk, and low risk (Akay and Erdoğan, 2017). In Terengganu, Malaysia, GIS in association with MCDA was used to assess the potential flood risk areas (Elsheikh et al., 2015).

4.3 Stage 3: risk monitoring and options

Based on the evidence and results that the risk matrix presents, the team and the community have to decide on the course of action and needed interventions. The available choices range from risk termination by eliminating the source of risk all the way to accepting the risk and thus deciding on means to tolerate its consequences, as Fig. 8.9 exhibits.

The decision on which option to follow depends on the criterion that the gray rectangles present to evaluate the magnitude and order of the expected consequence of the hazard. The criterion consists of economic factors, technical factors, environmental security; social issues; and organizational capacities. The team and the local community have to decide on weights for each parameter of the criterion. There are several approaches and models available for decision-making including computing the cost—benefit ratio to decide on the financial feasibility; calculating the economic rate of return; conducting a social impact assessment and environmental impact assessment; and lastly, conducting an institutional analysis to determine

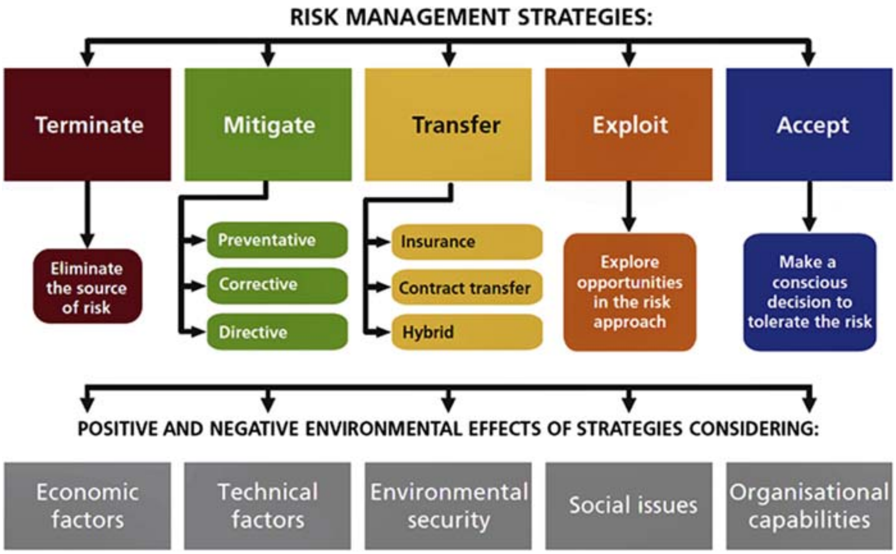

FIGURE 8.9

Options for risk management.

From Gormley, A., Polland, S., Rocks, S., Black, E., 2011. Guidelines for Environmental Risk Assessment and Management — Green Leaves III. In: Risk Management, vol. 2008. London, UK. Retrieved from: http://www.defra.gov.uk/publications/files/pb13670-green-leaves-iii-1111071.pdf.

preparedness and needed capacity building efforts. The criterion cannot depend only on one estimation; it has to rely on a holistic, integrated, and comprehensive evaluation of the consequences, which the previous two steps have highlighted. The parameters exhibited in the gray rectangle are essential for successful risk management.

4.3.1 The no action option

The team and the community might know the hazard and accept its impacts. Not to invest in risk reduction initiatives can be the accepted decision. Nevertheless, the need to monitor the hazard and check its development along both dimensions of the risk matrix is a must.

4.3.2 The minimum requirement option

If the hazard is new or its consequences are not clear, then monitoring and generating information are required activities. Precautionary actions are needed. Both the team and the stakeholders have to consider any unintended outcomes of risk mitigation.

4.3.3 The full-range option

In case the risk is not acceptable, and minimum interventions are not enough, then it is time for the full-range option. Within this option, the team and the local community should have several alternatives. First, can they transform a problem into an opportunity? If so, then how? The State of Florida, USA, declared the lionfish, a native to Indo-Pacific Ocean, as an invasive species and a severe hazard to swimmers. Activities to manage the spread of the lionfish included organizing fishing tournaments and upscale restaurants started serving delicious lionfish. The growing demand is controlling the population of this invasive species, thus protecting the reefs in the Gulf of Mexico (Gabriel, 2017).

If the no option alternative is not viable, then is it possible to transfer risk through insurance mechanism, for example. Within the past decade, the Algerians experienced several unfortunate events, mainly the Algiers floods, the Boumerdès earthquake, and the Ghardaia floods in 2001, 2003, and 2008, respectively, in addition to the annual forest fires. Among the interventions was devising schemes to ensure properties to avail resources for the rehabilitation and recovery following the disaster. The Philippines are susceptible to climate change and natural disasters. The average asset losses mount to US$3,500 million each year. In 2017, the Philippines, with the support of the World Bank, launched a new catastrophe risk insurance for the amount of US$206 million to cover losses resulting from climate and disaster risks.

Some risks require mitigation, such as floods. The team and the local community will have to consider engineered solutions, such as developing culverts and dams. Some interventions can be in the form of directives, such as evacuating vulnerable areas. Other risks, such outbreak of a pandemic, require radical solutions. The only choice is to eradicate the source of the hazard by all possible means.

4.4 Stage 4: act and address the risks

Now the team and the local community have laid out a scheme to cope with the hazards and manage risks. It is time to put this plan to the test. They have to answer the following questions:

1. Is the plan acceptable and meets social, economic, financial, and environmental criteria? For example, does it jeopardize social justice in the local community? Is it in line with the national strategy?
2. Will the selected options and action plans really achieve the goals the city set in the plan?
3. Is the plan feasible and doable within the available resources?
4. What are the benefits to the city if the plan is implemented? Or what losses will the city incur if the plan was not executed?

4.5 Prepare a contingency plan

A contingency plan is required. It assures that the city is prepared to face any expected disaster. The plan must consist of the following three components:

(1) Monitoring and information generation in all forms, i.e., qualitative, quantitative, temporal, and spatial. Monitoring and information generation is a *sine qua non* for risk assessment, analysis, and management. Monitoring and information generation will necessitate the development of Early Warning Centers and needed institutional framework developments to assure the flow of information, and the validity and reliability generated data for proper decision-making.

(2) Preventive and corrective measures, such as culverts and dams to protect the settlement and harvest water from flash floods.

(3) Supportive measures including, but not limited to, training, conducting drills and tabletop exercises, capacity building and development, and awareness raising

5. Can a smart city be a resilient city?

There is a growing interest in smart and digital cities. Dameri (2017) argued that in 1994, there was only one published paper on the smart and digital city. In 2012, the list of published articles increased to 184 papers. Despite this body of literature, there is no consensus on a definition of a smart city. It is not just a digital city that avails the Internet to the citizens. Furthermore, because many scholars examine the smart city out of its socioeconomic and political contexts, the concept of the smart city continues to be a normatively laden notion (Visvizi and Lytras, 2018).

Nonetheless, a smart city seems to be a metropolis that depends on information and communication technologies. It is an urban area of high social and human capital where the citizens are flexible, open-minded, creative and innovative, and have the affinity for lifelong learning. It is also a city whose municipality utilizes advanced technologies to manage and control infrastructures and transportation. In short, a smart city offers smart governance, education, health care, energy, technology, infrastructure, mobility, and buildings. It is an innovative metropolis that generates knowledge, nurturing a smart urban economy that can be sustainable if it succeeds in protecting the environment and achieving social equity. Residents of a smart city enjoy the highest quality of life (Dameri, 2017). Finally, a smart city does not exist in a vacuum. It is highly connected to global markets and serves the international economy.

A smart city is capable of gathering data as well as generating and disseminating information and knowledge. The team responsible for DRR and the local community are capable of exchanging information. They can use gadgets, such as smartphones, to the full potential effectively and efficiently. A city that has smart governance, smart, physical, and social infrastructures, and that is digital and globally connected seems to be capable of being resilient, given that the administrator and their constituents adopt DRR in their city planning. A smart city can easily address the five priority areas of the Sendai framework for formation the United Nations Office for Disaster Risk Reduction launched in 2015. The five priority areas are

1. Build capacity for DRR activities at local government and community level
2. Recognize the vital role civil society organizations play in implementing the new framework for DRR
3. Increase funding for DRR
4. Ensure strong accountability
5. Make sure there is coherence between all international development frameworks

To examine whether a smart city can be resilient, the author used Atlas.ti software for qualitative analysis. He prepared a hermeneutic unit of 60 published papers on risks, hazards, and smart cities, and then coded them according to the list of codes that Table 8.1 presents. The co-occurrence matrix is the frequency of joint quotations under two or more codes. The larger the joint frequency, the stronger the association between the two codes. Digital city, which reflects the use of remote sensing and GIS, IoT, and big data in day-to-day activities, associates with smart city. Digital city also associates with preparedness, global city, and pollution. Smart city links strongly with preparedness, remote sensing, and GIS. Finally, a global city most probably suffers from environmental pollution. Being a global city means it is a digital city. As stated earlier, among others, a smart city is both digital and global.

A smart city can be a prepared city. A metropolis capable of implementing measures for prevention, which in turn mitigates any risk that is the product of both susceptibility and exposure. Based on the co-occurrence matrix, it is possible to construct a conceptual model that attempts to explain relationships between the codes and their quotations in the 60 articles used in the analysis. Fig. 8.10 is a schematic diagram of the constructed conceptual model exhibiting the relationships and their directions.

Table 8.1 Co-occurrence matrix.

	Digital city	Ecosystem	Global city	Pollution	Preparedness	Remote sensing and GIS	Smart city	Total
Digital city	0							0
Ecosystem	3	0						3
Global city	7	2	0					9
Pollution	7	2	174	0				183
Preparedness	9	20	6	6	0			41
Remote sensing and GIS	14	10	0	0	70			94
Smart city	65	42	28	28	360	0	0	736
Total	105	76	208	34	430	213	0	1,066

GIS, *geographic information system.*

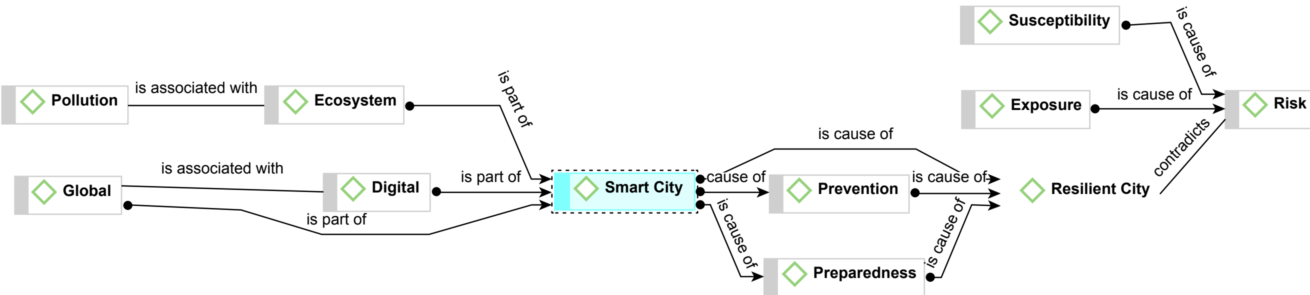

FIGURE 8.10

The conceptual model: A smart city can be a resilient city.

Since a smart city can be a resilient city, then its development might be sustainable, thus fulfilling the mandates of the New Urban Agenda and many Sustainable Development Goals (SDGs), especially SDG 11 that is to make cities and human settlements inclusive, safe, resilient, and sustainable.

6. Conclusions

Cities are subject to a wide range of crises and disasters. The sustainable urban development of a metropolis aims to guarantee the welfare and safety of the residents of the city. It might not be possible in vulnerable locations exposed to different sorts of hazards. DRR, hence, is an assurance for sustainable urban development.

DRR is an iterative process that requires an institutional framework that guarantees a continuous flow of information. A risk-informed community is probably sustainable, because DRR activities contribute to the safety and well-being of humans by reducing casualties and economic losses resulting from disasters.

A smart city can be a resilient one. It is digital and globally connected characterized with smart governance, citizens, and adequate physical infrastructures and social services. Accordingly, a smart city is capable of protecting its natural resources from excessive use and wastes, securing social justice, and initiating urban economic development. It can be a prosperous, resilient, and sustainable city.

Local administrations and municipalities, as well as communities at large, especially of cities in developing countries that are known to be vulnerable, are urged to follow the smart city paradigm to guarantee their resilience and sustainability. These administrations need to consider investing in both infrastructures for adequate flow of information, besides, human resources through education and health-care services.

Acknowledgments

I wish to thank my colleague, Dr. Ghada Yassine, for her comments on an earlier draft.

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PART

3

Smart cities' sustainability

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CHAPTER

9

Smart city as a steering center of the region's sustainable development and competitiveness

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Chapter outline

1. Introduction

Development of cities constitutes a major phenomenon in the contemporary world and is driven by globalization. Cities should be perceived as "primary economic organs" (Jacobs, 1970, p. 6) because they are considered an important source of economic growth on both a regional and a national level and also as a source of productivity due to their contribution to the creation of knowledge, innovation, and human capital (McCann, 2008, p. 359–360; World Economic Forum, 2014, p. 5). They have a significant economic, social, and environmental potential. Being the driving force behind innovation and development, cities implement modern technological solutions, which enhance their functioning, and some of them are considered as smart cities.

Cities are characterized by high dynamics of growth as the Gross domestic product (GDP) growth was 50% higher in cities compared to other territorial units of the European Union between 2000 and 2015. An increase in employment

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00009-0

was 7% higher in cities, while beneficial effects of this type were not recorded in other EU areas. There are 68% of the EU GDP (in the PPS) and 62% of jobs in 271 EU cities. In 2013, 59% of the EU population lived in them. Generally, cities are characterized by better accessibility in terms of road, rail, and flights (European Commission, 2016, p. 11, 56–83). They offer a wide range of services, including public ones, which could be easily accessed in comparison to other territorial units. Simultaneously, they experience diverse problems that are inherently associated with the urbanization process. However, in view of diversified challenges, nowadays it is important to promote competitiveness of cities, allowing for the sustainable development aspect, including smart cities.

Smart cities are knowledge-intensive economies within which networks and relationships are created, through which the knowledge is transferred. The existing relationships affect different layers of the system which form a single whole. Information and communications technology (ICT) is a driving force behind the growth of smart cities. In further considerations, smart cities are regarded as (territorial) socioeconomic and environmental systems. From the managerial perspective, the process of steering smart cities is aimed at using available resources effectively, solving problems immanent in urban areas and improving sustainable competitiveness taking the challenges of the broadly understood environment into account. Therefore, it may be assumed that *a smart city is steered* as the center of innovation and economy; it develops well and goes through successive development stages, while concurrently interacting with its environment in a complex manner. In this context, the smart city influences its environment, and, simultaneously, the city is influenced by it—*being a steering unit (steering city)*. In further considerations, both of these perspectives are considered as one.

The concept of a smart city as a steering center is put forward because the city is an open system of a complex and dynamic nature, in which not only a control (regulatory) process within the system is necessary but also the city influences its environment, that being a region or another superior territorial unit, other cities, or metropolises. Complex relationships are developed between the environment and the smart city, the latter being a creator and a developer, taking promotion of sustainable development into consideration.

The main aim of the chapter is to present the concept of the smart city from the systemic perspective and different layers that create this kind of a system. It is assumed that the smart city is a highly competitive city, and the competitiveness of the city should be created in a sustainable manner. Thus, the smart city may be regarded *as a steering unit,* influencing economic development and promoting competitiveness of the region in a sustainable manner.

The chapter consists of the three integral parts. The first part of the chapter presents the systemic perspective in the concept of the city, and then the approach to the smart city as a steering center is put forward because the city is an open system of a complex and dynamic nature, but the city influences its environment, thus being the steering unit. The priority for the smart city, regarded as a socioeconomic system, should be to achieve the sustainable competitiveness. Therefore, the second part of the chapter focuses on the concept of smart city's sustainable competitiveness, and some drivers of this competitiveness are presented. The third part of the chapter underlines that cities are diversified in terms of their adaptability to some modern diverse phenomena and processes, and at the same time, they can influence the environment, in which their role as a steering center can be fulfilled. The novelty of the approach to smart city as a steering center promoted in this chapter could be useful to analyze the existing relationships in the city in a more complex manner.

2. City as a socioeconomic and environmental system and a steering center

2.1 Systemic perspective in the concept of the city

From the point of view of a system, the city is considered a complex, dynamic, and functional whole (Parysek, 2015, p. 31); as a steering unit, it also influences the territory (environment) in which it functions. It may be perceived as a certain socioeconomic system (Stawasz, Sikora-Fernandez, 2016, p. 11, Parysek, 2015). Simultaneously being a specific organizing approach, a reference to a systemic research perspective makes it possible to provide a holistic overview of a given phenomenon (object). The concept of a system described by Bertalanffy (1984, p. 86) emphasizes that it is "a set of elements being in mutual relationships" (Bertalanffy, 1984, p. 86). In addition, it is indicated that it is not only a deliberately defined set of elements but also a set of relationships between such elements and their properties (Mynarski, 1979, p. 12). Properties refer to characteristics of objects, while relationships refer to interactions linking components with the whole; therefore, the whole has such properties that its components alone do not have (Mynarski, 1979, p.12). It is pointed out that "the system forms a complex whole, the operation of which results from the fact that its components interact between each other" (Rokita, 2011, p. 13). The environment of the system is also a set of elements and properties, which influences the behavior of this system (Mynarski, 1979, p.13); these elements include the elements not being part of the system but undergoing changes under its influence. Simultaneously, micro- and macro environments are identified (Jajuga, Wrzosek, 1993, p.20). The concept of the system is presented in Fig. 9.1.

The structure of systems is hierarchical, which means that each system consists of subsystems, which, in turn, include lower level subsystems, and each subsystem may be characterized by different functional properties. Internal relationships of the system and structural properties are taken into account. At the same time, a given (separate) system may constitute a component of another superior system (supersystem), while internal relationships of this system and its structural properties are important in this context (Mynarski, 1979, p. 15−16). Multidimensionality draws attention to the "ability to see complementary relations in opposing tendencies and to create feasible wholes with infeasible parts" (Gharajedaghi, 2006, p. 38).

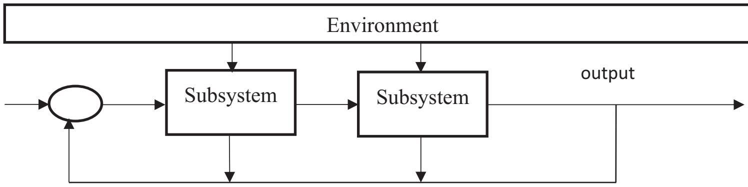

FIGURE 9.1

The concept of the system.

Modified Fig. 1.4 in Myszewski, J.M., 1998. Zarządzanie Zmiennością. Systemowe Spojrzenie Na Metody Statystyczne W Zarządzaniu Jakością (Managing Changeability. Systemic View on Statistical Methods in Quality Management), Warszawa:Orgmasz.

A feature of the systemic approach is contextuality, which makes it necessary to consider a phenomenon (objects, processes, events) in relation to the place in the surrounding world—to supersystems in particular (Jajuga and Wrzosek, 1993, p. 14). Because "everything depends on everything", it is possible to identify what can be control and what cannot. Therefore, while the system comprises a set of interactive variables that may be controlled, the environment should be considered as a set of variables that influenced this system but cannot be steered. However, apart from the variables that cannot be controlled, the occurrence of variables that may be influenced is also pointed out at present. The system has an increasingly higher ability to influence a significant number of things (Rokita, 2011, p. 24–25; Gharajedaghi, 2006, p. 29–32).

The city may be perceived as territorial social system, which involves a system in which the population living in a given territory permanently uses and controls (Chojnicki, 1999, p. 498). The further deliberations, concerning the concept of city being the system, also refer to smart city. *The city may be perceived as a complex system* due to its elements, structure, and relationships with the environment, and it may be treated as a functional system. The strength of existing relationships determines system cohesion; in particular, spatial relationships are of considerable significance in this case. The functioning of the system also depends on its external relationships with the environment, which are developed by external systems in relation to a given system. The environment of the system is also nature, which is a propelling source of systems of a material and energetic nature, which makes it possible to perceive the city as a socioeconomic and environmental whole (Parysek, 2001, p. 26–30; Chojnicki, 1999, p. 320–323, 312–313).

The environment of the system includes a set of objects related to the system of the same of a different type. The relationships that make up the structure of the system may be built up between system components or between these components and the environment, thus creating internal and external structures between which there are relationships (Chojnicki, 1999, p. 312–313).

To sum up, the city is a system because

- it includes elements—inhabitants, buildings, infrastructures, organizations, institutions, etc.,

- there are material, energy, information, and decision-making relationships between elements in it,
- there is a control and steering system (local government),
- there are relationships with the environment (Gorzelak, 2008, p. 89). The city is also part of space with specific features; therefore, spatial relationships between elements are important (Gorzelak, 2008, p. 89–90).

When considered a system, the city constitutes one of the levels of social reality alongside regional, national, supranational, and global realities (Chojnicki, 1999, p. 323).

3. Steering the territorial socioeconomic system

Nowadays, there are many global challenges (megatrends) that cities are up against including urbanization, demographics, and the emerging middle class, rising inequality, sustainability, technological change, industrial clusters, and global value chains, governance (World Economic Forum, 2014, p. 8–11). Because of extraordinary complexity and dynamics of their development, it is essential to manage such a system properly to contribute to and affect a specific state of the system. Still, the behavior of systems such as cities is subject to change and the development path of individual systems is different; thus, actions to be taken are aimed at shaping system states into those defined as desired, while the actions of this type are defined as forcing and make the control of this system possible. Consequently, it is necessary to determine the purpose of the system and the tasks to be taken by it (specific behavioral pattern), which are the steering standards for this system. When it is necessary to take certain forcing actions, they may be carried out by *regulating* (controlling) that involves the situation in which the system has to get into the desired state if there are deviations from the standards. However, another type of forcing actions involves "steering" associated with the determination of new standards and the effect on the system to achieve such standards (Jajuga and Wrzosek, 1993, p. 45–47). On this basis, *steering may be considered a desire to ensure a specific intentional action of the system* in changing conditions and the adaptation of the standards. Regulating is regarded as a certain case of steering (Koźmiński and Latusek-Jurczak, 2011, p. 42).

System steering may be related to influencing a given system to achieve and maintain intended properties of this system in the management. In this context, *steering may be carried out between a steering system and a steered system* (Myszewski, 1998, p. 18). On the other hand, Kornai distinguishes a real and controlling sphere, which is, therefore, a steering—managing—system (after: Jewtuchowicz and Markowski, 1990, p. 149). Steering is only an action related to system regulation to achieve the intended objective. It refers not only to the system per se but also to the aforementioned environmental influence. Steering may be carried out by developing the system or the scope of interaction (Noworól, 2007, p. 71).

In relation to a given territory, territorial management refers to "one of the subsystems of the territorial system and involves steering (managing) subsystems of the territorial organisation, including its structural elements to achieve the objectives set by the manager" (Noworól, 2007, p.71). This approach was, therefore, used for further considerations.

In open and complex systems, there is a material and information exchange with the environment characterized by changeability. However, such systems can accomplish relatively stable stages of dynamic balance, and after some time, there is a balance shift, and the system itself changes its structure and the abovementioned standards. Steering of such an open system is enabled by the feedback mechanism (Koźmiński and Latusek-Jurczak, 2011, p. 44). Solving emerging contradictions that result from different aims of subsystems and coordination of managing units' activities with a view to ensuring system development should be considered a primary task. This management system both regulates and steers development of the real sphere (Jewtuchowicz and Markowski, 1990, p. 149–150). The concept of the smart city as a steering system is shown in Fig. 9.2.

Although current considerations have focused on the issues that treat cities including smart cities as a system, attention should be paid to the perception of *a smart city that is part of another larger system*. There are changes in the relationship

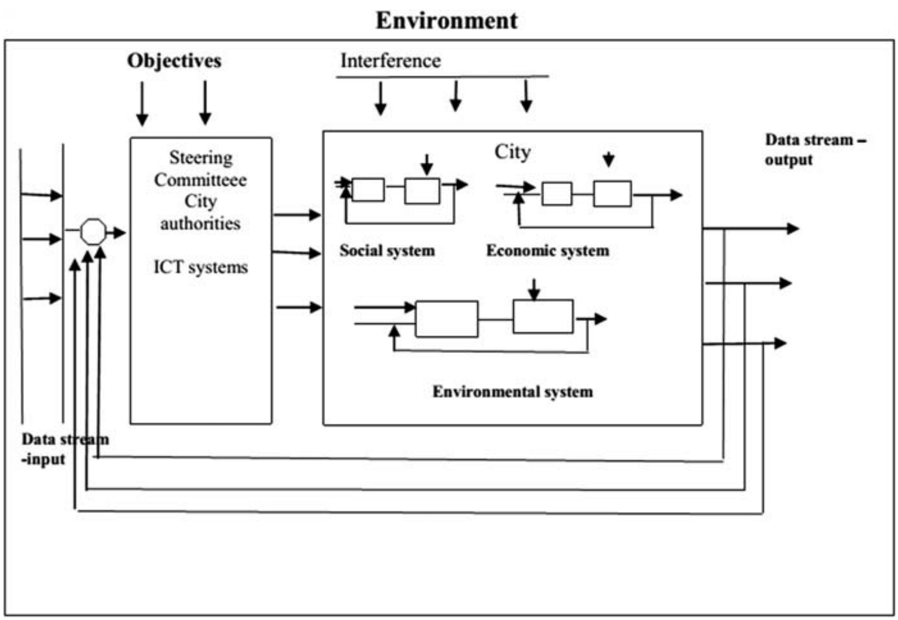

FIGURE 9.2

The smart city as a dynamic steering center.

Mierzejewska 2009; Chojnicki 1999; Parysek 2015; Myszewski 1998; Noworól 2007; Jajuga and Wrzosek 1993.

between the city and the environment, which is associated with the transformation of the development model from resource-intensive to innovation-consuming. With regard to the metropolis, the regional environment is not important in its development processes due to the fact that such cities require “high-quality” inputs, which a less developed environment of the region cannot provide, while resources are “drained” from its environment, which is happening in Poland and other countries, thus deepening the ongoing processes of territorial polarization. On a national scale, large cities in particular are considered not only as development centers but also as links between the national economy and the environment. In Poland, the largest cities are perceived as primary nodes of the functional and spatial structure of the country (Gorzelak, 2008, p. 95–97).

Hence, there arises a question about possible creation of sustainable competitiveness of smart cities. On the other hand, it is yet to be decided whether a smart city may be a steering center in terms of sustainable competitiveness and what the constraints are regarding implementation of this development model in such kind of cities.

4. Competitiveness and sustainable development of smart cities—two reconcilable priorities for policy

4.1 Sustainable competitiveness of smart cities

The concept of smart cities was a response to emerging challenges, including those related to the development of knowledge, ICT, and social inclusion. This concept emphasizes the role and the *importance of ICT* in creating networks and building framework conditions and the environment in which innovations are created, constituting an important factor of competitiveness. Therefore, it is pointed out that smart cities are “innovation territories with developed knowledge-intensive activities, institutions, and routines for cooperation in knowledge creation and innovation, advanced broadband infrastructure digital spaces and e-services and proven ability to innovate and resolve problems collaboratively” (Komninos, 2015, p. 4). Other definitions refer to various elements (planes) of city life (Visvizi & Lytras, 2018a). A smart city can therefore be perceived through its attributes: *using the technology* to facilitate the coordination of city subsystems, and at the same time becoming smart due to the improvement of subsystems, is associated with new opportunities, well-being, and economic growth (Glasmeier and Christopherson, 2015, p. 6). It also involves more effective management methods (Szymańska and Korolka, 2015, p. 66).

The definition of smart cities proposed by Caragliu et al. also takes into account a broader perspective on this type of cities, according to which “a city is smart when investments in human and social capital as well as traditional transport and modern (ICT) communication infrastructure contribute to the sustainable economic development and high quality of life with wise management of natural resources through participatory governance "(Caragliu et al., 2011, p. 70); they also identify the features of this type of cities that are associated with competitiveness.

Cities compete at various levels: international, national, and regional (Begg, 1999) ones. *Their competitiveness is associated* with their economic position in relation to other cities, which is determined by a relatively high level of income per capita or employment (Turok, 2005, p. 25–26). It can be seen as a function of complex relationships between variables (determinants), which include the ability of enterprises to sell products on a competitive market, the value of products and the efficiency of their production, the size of the use of human, capital, and natural resources, which respectively refers to trade, productivity and employment rate, and thus to the determinants of growth and prosperity of these units (Turok, 2005, p. 26). Currently, when creating the definition of competitiveness, its wider aspect should be taken into consideration because a competitive city is the one that improves economic performance and well-being by not straining environmental and social factors through development (Giffinger and Haindl, 2009).

Attention is therefore drawn to the need of achieving sustainable development by proposing the *concept of sustainable competitiveness*, which—in relation to a smart city—should be associated with its ability to "deliver the beyond-GDP goals for its citizens today and tomorrow" (Aiginger et al., 2013, p. 13), indicating growth factors and focusing on goals that are going to be achieved, apart from economic goals, such as social inclusion and sustainability (Aiginger et al., 2013, p. 13). The social and environmental aspect may be found in another definition of competitiveness of the city, which defines sustainable competitiveness as an ability of cities to continuously grow and develop, while they are supposed to ensure social cohesion and appropriate environmental quality at the same time (Cities as Engines of Sustainable Competitiveness et al., 2014). Attention is also paid to the occurrence of symbiotic relationships between the competitiveness and the well-being of local units. This well-being may however be limited by the occurrence of external effects (Huggins and Thompson, 2012).

The *competitiveness of smart cities* should be perceived as the ability of the territorial unit, i.e., the city, to "offer an attractive and sustainable environment for companies and inhabitants"[1] (Dijkstra et al., 2011, p. 4), which contributes to the achievement of economic, social, and environmental goals both in the short and long term (Dijkstra et al., 2011, p. 4). However, a certain level of system equilibrium should be ensured. As a result, it should also be associated with the potential of the smart city—socioeconomic system,[2] which creates, shapes, and develops the potential through a set of factors, policies, and institutions as well as other entities contributing to the achievement of the appropriate level of city's sustainable productivity,

[1] The definition that has been proposed applies to the region (Dijkstra et al., 2011), and it was adopted for the purposes of the concept of smart cities.
[2] Therefore, we refer here to both the factor-based and result-based competitiveness. See: Misala (2003), by referring to the competitiveness of the national economy.

while ensuring its inhabitants' appropriate living standards (we refer to the definition proposed by: World Economic Forum, 2014, p. 12).

4.2 Drivers of smart city's sustainable competitiveness

A smart city can be described using a diverse set of determinants, including those directly related to the competitiveness of the economy, as well as those respecting its individual social and environmental dimensions. According to one of the divisions, six characteristics describing a smart city were distinguished, such as smart economy, smart people, smart governance, smart mobility, smart environment, and smart living, along with the identification of factors and indicators concerning individual characteristics (dimensions) (Giffinger et al., 2007). Others identify the components/dimensions that create the structural characteristics of the smart city (Alawadhi et al., 2012; Castelnovo et al., 2016, p. 728, Visvizi and Lytras, 2018a). However, the list of factors is not closed, and an additional difficulty is the fact that there are a number of links between factors shaping smart economy, which makes it difficult to clearly identify cause-and-effect relationships. Therefore, it is advisable to use the approach treating the development of smart economy as a self-reinforcing process in the course of which a set of factors determining this development and being "in the disposal" of the smart city, which is also affected by other factors having an influence on this city, creates a new combination of factors determining the development (and competitiveness) of the resulting interactions. However, it should be noted that these processes may proceed in the opposite direction (Bruneckiene, Sinkiene, 2014, p. 890). Smart city is also identified from the angle of important key systems (Dirks et al., 2009), and the framework for the assessment of smart city governance is determined (Castelnovo et al., 2016).

The determinants of the competitiveness of smart cities were further discussed using the systemic approach. As already indicated, the city is a territorial social system comprising two layers: social layer created by individuals and complex components, which mostly include social systems of economic, cultural, and political activities (cf. Visvizi and Lytras, 2018b). Separated as a territory, the other layer of the material base of the system includes the sphere of land natural elements and the sphere of artificial elements (economy), which are the product of human activity. Relationships bind individual components of the system (subsystems) within as well as between them, and such components are complex components (Chojnicki, 1999; Mierzejewska, 2009, p. 91—93). They may constitute separate systems, which are, at the same time, subsystems of the smart city, i.e., *social, economic, and natural ones*; such subsystems are connected *by mutual dependencies* (Mierzejewska, 2009, p. 91), presented in Table 9.1, also including components essential for developing competitive economy of the smart city and shaping its competitive potential.

Therefore, when shaping the sustainable development of cities, a certain level of equilibrium in individual subsystems of the city (partial equilibria) should be ensured, and appropriate relationships should be created. It is necessary to ensure natural,

Table 9.1 Smart city as a socioeconomic system.

Subsystems	Characteristics	Economy—elements important for competitiveness
Social	Human units, groups of people, social organizations, institutions with a material base, and networks of relationships. Institutions including standard and value systems, city management and administration method, and comanagement by the inhabitants	Human capital (including structure, quality, functionality) Social capital Changes in the social and professional structure Social creativity Attitudes of local communities in the context of creating a civil society, including economic and social activity
Economy	Economic entities conducting economic activities along with their material bases, relations between such entities and associated with other subsystems of the city and with the environment, created during the operation, including management	Financial independence of entities Technical infrastructure system, hard and soft, including information and communications technology, infrastructure Information resources Social infrastructure Efficiency of institutions Sectoral diversification of the economy—modern structure and innovation, development of creative areas of the economy Involvement in export activities Innovation of the economy Knowledge-based economy Organization
Nature	Elements of the natural environment, relationships between the elements that make up living conditions, ecological ones, management.	Location and location rent, natural conditions Resources and forces of the nature Production spaces Environmental benefits of locations

Based on Parysek, 2015, p. 36; Mierzejewska, 2009, p. 121 table 4.3 and modifications; Giffinger et al., 2007, p. 12; Pietrzykowski, 2010, p. 158–169.

social, and economic equilibria, spatial subsystem equilibrium, and general equilibrium between them (Mierzejewska, 2009, p. 121–122, 144–148, p. 148–157).

Therefore, it can be assumed that the competitiveness of a smart city is described by the development indicators of individual subsystems and therefore the system of weights that can be helpful in comparing the competitiveness of different smart cities. If the effectiveness of such systems increases, they contribute to the competitiveness of the city to a various degree. The question is which target values should be assumed to determine the degree of their development. In the context of creating the competitiveness of smart cities, it is considered to be determined by the components of the analyzed subsystems indicated in Table 9.1; in particular, it is worth taking the following components into consideration:

1. **Institutions, including regulations, standards, and policies, as well as policies and regulations concerning the business environment,**[3] belonging to both social and economic sphere and shaped by mutual interdependencies.
An effective city management or a proper decision-making process establishes frameworks for creating the competitiveness of the smart city. This is associated not only with the achievement of policy priorities and undertaken reforming actions but also with leadership associated with the creation of the vision of the city and effective implementation of actions. Not only political and legal systems of city government, relations with different levels of government, and relations with other entities operating within the city area but also leadership and vision of city development and brand should be taken into account at this point (World Economic Forum, 2014, p. 12). The aim of the actions taken is to contribute to the achievement of public value. The smart city concept emphasizes the importance of participatory governance (Caragliu et al., 2011). The active participation of inhabitants in the city management process and their involvement in the decision-making process and the evaluation of actions are an integral element. Their positive evaluation results in an increase in the level of trust of city inhabitants in relation to actions carried out by politicians (Deakin, 2014; Castelnovo et al., 2016, p. 730−731). ICT is treated as enabled governance (Misuraca, 2010), and ICT-enabled solutions affect the e-government by influencing the quality of relationships between authorities and its parts (constituency), including in the scope of connections between people, authorities, and other entities by digitizing existing services or offering new ones, complementing traditional public policy objectives in respect of cities (Castelnovo et al., 2016, p. 725−726). Modern technologies offer new possibilities in the field of management and decision-making process, contributing to the implementation of the so-called open governance, which is the opposite of the traditional top-down approach. Therefore, ICT plays the role of enabler in the scope of open governance by facilitating the implementation of innovation in the public sector. The following our approaches to the role that ICT may play in the implementation of open governance are identified: it facilitates the data collection process and the size of available data, and at the same time more and more data are shared by the local government, as a result of which the transparency of actions carried out by authorities increases; inhabitants may use such data, for instance, to create the policy and thus to contribute to the sustainable development; use for crowdsourcing, cocreation, and joint decision-making (Open Governance, 2016, p. 6−9); regulations and policies regarding the business sphere,

[3] See: World Economic Forum, 2014, p. 12.

which should contribute to the creation of the environment favorable to investors, etc. Factors which will facilitate the implementation of new solutions (projects) concerning smart cities include the clearly precised vision, involvement of city inhabitants to avoid polarization, and the significance of inspiring leaders—city champions, increasing involvement of inhabitants and creating the sense of ownership. It is also important to create the unit that acts as go-between ideas, diversification of stakeholders, beneficiaries, efficient processes, and coordination of ideas, stakeholders, and beneficiaries (Mapping Smart Cities, 2014, p.11). The proposed solution to solve existing problems could include open service platform, e.g., open data, open services, smart tickets (implemented in Barcelona, Helsinki, Copenhagen, Malmo, Amsterdam), single access points for government services, e.g., online government portals, eGov (in Barcelona, Manchester), a local integrated sustainability initiatives (e.g., local and smart energy management, monitoring in Amsterdam, Barcelona, Cologne) (Mapping Smart Cities, 2014, p. 83, 85).

2. **Financial potential of the smart city**—the budget of the unit affects the competitive potential and, at the same time, the conditions that may become city development factors. Local governments may invest financial resources in certain areas that affect the creation of the region's competitive potential (Pietrzykowski, 2010, p. 165) and may promote modernization and reinvestment, including technological infrastructure improving its functioning. This should contribute to the improvement of the competitiveness of the smart city on a global scale, which requires significant financing. It is necessary to ensure that capital investments bring certain value not only for individual entities but also for the entire city. Therefore, the importance of public–private partnerships in terms of the performance-based revenue models is emphasized. The current role and involvement of entities of the private sector and other entities as providers of services in the city and financing should be modified as they should act as entities actively cooperating with various authorities, also at the stage of planning and developing new solutions, etc., or in the scope of implementing smart infrastructure. It is also necessary to change the approach to the traditional financing model for infrastructure that has mostly used financing resources so far and to take funding resources implemented through specific mechanisms into account, such as green bonds in the United States (Hamilton and Zu, 2017).
3. **Economic entities along with their economic base—susbsystem of economy with modern structure**—economy characterized by modern structure, high productivity, significant share of modern industry sectors, and modern services. There are also creative industries. In the context of openness, it is an environment conducive to the development of entrepreneurship, an entity that is significantly involved in export activities, in particular in sectors with high knowledge content (industry and services). Export activities of enterprises are conducive to the establishment of connections, including global ones, and to the improvement of GVA.

4. **Innovation—creation of knowledge and innovation**—traditionally recognized as a factor of competitiveness of cities in the context of dynamic changes occurring in the environment. The way how the innovations are implemented and introduced to the market has changed. Apart from the traditional model of innovation (closed innovation), assuming that the process of innovation creation is closed and implemented within the company which develops own innovative ideas and then by oneself introduced into the market, financing them, the model of open innovation is proposed. In this, model knowledge comes from external (to the company) environment due to the cooperation with many entities, which also utilize this knowledge (Chesbrough, 2006). Chesbrough indicates that open innovation is "a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology" (Chesbrough, 2006, p. XXIV), and it is "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and nonpecuniary mechanism in line with the organization's business model" (Chesbrough, Bogers, 2014, p. 12). One of the principles of open innovation is "not all the smart people work for us. We need to work with smart people inside and outside our company" (Chesbrough, 2006, p.XXVI). ICT enables connecting people, and from the wider perspective is regarded to be so-called one of the "erosion factors" that leverage and connect dispersed knowledge (Chesbrough and Bogers, 2014), being the engine of changes and innovation. The role of cities in ICT-based innovation has been changing, which have been concentrating on broadband network development, and at present, they are focused on support to ICT applications, which improve the quality of living for their inhabitants. Cities are regarded to become not only the object of innovation but they are also treated as innovation ecosystem in which the process of creating the common intelligence and cocreation of the inhabitants' potential is conducted (Schaffers et al., 2011, p. 432). This requires the partnerships implementation and strategy between the major stakeholders, because the importance of share in research and sources of innovation is stressed. These are the experimental technology platforms, ICT tools, know-how, e-service applications, and others. However, it is necessary to assure the access to them through the cooperation models, share of knowledge, and that of resources (Schaffers et al., 2011, p. 432–433). Smart city implies the innovative economy in which the ICT plays a significant role through intelligent clusters' creation including enterprises and health, through creating the intelligent districts of city or new enterprises (Schaffers et al., 2011, p. 435).
5. **Infrastructure as a factor determining the functioning of entities and, at the same time, other subsystems.** The significance of infrastructure in the context of connectivity can be understood in two ways: as hard infrastructure, e.g., transport and communications ones, but also seen through the prism of logistic systems enabling connections with clusters/the global value chain (World Economic Forum, 2014, p. 13). The level of their development, quality, and adaptation to the needs of managing entities and inhabitants is also important. In

particular, modern technological solutions make it possible to improve the efficiency and effectiveness of public transportation and the quality of life of inhabitants.

Therefore, the environment that supports the digital applications is created through development of broadband network enabling connectivity with inhabitants and organizations, enrichment of the existing infrastructure and spaces—systems and smart devices etc., and then creation of application, enabling data collection and processing, etc. Therefore, indicating the key applications, we can mention smart transport, smart mobility, and smart parking. Smart measurement of energy consumptiom is another area of application, monitoring of environment, warning system, embodied system (Schaffers et al., 2011, p. 435–436). Projects that refer to city transport are smart cycling plans though cycle sharing, social sensors, electric bikes, smart cards (Copenhagen, Paris, London), integrated multimodal travel though smart tickets, multimodal travel, travel information (e.g., Copenhagen, London, Helsinki, Glasgow, Hamburg, Dublin), intelligent traffic routing (Barcelona, Eindhoven), and key technologies including geosensors, data mining, and smart cards (Mapping Smart Cities, 2014, p. 83, 85).

6. **Human and social capital**—the importance of the quality of human capital in terms of its importance in the knowledge creation process is emphasized. However, social capital increasing the productivity of investments made, treated as soft connectivity, and interpenetrating individual components of the system should be taken into account. Admitting that technology plays a decisive role, human capital is also of utmost importance because it enables to embody the intelligent activities in the life of city inhabitants. The indicators referring to education, qualification, lifelong learning, also creativity, participation in public life, and flexibility describe this dimension (Dameri, 2017, p. 5–6). These are also persons well-equipped in the e-skills, working in the environment that is supported by ICT, with good access to trainings and education (World Economic Forum, 2014, p. 28).
7. **Natural environment** that helps inhabitants and entrepreneurs to develop their activities.

   When implementing the smart city concept, more attention should be paid to the production of energy from renewable resources, decreasing the energy costs, reducing the CO_2 emission, promoting the efficient utilization of energy, implementing the high quality of transport, which will contribute to the pollution reduction, and introduction of the means of transport that promote the sustainable mobility (Dameri, 2017, p. 11–12). As regards they focus the projects which could make a contribution to smart city, the focus on environmental issues and so-called green solutions, including solving the environmental problems through improving energy efficiency, smart transportation (Mapping Smart Cities, 2014, p. 59–60). Solutions referring to technology (building) and management through smart plugs, smart and green technology, and sensors were applied in Amsterdam, Helsinki, Bremen, including management of power and lighting in the buildings (Barcelona, Milan), and as a result, the energy savings were recorded (Mapping Smart Cities, 2014, p. 83, 85).

The smart city has many subsystems. While developing the competitiveness of the smart city, causal factors of this competitiveness that create specific subsystems should be therefore supported. However, one should consider that these separated subsystems are not exclusionary but complementary in the character they interpenetrate, between which there are mutual interdependencies and interactions, included within them; they also establish relationships with the environment. The system of this type is dynamic because it is created by a specific combination of transforming factors in a given state.

5. Smart cities in the process of changes: adaptability versus impact

We are currently entering "the age of urban transformation in the context of uncertainty, risk and policy upheaval" (Editorial Statement, 2017, p. 381) caused by numerous diverse phenomena and processes: the crisis, various shocks, globalization, including production globalization, popularization of digital technologies and the Internet, or new business models (Sunley et al., 2017, p. 384–385). It is important to understand that cities that were previously considered as growth centers have a different potential to adapt to those challenges, to meet them, and to respond to them, which may lead to different and often unforeseen results. This means they are characterized by *differences in adaptability* because some cities are developing, while others are experiencing opposite processes, and some of them are able to reinvent themselves. Some cities are entering a new path of development, also implementing innovative solutions (Editorial Statement, 2017, p. 381).

In this context, creation of the competitiveness of cities is related to their adaptability, which is not so much about adapting to new challenges but about taking advantage of new opportunities that they create. It is also about *creating their adaptive capability* associated with the process of continuous learning, in particular new things (Sunley et al., 2017, p. 385; Reeves and Deimler, 2011), which in relation to smart cities should also be associated with the promotion of inclusive growth. In this way, while ensuring their future, we ensure their competitiveness. Key sources of adaptive capability include agglomeration of knowledge, employees, and human resources; industrial structure (capturing driving industries that inevitably determine adaptability); diversified resources and innovations, in particular institutions affecting the supply of educated employees; and implementation of a new industrial path (Sunley et al., 2017, p. 386–389). One should adapt to those changes to steer this system.

It is worth noting that the contemporary urbanization processes are associated with the changes undergoing in the cities of today and with the fact that "new" cities are created on the "old grounds" The city is subject to (internal and external) urbanization flows. It is necessary for these processes to be carried out according to the intended directions. Immaterial flows include creation and flow of knowledge, information, or ideas or access to specific services with the use of ICT, while material flows include delocalization of households and businesses and investment flows, which, at the same time, indicate attractiveness, power, and advantages of cities. Push-pull factors of urbanization are identified. Push factors involve those that motivate households and businesses to leave an area, while pull factors involve those that attract such households and businesses. Consequently, it is important to develop a push-pull strategy and then to construct scenarios of evolution in the competitive and cooperative environment (Klasik, 2018; Klasik, 2011). In this context, one of such scenarios may include sustainable competitiveness carried out by smart city.

On one hand, the smart city should become adapted to external challenges, whereas on the other steering, the smart city is also associated with *the process of creating relationships with the environment.* Cities may act as a catalyst for the development of a region, e.g., through their contribution to GDP and income of inhabitants, provision of more job opportunities, attraction of human resources, or through proenvironmental effect. However, what should be considered is that there are factors that do not display such a positive effect. In particular, those factors whose development is carried out outside the city, including such contacts willing to carry out with other smart cities not located nearby, are considered, e.g., development of technologically advanced services. Supporting the development of the creative class may contribute to a positive impact of the city for the development of the region and, thus, development of tourism, recreation, housing situation, and service (Zakrzewska-Półtorak, 2016, p. 288−289). A strong metropolis may affect the development of the region and, at the same time, of cooperation with remote centers, which may cause other regional centers to be excluded (Zakrzewska-Półtorak, 2016, p. 289).

At the same time, strong functional links with the environment as well as development of clusters and regional innovation networks are conducive *to the positive impact of cities*. Sustainable development of the city does not only affect the accomplished benefits of increasing energy savings and the use of collective public transport (Zakrzewska-Półtorak, 2016, p. 289). However, development of smart cities is not always beneficial because certain social groups that do not use ICT and technological advancements may be excluded. Consequently, it may lead to the creation of the so-called dual city, or the two-speed city. Thus, there arises another problem—how will smart cities be able to address ever increasing inequalities and social polarization? Therefore, it is not the creation of smart communities but their adaptability to use ICT for social needs that matters. There are negative effects of the development of new—in terms of technology and network—infrastructure (Hollands, 2008, p. 314−316).

To steer and be a steering center, system variability modeling is required. Owing to a systemic approach and application of system dynamics methods, it is possible to model the structure and variability of complex systems and processes occurring

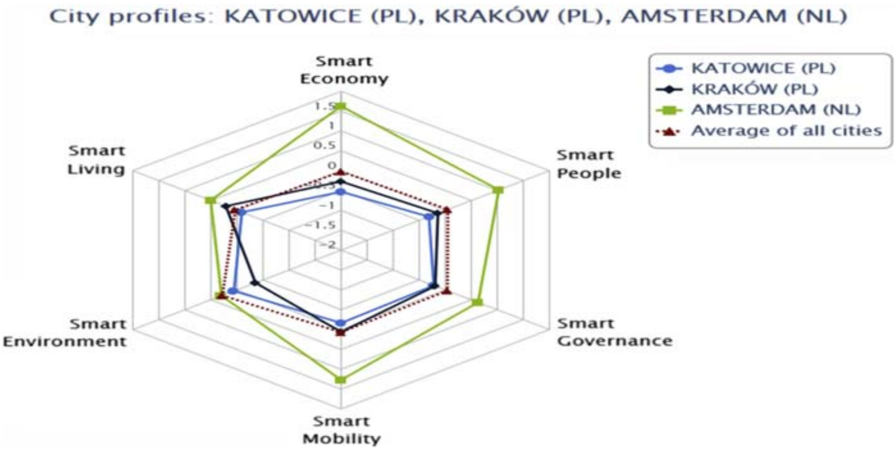

FIGURE 9.3

Profiles of selected smart cities in terms of some of their characteristics.

Europeansmartcities 4.0, 2015. http://www.smart-cities.eu/?cid=5&city=47&ver=4.

in them, allowing for feedback describing cause-and-effect relations occurring between system elements. In terms of smart city—related considerations, it also needs to constitute a coherent whole (Hoffmann and Protasowski, 2013, p. 19). Thus, for each selected object, e.g., a smart city and its environment, its level can be distinguished in relation to the aspect being considered, i.e., its instantaneous level defining, among others, system status; a flow meaning a stream determining the rate of change of level values and decision-related variables which are responsible for regulation based on the information about system statuses (Łukaszewicz, after: Hoffmann and Protasowski, 2013, p. 19—20). Therefore, system steering requires a detailed identification of its individual elements and existing interrelations not only within the system but also with its environment, at a given moment, which should also enable creation of scenarios for its further development. It is up to the managing entity to decide which scenario will materialize. One of them may allow for the creation of a smart city.

The analyses are taken to define to which degree the city is smart, and the six dimensions were identified. The situation of city Katowice and Kraków against Amsterdam, which was regarded to be the most successful smart city in the EU-28, is presented in Fig. 9.3.

6. Conclusions

Cities which may constitute steering centers, and smart cities, in particular, are affected by a complex set of phenomena and processes. Objectives which those units are to pursue are not only limited to competitiveness per se but also include sustainable development. As emphasized by Komninos, “the latent and explicit promise of the intelligent city paradigm is to set out the conditions for more effectively addressing the great contemporary challenges of urbanisation, growth, sustainability, and inclusion” (Komninos, 2015, p.16).[4] Thus, there arises a question: how to ensure accomplishment of sustainable competitiveness in the context of a smart city?

When shaping a smart city and its development, meaning undertaking steering activities, it is important to pay attention to economic effectiveness and competitiveness on the one hand, but also sustainable development on the other hand. The adopted *concept of the smart city as a steering center* made it possible to draw attention to the city as a complex, dynamic, and open system in which both the regulation process within the system and its impact on the environment are necessary. Attention is therefore drawn to the need to pursue sustainable development, and hence the concept of *sustainable competitiveness*. It may be said that the smart city covers the following subsystems of the city: social, economic, and natural, all of them linked by mutual dependencies. Therefore, competitiveness of a smart city is described by individual subsystem development indicators. Creating competitiveness of cities is also related to their adaptability which is *not so much about adapting to new challenges* but *about using new opportunities they create*. A smart city also has a differentiated effect on the region in which it is located. However, the diversified challenges brought about the necessity to implement the innovative approach to tackle them, and at the same time to steer the city. We can agree that “smart cities emerge not just as an innovative modus operandi for future urban living but as key strategy to tackle poverty and inequality, unemployment, and energy management” (Mapping Smart Cities, 2014, p. 17).

This article may be a contribution to further considerations regarding smart cities’ ability to achieve sustainable competitiveness and the role of ICT in its creation. Further research should focus on an in-depth analysis of individual smart city subsystems in the context of creating a smart city and its competitiveness, existing dependencies, and influences, while bearing in mind that they are dynamically created and complicated and that they penetrate individual subsystems given that the city is stil alive. As a result, evaluation of their effectiveness may be helpful in determining the direction of further actions in the field of smart city steering, also in the context of proper shaping of its relations with the environment.

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CHAPTER

Smart cities and the search for global talent

10

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Chapter outline

1. Introduction

The role of cities cannot be overestimated in the 21st century, often called the metropolitan century (Kelly et al., 2017). Nonstate actors increase their role in international relations as power diffuses and decentralizes. It happens because of globalization, the technological and digital revolution, the rise of the global middle class, and the changing location of the center of mass of the global economy. Global business starts to plan strategy from a city rather than from a country perspective. It seems natural as, despite covering just 2% of the Earth's surface, cities produce more than 80% of global GDP (The Economist Intelligence Unit, 2013). They also consume 60%−80% of energy worldwide and are responsible for large emissions of CO_2 (Albino et al., 2015). "Cities are where people go to trade, and live to trade, a unique combination of residential, industrial, business and administrative activity. Cities drive all national economies" (Jacobs in Mainelli et al., 2008). They are also said to be more in favor of globalization processes than contemporary countries, where more and more often protectionist ideas surge (Kelly et al., 2017).

The global picture is changing toward more diversity and more individually tailored solutions. Cities are much agiler and act more pragmatically than states. Thus, they may play a key role in the complex international relations of today

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00010-7

and tomorrow and serve as significant nodes in the global order. Just as any other actor in the world economy, cities both collaborate and compete. They cooperate in the fields of anti-terrorism, public services, migration, cybersecurity, cultural diversity, environment protection, public transport, and infrastructure. They compete over talents, capital, and location of key institutions, corporations, and events, as well as investments and tourism.

Contemporary cities do not narrow down their international activities to the closest neighborhood and do not respect geographical boundaries in fulfilling their tasks and pursuing their policies. Following the revolution in the global economy, technology and communications, national borders and geography matter so little that almost every city, if only its leaders and citizens wish so, can go global. But, to pursue this, they have to be smart.

Over the past 20 years, the concept of smart city has become increasingly popular in the scientific literature. Its definition has been modified several times as new aspects and features have been added (Visvizi and Lytras, 2018a). The role of ICTs and their infrastructure is crucial to understand the "smart" element of the definition and the concept. As Hall (2000) elaborates, a smart city is the one that "monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities and monitor security aspects while maximizing services to its citizens" (Hall, 2000 in Gil-Garcían et al., 2015).

Another definition, however, is more useful when the purpose of this chapter is concerned. Some authors acknowledge that "smart cities have a high productivity as they have a relatively high share of highly educated people, knowledge-intensive jobs, output-oriented planning systems, creative activities and sustainability-oriented initiatives" (Kourtit et al. (2012) in Albino et al. (2015).

Today, it is impossible to develop smart city solutions without reaching to various cities for advice and without learning from their experiences. Good practices, as well as extraordinary talents, are necessary as every field is complex and demands a specialized expertise (cf. Visvizi et al., 2017). For example, just as other stakeholders of the global economy, contemporary cities often tend to develop their niche or niches and become specialized, go-to places in certain fields. No city can be an omnibus dealing with every sphere of the economy. Even though London and New York tend to win in the majority of rankings of go-to cities, they do not score first in every category. While pursuing toward greatness in their niche fields, smart cities need to step up in several basic categories—such as public transportation, green zones, inequalities, and local health care—too. And this is where talents step in.

Needless to say, the human factor is fundamental when the development of cities is concerned. This is the goal which every city should aspire to: "that the people who live there and their leaders use all their talent to achieve progress" (Berrone and Ricart, 2017). Hence, in this chapter, we explore and develop the concept of global talent inside contemporary cities and the cooperation and competition over talents that can help to make cities smarter. Specifically, such topics as the quality of life, the role of foreign-born residents, creativity and culture, education, and higher education are discussed. Some examples and practices from around the world are offered.

2. Smart cities and the global talent

All leaders worldwide try to benchmark their services against other cities. In such actions, it is necessary to acquire some standards. In 2014, a normative ISO was issued in the field of urban planning: *Sustainable development of communities—indicators for city services and quality of life*. ISO 37120 is the first ISO standard for smart city indicators. It is being developed as part of an integrated suite of standards for sustainable community development under the ISO's Technical Committee 268. In general, ISO 37120 defines 100 city performance indicators that could or should be measured, and how. Structured in 17 themes, ISO 37120 defines 46 core and 54 supporting indicators that cities either "shall" (core) or "should" (supporting) track and report. Note that ISO 37120 conformance will require third-party verification of data, and the organization is in the process of defining an audit process with pilot cities. ISO 37120 also provides for a set of profile indicators, such as population and GDP, to help cities determine which cities are most relevant for comparisons (Fig. 10.1).

It is important to highlight that, according to such experts as George Karayannis of the Smart Cities Council, education is one of the central themes—if not the key theme—of the ISO 37120. As a factor essential to human development, it "powers scientific advancement and economic development, enables people to provide for themselves and their families, and allows for individual enrichment

FIGURE 10.1

ISO 37120 themes.

Source: https://smartcitiescouncil.com.

and personal growth." Under this topic a proxy of talent is used, based on an open data[1] initiative that provides seven education-based indicators: female student enrollment, primary education completion, secondary education completion, student/teacher ratio, male student enrollment, total student enrollment, and higher education degrees (Smart Cities Council, 2014). Needless to say, a high level of education and at least satisfactory performance of a city in this field heavily influences its future performance in remaining categories, such as urban planning, wastewater, telecommunications, safety, and others (Lytras and Visvizi, 2018). All of them will be managed mainly by specialists either educated in the city or settling down in the city so that their children benefit from high-quality education (if they have them).

In terms of Higher Education Degrees, such cities as Melbourne with 46.6% of the population with Higher Education Degrees (2013), Toronto, Barcelona (28.2%, 2014), and Rotterdam (26%, 2014) lead. Cities such as Amman (0.1%, 2013) perform very poorly on this item, because of, i.e., the difficulty in obtaining the data. Smart cities are or aspire to become global talent hubs and knowledge economies. They pull talents and have their say in a global competition over bright minds: highly skilled employees, ex-pats, international students, researchers, and professors. They can do so due to agility, branding, GDP growth, and the quality of life they provide. Here, we expand some of the characteristics that we consider to be of special importance. We hope this approach will contribute to the research on smart cities and the understanding of the concept.

2.1 Quality of life

The general smartness and concrete smart solutions matter the most for cities that wish to counter inequalities and build high-quality living conditions. They include public transportation, care over the environment, safety on the streets, health care, efficient and noncorrupted local administration, and many others. Contemporary cities that wish to develop and pull talents cannot afford not to be smart. It is impossible to fully eradicate income and other inequalities in cities. The way local authorities manage them may either hamper or improve the smart status of a city.

When the quality of life is concerned, the size of the city matters. It is reflected especially in the Mercer's Quality of Living Ranking (2017) that takes into account political, economic, and environmental indicators. It is dominated by middle-sized European cities such as Vienna (first), Zurich (second), Munich (fourth), Düsseldorf (sixth), plus Vancouver in Canada (fifth) and two cities from the antipodes: Auckland (third) and Sydney (10th). Bigger global cities obtain lower positions: Singapore is 25th, San Francisco is 29th, Tokyo 47th, and Dubai 74th (Mercer, 2017). Similarly, The Global City Talent Competitiveness Index 2017 states that costs of living are lower in such cities as Gothenburg or Dublin than in global metropolises, but the quality of life in the former ones is higher and includes also a

[1] http://open.dataforcities.org.

modern infrastructure and connectivity. The authors underline especially the agility and the innovation-friendly environment of the middle-sized cities.

The Anholt-GfK City Brand Index study with yet another methodology based on six dimensions—presence, place, prerequisites, people, pulse, and potential—proves that global cities lead when the spirit and dynamism are concerned: Paris, London, and New York obtain three leading positions. They lead in the presence (their global status), place, and potential categories but lose ground when it comes to prerequisites (where basic requirements play a key role) and people (friendliness and diversity). This is where other, again smaller cities such as Berlin (7th in the general ranking), Amsterdam (8th) and Toronto (11th) perform better (GfK, 2016).

With internal migration added, migration also makes economic inequalities and divisions strikingly visible. These inequalities, one of the major negative effects of globalization and a cause of gentrification, are visible in global cities more than anywhere else. They cause backlash, demonstrations, and transnational movements, such as Occupy Wall Street. This movement organized protests in the financial and other districts of New York that inspired further demonstrations in cities around the world.

2.2 Foreign-born residents

Global cities are inhabited in a significant percentage by foreign-born residents often called ex-pats, meaning highly skilled professionals, working in banking, services, or technology. Another group of foreign-born residents are immigrants that are poorer and less educated, but bigger in numbers, and go where employment is. All of them create the spirit of a city, based on their ambition, hard work, and entrepreneurial nature.

Dubai has 83% of foreign-born inhabitants, New York has 37%, and London 31% (Longworth, 2015). Paris with just 12.4% of foreign-born residents is an interesting case, explained, for instance, in InterNations Expat Insider 2017 survey, where respondents were asked about their favorite cities to live in. Paris was chosen as the third worst. 43% of respondents were feeling unwelcome in the French capital, 31% were not feeling well with the necessity of speaking French, 62% pointed at difficult housing situation, and 71% found Paris expensive (Hoad, 2017).

According to this survey and its respondents, Manama is the best place for expats to live in, and Prague is the runner-up. The Bahraini capital is acknowledged especially for the fact that one does not have to speak Arabic to get by there (92% of respondents confirm that), for the friendly attitude of locals toward the outsiders (84%), and for the easiness of finding accommodation (88%). Responders found it generally hard to start one's life in Prague, but the Czech capital scored high in career opportunities, quality of urban living, leisure options, transportation, and affordability of health care that play a significant role in further stages of stay (Hoad, 2017). Santiago de Chile also serves as an interesting example. Following the introduction of certain public policies, the city started to be called "Chilecon Valley," particularly because of improving the business environment and living conditions, also for ex-pats. It is estimated that investors from approximately 80 countries operate there today (Rybka-Iwańska, 2017).

Another report, the Global City Talent Competitiveness Index (2018), brings about some other interesting examples, such as Eindhoven with its Brainport, open wide for the diversity of cultures and nationalities and thus inspiring innovation and thinking out of the box. For example, Eindhoven's Holst R&D Center employs people representing some 30 nationalities. Another company, ASML—the world's leading chip-making equipment producer—employs some 10,000 people representing 90 nationalities. Such diversity enables companies to operate freely and flexible on the global market. Also, their employees work in agile teams, using Scrum methods, very much appreciated and acknowledged by millennials.

Millennials, the best-educated generation in the humankind history, expect a lot from the countries and cities they live in, as well as from their employers. According to "Forbes", millennials want to be "connected to causes": This generation wants to live, study, and work in places and conditions, where they can have a positive impact on their community and where they can ensure a good future for their children (Godfrey, 2016). The number of educated people increases the quality of life in a city and people move there so that they can benefit from it. Shapiro (2006) considers "smart cities to be metropolitan areas with a large share of the adult population with a college degree."

The connection to causes is one of the reasons for the magnetism of the Silicon Valley located in the southern San Francisco Bay Area. Simon Sinek in his bestseller book (Sinek, 2011) examines the example of Apple and define the biggest pull factor for talented, engaged, and loyal employees: People crave to participate in initiatives that are bigger than them. This is why IT engineers and other creative individuals from all over the world want to live and work in Silicon Valley. They feel that this part of California changes the way people and the whole world function. The phenomenon of the Silicon Valley would not be possible without the long-standing image of San Francisco and California as these are parts of the United States where diversity, freedoms, and openness are acknowledged and praised.

There is no doubt that Silicon Valley is a global leader when the location of start-ups is concerned. Tel Aviv with its unique entrepreneurship and creativity culture is, by all means, the runner-up. Dan Senor and Saul Singer in their New York Times bestseller "Start-Up Nation: The Story of Israel's Economic Miracle" craft the story of Tel Aviv (and Israel as a whole), a city that provides a perfect environment for thinking out of the box, creativity, and innovation, named as the world's smartest city by the Smart City Expo World Congress in Barcelona in 2014. As the authors explain, the story of Israel's and Tel Aviv's start-up phenomenon "is a story not just of talent but of tenacity, of insatiable questioning of authority, of determined informality, combined with a unique attitude toward failure, teamwork, mission, risk, and cross-disciplinary creativity" The authors admit as well that the geopolitical situation of the country and the need to constantly struggle for its existence, independence, and development make people engaged into—indeed—a case that is much bigger than themselves.

2.3 Creativity and culture

Creativity is an interesting concept related to a broad notion of smartness and smart cities: "Smart is used as a synonym of creative. '(…) creative or smart city experiments (…) aimed at nurturing a creative economy through investment in the quality of life which in turn attracts knowledge workers to live and work in smart cities. (…) The nexus of competitive advantage has (…) shifted to those regions that can generate, retain, and attract the best **talent**'" (Thite, 2011, in Albino et al., 2015). The "Creative Cities Network," the UNESCO initiative, corresponds with this trend. It is currently formed by 180 members from 72 countries covering 7 creative fields: Crafts and Folk Art, Design, Film, Gastronomy, Literature, Music, and Media Arts. All these cities have a common objective: placing creativity and cultural industries at the heart of their development plans at the local level and cooperating actively at the international level. This initiative is a sample of how cities that self-recognize themselves as creative seek to promote and attract certain professional profiles. This network was created in 2004 and 180 cities, which currently make it up, work together toward a common objective: placing creativity and cultural industries at the heart of their development (Creative Cities Network, 2018).

Some authors like Albino et al. (2015) state that from the "people" perspective, creativity is recognized as a key driver of a smart city, in the same way as learning and education. Komminos (2006) considers smart cities as "territories with a high capacity for learning and innovation, which is built-in the creativity of their population, their institutions of knowledge creation, and their digital infrastructure for communication and knowledge management."

Cultural offerings are essential for vivid cities and their middle-class inhabitants. Culture is a very competitive field of activities, especially in dynamic urban ecosystems. The lyrics of Frank Sinatra's "New York, New York"—including "I want to wake up in that city that never sleeps"—are a pop-cultural proof of this phenomenon and are applicable to all major cities. Their cultural offerings are rich and are provided to their inhabitants in the 24/7 rhythm. One can experience art and culture whenever they want and in any demanded form. Global, highly educated, skilled, and hard-working citizens want the best kind of leisure and culture. They take advantage of high culture—operas, theaters, galleries, but they also like and need the popular one—sports, concerts, and restaurants. This is why, for example, Bilbao with its tremendous Guggenheim Museum and Abu Dhabi with its own Louvre score quite well in the Global City Talent Competitiveness Index 2018.

According to the study of Totally Money, the cultural offerings of leading cities of the globe are indeed rich. For instance, Paris has 245 theaters, 17 museums, 69 art galleries, 6 concert halls, and 100 Michelin-starred restaurants. London is even richer in high culture—with its West End having almost 900 theaters, 186 museums, 125 art galleries, and 17 concert halls. And it locates 67 Michelin-starred restaurants. New York is home to an astonishing number of art galleries (142) and also of 533 theaters, 123 museums, 16 concert halls, and 77 Michelin-starred restaurants.

Tokyo specializes in museums (280) and Michelin-starred restaurants (217), but the number of theaters (95), art galleries (72), and concert halls (14) is also significant (Totally Money, 2017).

2.4 Education

The stock of human capital in a metropolitan area can be measured in various ways. Winters (2011) notes that the share of the adult population with a college degree is a strong predictor of future population growth. When one looks at the reasons why cities grow in terms of human capital, some studies show that the salaries in the cities with the highest level of education are higher than in less-educated cities (Winters, 2011).

When it comes to pulling talents that are still in school, Singapore serves as an outstanding example. According to the UNESCO Institute for Statistics, there were almost 53,000 international students in Singapore in 2014 (40,000 in 2009), which put the country in 18th place globally—and in first when population size is taken into account (The Guardian, 2014). The 2016 edition of the Brand Finance—Nation Brands study states that “a high-quality education system based in English makes Singapore a very easy place for ex-pats to settle” (Brand Finance, 2016). This quality has been acknowledged also by the Organisation for Economic Co-operation and Development in its annual Program for International Student Assessment global education survey, where Singapore ranked first and strongly outperformed all other 71 economies in science (OECD, 2015). The Global Human Capital Report delivered by the World Economic Forum (WEF) acknowledges Singapore as having “the world’s second-highest proportion of high-skilled employment with significant strengths in the quality of its education system and staff training” (World Economic Forum, 2017). Moreover, the Global Competitiveness Index of WEF ranks Singapore third in the world and praises it for its leadership in higher education and training, as well as for its public sector performance (World Economic Forum, 2017).

Eindhoven also has high-quality international schools that are easily accessible. Needless to say, they include openness, mutual understanding, cultural diversity, and operating in multicultural societies in their curricula. According to the authors of the GCTCI (2018), such solutions will pull talents even in the “future of work” times, when specialists will have multiple employers in a lifetime and several at the same time. In such circumstances, the cooperation of various companies (big, small, international, local) and local governments will be more than necessary.

Smart cities attract people also because of the disposal of flagship universities. When students graduate, they are often likely to stay in the area after their education is complete (Winters, 2011). According to several studies, the reasons behind such decisions are that students have gained human capital including networks with professors and other students, as well as employment experience with local companies. Winters (2011) studied this relationship applied to areas within the same state and not from areas outside the states (the study is USA-based). The results of this research deliver an explanation of the reasons behind the growth of smart cities at least at a first level.

Companies and academic institutions can produce better results when they collaborate to obtain practical applications from academic initiatives. Some examples are the collaboration between the Clemson University International Center for Automotive Research in South Carolina with BMW, connecting researchers with professionals. North Carolina State and Red Hat, the largest open-source software company, maintain a symbolic relationship, sharing resources and creating a "robust ecosystem" between the company and the university. Such a collaboration creates a system that evolves the concept of smart cities to the smart nation (Deloitte, 2017). Therefore, as the report highlights, a new concept—"The Open Talent Economy"—is used when the development of a smart nation and a smart economy are concerned: As technology advances with the increasing mobility of the talent, innovation and education are transforming the concept of work, compelling to the local governments to focus on programs that help build the next-generation workforce, including the millennial generation in a prominent way. This report points out that open data can facilitate business including the availability of talent, skills, and education around the vicinity.

Another example can be found in the case of Rhode Island that suffered high rates of unemployment. The strategy was to define high-impact activities that would help drive economic development. Strong industry clusters were detected, based on emerging technologies, mixing STEM and small- and medium-sized enterprises. The goals were accomplished with a great influx of talent that, in turn, starts, attracts, retains, and grows companies.

One example of smart cities ranking based on education is "The Cities in Motion Index" (CIMI, 2017) that analyses the levels of education and human capital of smart cities. CIMI has been designed with the aim of constructing a "breakthrough" indicator in terms of its completeness, characteristics, comparability, and the quality and objectivity of its information (Berrone and Ricart, 2017). One of the elements that we consider most relevant is that its objective is to enable measurement of the future sustainability of the world's main cities. In other words, the indicators are relevant to the extent that they allow us to manage them.

Employment goes where the talent is—quite the contrary to the past (Lanvin and Evans, 2017). If cities want to retain their "smart" status, as well as their spirit of dynamism and innovation, they need to keep pulling talents from many sectors and provide for a melting pot of their ideas.

Interestingly, according to the Global Cities Talent Competitiveness Index (GCTCI, 2017), these are not necessarily truly global cities that attract the most talent. In the top 10 of the ranking, one can find cities such as Helsinki (third), Gothenburg (fifth), Eindhoven (ninth), or Dublin (10th). In the 2018 edition, the dominance of Europe is confirmed. The authors admit that Europe has a very strong presence in their report due to a broad Eurostat data coverage and availability. The middle-sized cities' dominance does not depend on that, though. The authors underline that especially Nordic cities are so good at introducing and cultivating talent attraction programs that their leading position in the ranking will not be jeopardized even if the number of cities covered is multiplied.

Moreover, even though the Academic Ranking of World Universities, known also as the Shanghai List, has been always dominated by American and British universities, cities of these countries do not dominate the GCTCI. San Francisco (4th) and Los Angeles (9th) reached top 10, but New York is placed relatively low (14th), and Boston or Chicago are not included in the ranking. This situation is repeated in the 2018 edition of the GCTCI, where Washington DC is 6th, San Francisco 8th, but Los Angeles falls to the 13th place, Chicago is 21st, and New York is only 26th.

London also did not perform best and is placed only on the 16th place (Lanvin and Evans, 2017). This may be caused either by the fact that this was just the very first, beta version of the index (and authors remind the readers about this limitation) or by the fear of possible effects of the Brexit referendum. Interestingly, in the 7th edition of Price Waterhouse Coopers' (PwC) 2016 "Cities of Opportunity" study, based on data from 2014 to 15 (before the Brexit referendum), London strongly outperformed other cities in the categories of intellectual capital, innovation, and city gateway (1st) and performed very well in technology readiness (2nd) (Coopers, 2016). The 2017 edition of the report has not been published.

From another angle, MBA students are attracted by a mix of components: international attraction of the city, quality of life, and cost of living. A global survey made by PwC (2012) found that millennial generation (born between 1980 and 2000) are concerned for more in life than "just a job" or steady climb through the corporate ranks.

A recent study (Bofarull, 2017) has detected the challenges cities are facing. For all these issues, the report considers that cities need an actionable metric they can use to predict and measure their ability to attract and retain global, highly skilled talent. The authors of the study introduced a new metric so that they can measure the talent attraction: the number of international full-time MBA students currently enrolled in top business schools as full-time MBA program is generally a tough choice. It requires between 12 and 24 months of full commitment and the cost of opportunity of other incomes during this period. The last ranking shows that the United States still obtains the leading position: Boston is first, New York second, Chicago fifth, San Francisco eighth, and Route 40 North Carolina ninth. The ranking includes also top three European cities in MBA talent attraction: London, Paris and Barcelona, as well as Singapore on the 10th place.

3. Conclusions and recommendations

It is well observed that cities are more pragmatic and policy oriented than nation states, or, as Longworth writes, "there's a large gap between what cities need and what national governments provide" (Longworth, 2015). They are economically vibrant and innovative. Their success is based on financial, human, intellectual capital, and technological flows. They are active in the fields of image building and recognition. As we have discussed in this chapter, the concept of the intelligent city is very broad. Apart from a technological component, it is essential to incorporate human capital within its definition (cf. Visvizi and Lytras, 2018b). Technology allows us to extend human knowledge, expand, and develop it, and this is where talent and the search for talent make sense. As we have already expressed, cities collect much of the economic development of the countries and gather most of their inhabitants, and it is the responsibility of local and state governments to provide them with resources to ensure that the lives of their inhabitants are more than average. In this sense, the improvement of the quality of life of cities in a sustainable way is the goal of smart cities around the world. This quality of life is accompanied by many variables, but talent seems to be key for the readiness for the technological revolution. Cities compete for talent, as a scarce resource, and talent can be considered the new gold or the new oil of this century.

There should be no doubt that the future of cities, societies, and states will be defined by their ability to gain and retain talents. In his best-selling book "*Homo Deus. A Brief History of Tomorrow*" Yuval Noah Harari builds a thesis that the future world, to a large extent, will not witness wars as they will turn obsolete. If any armed conflicts erupt, they will do so in the peripheries and will not be fought by the major global actors. The latter ones will more and more compete over talents, knowledge, and R&D features, and those cannot be gained by weapons but rather by the abilities of powers to attract the brightest of the brightest minds by many different means (Harari, 2017).

What should the cities do to win or at least build leverages in this competition? Following our research, we recommend certain ways to pursue. First, the leaders of the cities need to acknowledge the fact that the competition over talents is real and that it is global. Second, they need to measure their assets, set up their goals—what field does a city want to excel in and what fields it needs to enhance with the help of external talents—and build a strategy around them. Both the leaders and the inhabitants of the cities need a certain level of awareness and a common ground around the issues of what they need talents for. While measuring their assets, cities need to analyze their existing human and intellectual capital, as well as living (including the access to health care and public transportation) and especially educational conditions. Third, leaders need to analyze the additional factors that may play a role for talented people to settle down in their cities, such as the cultural and leisure offerings, flight and roads connections and infrastructure, the openness for diversity, and others. And finally, they need to implement, constantly and consistently evaluate, and adjust their strategy.

The current and future generations will pursue the lifelong learning and reskilling so that they can keep up with the changes in global economy and technologies. This applies also to the leaders and their cities. In attracting talents, they will need to learn and adjust their strategies to new challenges and new conditions on a daily basis. The agiler a city becomes, the bigger its chances in the global game over talents become.

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CHAPTER

Knowledge society technologies for smart cities development

11

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Chapter outline

1. Knowledge society in the new era

The world is immersed in the era of the knowledge society. Unlike the information society, the knowledge society goes further and is able to transform this information into solutions that allow effective actions to be taken to improve society. In such a way, this knowledge society is based on the generation, distribution and use of knowledge to improve the quality of life of citizens.

The technologies that have played an essential role in this development correspond to the area of information and communications technologies—ICT. They are the set of technologies that allow us to interact with the digital world and analyze the data acquired from it. The set of technologies reviewed in this chapter are the new communication technologies, the geopositioning services, and cloud computing paradigm. All of these technologies working in a combined way allow enabling new forms of building the knowledge society.

Currently, there are many applications of the knowledge society in the real world. Perhaps, one of them that has contributed more to the increased of wellness of the citizens is the smart city concept. A smart city can be defined, therefore, as a model of urban management able of responding to the problems and needs of 21st century cities, which arises as a result of the development of the current knowledge society and its technological environment.

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00011-9

There are many smart city applications oriented toward improving the life of citizens (Gilart-Iglesias et al., 2015; Mora et al., 2017; Chen and Tsai, 2018). In this chapter, we put the focus on the urban planning of the city as one of the key processes to handle the sustainable and integrated development of today's cities. The concept of "smart urban planning" (Babar and Arif, 2017) mainly relies on conducting this task aided with new knowledge technologies.

The remaining part of this chapter is organized as follows. Section 2 describes the connection between the knowledge society and new technologies in the governance of cities. Next, Section 3 introduces the smart urban planning concept, and finally, we conclude the chapter in Section 4.

2. Knowledge society and new technologies in the governance of cities

The ICT and the knowledge society have definitely changed the way in which citizens relate to the city (Mueller et al., 2018) and the way in which its management is carried out, and this new way of developing activities in the city also implies a change and modernization of their public institutions. This means, as shown in Fig. 11.1, that the smart city model only makes sense if it is linked to innovation to define a future city project to ensure together, in a balanced manner, the social sustainability—cohesion and social development, the economic sustainability—a competitive economic strategy, the environmental sustainability—awareness and care for the environment, and the accessibility—social integration.

Within this context, it is clear that the concept of city governance requires major changes to respond to the new realities. The knowledge society and the latest technologies play an essential role in the governance of the city and its objective of achieving a sustainable economic, social, and institutional development, by promoting an intelligent balance between institutions, civil society, and the economy market. For this purpose, a smart city model allows governance to progress from its traditional structures to a greater relationship between public institutions and their environment (Meijer and Rodríguez-Bolívar, 2016).

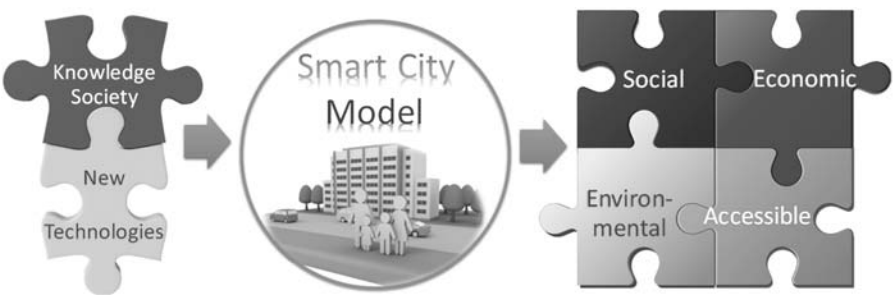

FIGURE 11.1

Smart city model and sustainable urban development.

The possibilities offered by new technologies to maintain an efficient political and administrative structure are well known by public opinion: to facilitate the management of the city among the different administrations or institutions, to optimize the management of services and resources, to speed up administrative procedures and proceedings, to provide citizens with access to basic services, and to promote a sense of citizenship and citizen participation (Hanna, 2010; Lv et al., 2018; Lytras and Visvizi, 2018). In addition, new technologies allow connections for greater political, social, economic, cultural, and ideas exchange with other cities at all levels of government.

In the field of urban planning, the planning and design of cities nowadays cannot be understood without the participation of citizens. Increasingly, an informed citizenry constitutes an active citizenry capable of self-organizing, having an opinion, and making the best decisions about the matters that affect the community. Therefore, beyond the urban development projects' conventional periods of public exhibition established by law, it is necessary to set in motion innovative citizen participation processes before any urban development project has begun its development. The benefits of ICT for this purpose are very important and varied (Alfaro et al., 2017). For example, they can provide citizens with web 2.0 platforms that allow them interact and discuss the projects that should be developed with priority in the city or with citizens' mailboxes in each website to facilitate consultations or suggestions on any matter related with the city, in addition to offering information on any urban project in all its phases of development.

Knowledge is no longer found especially in a given space, and civil society plays an essential role in its production (Cossetta and Palumbo, 2014). People are the main source of information to build knowledge about the real problems and needs of the city they inhabit. It is only necessary to offer an effective channel of communication between citizens and public institutions to obtain, directly and in real time, accurate and up-to-date information about the experience of citizens in the city, the problems they perceive, and their priority (Dameri, 2017).

The latest technologies are the key for developing these communication channels, which must be accessible and simple to use—through intuitive applications for mobile devices, for example—so that they can be distributed among the greatest number of citizens. In this way, it is possible to obtain up-to-date information and build knowledge on any issue that affects the public space in the city: urban accessibility, operation of urban facilities and services, operation of public transport, cycle and pedestrian paths, and needs in specific environments such as schools or parks in certain time bands. In addition, involving citizens in solving the problems of the city allows neighbors to identify with their neighborhood and feel it as their own, preventing its abandonment and long-term deterioration (Jaššo and Petríková, 2016), which also means the improvement of the relationship with the nearby neighborhoods and with the rest of the city. The democratization of urban planning and the active citizen participation processes are mechanisms against exclusion and for social development (Pearce, 2010).

Therefore, the commitment to social cohesion finds an important space in the city of the knowledge society, where citizens interact by developing more participative and interactive dynamics, with each other and with the city, thanks to technology, even allowing their habits, preferences, and positioning are known. Knowing citizen traceability, i.e., the level of use that citizens make of public space—what obvious and not-so-obvious places they use to develop a specific type of activity such as running, riding a bicycle, or doing other sports—allows, for example, the inclusive spaces of a city to be identified, i.e., the spaces used by all people regardless of their abilities or profiles, as well as learning from these spaces to serve as urban design models (Pérez-delHoyo et al., 2017). This information allows for better planning of the city, not only respecting those habits and preferences but also discovering new singularities and opportunities. These initiatives set in motion management dynamics within the context of the smart city that contribute to social cohesion and the empowerment of citizens.

On the other hand, knowing the habits and preferences of citizens helps us to plan and design the smart city (Mora et al., 2015; Lenormand and Ramasco, 2016). The role of citizens has changed definitively by participating in what researchers have started to refer to as an "urban planning of ideas." For this purpose, the virtual space is a new social space, and specialized social networks are a very powerful source of information.

But the city of the knowledge society can go a step further, by adapting itself to citizens instead of citizens having to adapt to the city. The latest technologies allow citizens to be identified when they approach an urban environment and transform some of its elements—such as traffic lights, information panels, or others—to facilitate the use of these environments by citizens according to their abilities (Pérez-delHoyo et al., 2016). All these initiatives are part of the smart city project, thanks to technology (Etezadzadeh, 2016).

In short, in the field of cities' government, it is a need to humanize the smart city concept and work on initiatives that relates to the citizen as a receiver of actions that improve quality of life and serve to acquire information for planning and designing smart cities. In this way, it is a challenge for the government to move toward a type of city that could be called "citizen-centric smart city", in which a circular relationship between administrators and citizens is built to improve their quality of life, focused on their needs, habits, and preferences. Fig. 11.2 illustrates this idea.

3. Technologies for smart urban planning: a citizen-centric approach

From the point of view of urban planning, the smart city is a new urban model based on knowledge in a deep research exploration and a wide application of the latest information and communication technologies (Kummitha and Crutzen, 2017).

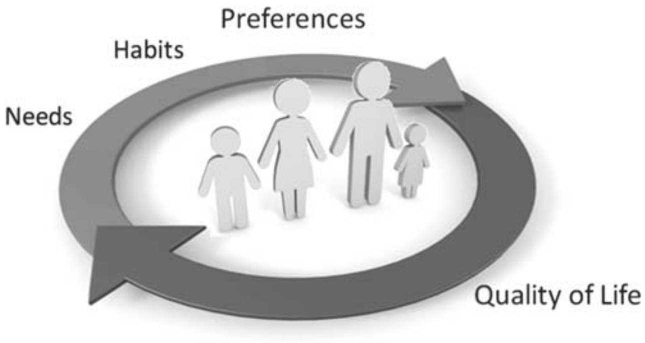

FIGURE 11.2

Citizen-centric smart city.

An urban development model aims to solve real problems and needs and pursues specific objectives and strategies. It is the reflection of the evolution of a society and draws a vision for the future city by answering the questions: what kind of place do we want the cities to be? and how should the goal of quality of life be defined? (Saaty and De Paola, 2017).

As already mentioned in previous section, the smart urban planning concept, within the context of smart city, cannot be understood without citizen participation. The knowledge society and the latest information and communication technologies have transformed the traditional meaning of citizen participation, by placing people at the center of planning, design, and management of the cities of the future (Castells, 2011). Consequently, we are witnessing a reformulation of the urban planning paradigm (Landry, 2016; Marsal-Llacuna et al., 2011).

Urban planning becomes a process where the city learns from itself and from the people's habits, needs, and desires. A process that uses the imagination and collective intelligence of citizens cocreate and shape the city of tomorrow. This citizen-centric approach is critical for the future of urban planning within the context of smart city.

A wide and proper use of technology is essential for urban planning to push ahead in this direction. The new information and communication technologies, the geopositioning services, and cloud computing paradigm offer new opportunities for cities to be smarter and more sustainable. Fig. 11.3 schematically draws this idea.

This recurring idea is discussed in this section. The discussion is conducted by the analysis of some current approaches and the study of some real cases on how technologies can improve urban design and planning processes.

One of the core urban initiatives in which technologies have facilitated new opportunities has been to give citizens a voice to express their opinion on the projects that are carried out in the city. For this purpose, ICT provide institutions with open public debate spaces on the internet where citizens, anonymously or as registered users, can comment and contribute ideas to improve their city. Good examples of these initiatives are some projects developed by some municipalities

FIGURE 11.3

Key technologies in urban planning for smart city.

in Portugal: the e-Democracy Service supported by a Geographical Information System—GIS—developed for the public discussion of Oporto's Municipal Master Plan (Oliveira et al., 2004) and the use of an interactive discussion map for public discussion of Lisbon Master Plan (Pina, 2012). In both projects, GIS technologies have served to drive public participation processes.

Geographic Information Systems in Public Participation—PPGIS—is an area with an increasing importance in the context of Geographic Information Science. These technologies have been used on a larger scale for a large number of different and varied projects, for example, to elicit information on outdoor places important to citizens in Wiltshire, England (Ridding et al., 2018); for the environmental planning and management of Mt. Baker-Snoqualmie National Forest in western Washington, USA (McLain et al., 2017); and for analyzing how landscape values are perceived by citizens in different areas of Europe (Garcia-Martin et al., 2017), among many others participatory mapping studies. The relationship between GIS and the knowledge society has allowed participatory mapping methodologies to be implemented. Mapping exercises are capable of providing communities with useful information.

Processes for informing citizens in real time about the number of urban opportunities in a particular urban area, i.e., information on shops, facilities and services available, cultural routes and itinerary,es, up-to-date traffic or public transport information, are also possible, thanks to ICT technologies. Knowing this information allows citizens to make smarter use of the opportunities offered by a city, reduce transport times, and use the appropriate services at any particular time. This intelligent use of the services and resources of a city is more in line with the principles of sustainable urban development. Processes for informing citizens have been mainly based on the calculation of close relationships and intensities of use, and they have been primarily supported by Global Positioning Systems technologies—GPS—for positioning and GIS technologies for displaying data and spatial analysis.

There are many projects recently developed in this field, for example, a smart decision support system determining the most efficient way to plan the tourist itineraries. Operations are managed through a mobile app/website. The system was implemented in the city of Melbourne, Australia (Bagloee et al., 2017). Another recent initiative funded by the German Government is about providing citizens with personalized, context-aware intermodal travel information. The aim of the initiative is to enhance travel information systems by analyzing the available itineraries to better suit the traveler, based on his personal preferences, context information, and popular selections (Samsel et al., 2016).

On the other hand, urban geospatial data allow local industry and public institutions to develop applications that improve life of citizens. Therefore, the management of geospatial data is a big challenge for smart cities. Emerging technologies such as Semantic Web technologies to build up relations and connections between concepts, or open data web applications with well-performing search engines, can help public institutions to contextualize geospatial data by transforming the general information into useful knowledge. This knowledge will enable citizens, businesses, and public institutions to codesign new public information services to participate and understand what is going on in their city. In addition, geospatial data and open data are often used within the context of big data (Wu et al., 2018). Therefore, the use of cloud technology is almost mandatory. In line with this approach, some projects have been developed, for example, the European Union funded Project Smarticipate (Smarticipate Project, 2018), which is driven by the pilot cities of London; Britain; Rome, Italy; and Hamburg, Germany, with the aim of empowering citizens and businesses and fostering their involvement in the city's governance system. The development of iterative processes in the field of the participatory urban planning and user-centered design of applications are some of the actions that have been carried out (Vogt and Fröhlich, 2016).

Moving on to other issues, the knowledge of the people's habits, preferences, needs, and desires is an essential factor for the smart urban planning within the context of smart cities. The study of urban places preferred and citizens' movement patterns supports a better understanding of modern cities and enables a more comprehensive strategy for urban planning (Mora et al., 2015).

In line with this overall vision, a wide range of studies has been developed, for example, using GPS and mobiles devices to analyze the movement patterns of taxis between different urban areas in Beijing, China (Chen et al., 2017); the sociospatial and temporal complexities of older adults' mobility in Metro Vancouver, Canada (Franke et al., 2017); or the spatial behavior of backcountry skiers in Tatra National Park, Poland (Taczanowska et al., 2017). The large development of ICT allows us to interact with an urban environment providing a huge amount of data and information about the cities we live in (Bohn et al., 2004). In these cases, the cloud is an essential tool for conducting advanced data analytics (Babar and Arif, 2017).

Internet of things (IoT) devices, smart phones location data, and smart cards data have been used in a large number of urban planning initiatives within the context of the hyperconnected society and the big data phenomenon. Big data has aided understanding of human mobility (Lu et al., 2017). For example, to explore the spatial distribution and density of recreational movement in multiple-use urban forests in Helsinki, Finland (Korpilo et al., 2017) or the bike-sharing travel patterns and purposes in New York City (Bao et al., 2017). Much research on Geo-IoT technologies has been conducted even to described future scenes (Kim, 2018).

The study of the citizens' mobility has seen significant growth due the prevalence of mobile devices. By combining these data with the city's points of interests, both travel patterns and purposes can be known. Increasingly, the methods for addressing the aspects that affect the functioning of the city are based on evidence, i.e., in the study of the citizens' behaviors. For this purpose, many methodologies have been developed, for example, to improve urban accessibility for people with disabilities, a computational method based on new communications technologies (Gilart-Iglesias et al., 2015; Mora et al., 2017). The means of public transport—trains, buses, and bike sharing— are also being continuously monitored with sensors that send important information about urban routes, travel times, and traffic intensity to the cities' governments. A good example of this trend is the information system on the public transport of London, Britain (Ferrari et al., 2014).

Actually, these participatory processes based on the analysis of urban dynamics are part of a challenging field of research to improve urban planning. To this end, some recent studies identify trajectories from origin-destination data and potential development axes (Bahbouh et al., 2017) and propose new algorithms to extract knowledge, i.e., patterns, rules, and regularities, from user trajectories (Cesario et al., 2017; Qian and Lu, 2017).

On another level, sensor networks allow cities to monitor their environmental conditions and, therefore, not to make the mistakes of the past and move toward more sustainable development models. Environmental pollution monitoring is a major concern in the development of smart cities. Indeed, the World Health Organization launched the Global Platform on Air Quality and Health, for governments to collaborate in the development of strategies to reduce air pollution. Within this program, a lot of actions have been conducted. A recent example is the monitoring environmental parameters in the city of Pisa, Italy (Bacco et al., 2017). Urban noise has also been properly monitored to obtain useful information for urban planning. A good example of this initiative is the experience developed in the city of Dublin, Ireland (Alfaro Navarro et al., 2017).

FIGURE 11.4

Knowledge sources for understanding city needs.

However, as drawn in Fig. 11.4, the knowledge needed for city planning includes the physical, social, cultural, technological, and economic domains and incorporates multiple perspectives, such as the understanding of social and cultural dynamics and needs, to create new knowledge.

A good deal of recent research concerns locative social networks as open sources of data to acknowledge which city places are preferred, used, and liveable. Some of these studies propose methodologies, for example, to identify city's successful public spaces through the location-based social media network Foursquare (Martí et al., 2017); to discover popular tourist attractions within the urban areas through the Flickr geotagged images (Peng and Huang, 2017); or to depict urban boundaries with geolocated Twitter data (Yin et al., 2017). The generation of data and communication to the social network is usually done automatically through users' mobile devices, such as smart phones and other wearables provided with GPS technology.

In regard to this valuable information for the planning of cities, an important issue to be taken into account is how to show the data retrieved from different sources. Many studies focus on how visualization of social network data allows researchers and professionals from the field of urban planning to explore the relationship between citizens' movements and activity distributions all over the city (Zeng et al., 2017). For smart urban planning, it is essential to understand the relationship between activities and human mobility. Given the pace of technology and the current use of mobile phones, there is a large amount of data that can be used to create high reliability models. In this regard, some of the studies referred to above propose novel data representations such as graphs to characterize spatial and temporal people mobility (Wu et al., 2017). In addition, some studies propose visual analytics systems to measure opinion propagation, for example, among Twitter users (Xu et al., 2013), and others focus on the analysis of urban emotions (Resch et al., 2015, 2016).

Comprehensive systems and solutions for smart urban planning and smart strategies for developing more resilient and sustainable cities (Falco, 2015; Mora et al., 2017; Visvizi and Lytras, 2018) have been proposed over the past few years. This has become a growing trend, and therefore, in a near future, other systems and solutions for smart cities will be suggested. All of these smart initiatives, which are aimed to help cities for a more sustainable development, are without a shadow of a doubt the result of the joint efforts and collaboration of different fields of knowledge.

4. Conclusions

The accelerated technological development in recent years has transformed the way of living and understanding the world. As a consequence, the current knowledge society and its technological environment have brought profound social and economic changes.

Today's cities need to position themselves in a competitive global context and they have to assume a new lead role. The current context opens new possibilities for city development and allows adopting modern strategies to address their challenges. In this sense, the concept of smart city represents a model of urban development base on smart application of technology. To become it, cities may face a new key challenge, which is to begin incorporating technologies as a part of the urban organism. The concepts of ubiquitous and smart cities make use of processing technologies, sensing, and communications to provide intelligence to the city, while offering connectivity resources, power supply and interoperability. These conditions facilitate the deployment of interconnected smart elements that provide services to citizens for efficient decision-making and to make better use of resources. To consolidate this smart urban model, a commitment is required from the responsible for management and city government.

Definitely, new technologies and communications solutions have revolutionized the way of knowing cities and, consequently, the way of planning and designing cities. Communication technologies, geographic information systems, and cloud computing paradigm are some of the most relevant technologies, which currently help cities move toward a smarter, more sustainable, and inclusive development model.

Acknowledgments

This work has been funded by the Conselleria de Educación, Investigación, Cultura y Deporte of the Community of Valencia, Spain, within the program of support for research under project AICO/2017/134.

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CHAPTER

How can artificial intelligence respond to smart cities challenges?

12

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Chapter outline

1. Introduction

Nowadays more than half of the world's population lives in urban areas, and it's estimated a 23% increase by 2050, which could add more than 2.5 billion individuals dissipated among cities and megacities (United Nations, 2018). This rapid urbanization led to serious problems such as pollution, traffic, security and privacy issues, and even crime. These all create demand for smart cities solutions. Therefore, cities will be more pressured to provide better quality services, increase efficiency and diminish associated costs, increase the level of productivity, and address congestion and environmental issues. All these pressures will motivate cities to become *smart* and to develop and implement various *intelligent* solutions to increase their competiveness and achieve sustainable development and growth. In the last years, even the smart cities research evolved to a multidisciplinary field; computer science and engineering are still their basis (Lytras and Visvizi, 2018).

Artificial intelligence (AI) is a promising concept for smart cities development because they have a wide variety of technologies that can be integrated to improve

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00012-0

citizen life, economic competitiveness, and environmental conditions. The most advanced technologies such as robotics, natural language processing (NLP), machine learning (ML), voice recognition, image recognition, etc., should help to find solutions for pollution, equal access to education and services, traffic congestion, poverty, criminality, etc., and to ensure a sustainable development of cities. This chapter identifies the main challenges associated with smart cities development and explores how AI technologies can serve as tools to address/preempt related risks.

The chapter is structured as follows. The next section presents the main challenges of smart cities. The third section reviews the definition and branches of AI technologies as well as the domains or the activities where these are used. The fourth section assesses the applicability of AI to overcome the smart cities challenges. Conclusions and recommendations follow.

2. Main challenges in implementing smart cities solutions

Increased shifts of the population from rural to urban areas require that smart cities reconsider how they can provide a better and improved quality of life for their citizens. Although, smart cities produce most of the global GDP, not everything happening within these agglomerations implies positive externalities (Monzon, 2015). As cities continue to grow, the challenges associated with rapid and unplanned urbanization will be more severe. This way, smart cities challenges must be taken into consideration in an integrated way so that they become better places for living, working, and interacting. A comprehensive framework has been developed to assess the most important challenges in implementing smart cities solutions, which enable tools such as ML, deep learning, big data, and other AI technologies to enhance the quality and efficiency of services and resources. Each framework dimension is in close relation to the smart cities action fields (Giffinger et al., 2007). Table 12.1 presents these dimensions and related challenges in smart cities development that may affect more than one action field.

Budgetary constraints represent an important challenge in implementing, maintaining, and even improving smart cities solutions. The development of smart city in general, and smart economy in particular, needs the procuring of funding instruments and procurement schemes adequate for city challenges in accordance to citizen's needs. Smart cities may require the adoption of new technologies, safety and security features, and intelligent solutions to address issues such as air pollution or waste management, which may prove to be too costly for the local governments to implement. The lack of finance may turn out to be an obstacle in finding and implementing smart city solutions. Finding the proper financial tools to create smart cities may help reduce costs, maximize revenue potential, and improve the quality of life for citizens. Overall, cities can adopt a diversity of approaches to finance smart city projects/solutions as such: debt instruments (commercial banks, municipal bonds, etc.) and funding sources (property taxes, tolls, and user charges, etc.). Efficient smart cities development requires besides financial costs analysis, a financial evaluation of the risks involved, hidden and unforeseen costs, in conjunction with

Table 12.1 Dimensions of smart cities and related challenges.

Challenges	Dimensions					
	Smart economy	**Smart mobility**	**Smart people**	**Smart living**	**Smart governance**	**Smart environment**
Budget constraints	x					
One-size-fits-all approach	x			x	x	x
Digital skills and curriculum reforms			x			
Security and privacy problems				x	x	x
Citizen's inclusion		x	x	x	x	
Governance and regulatory framework					x	x
Traffic congestion		x				
Pollution		x				x

Source: Author's elaboration.

financial solutions (European Commission, 2017). Financial burden associated with successfully achieving smart cities goals can be alleviated by means of private capital, public-private partnership, or public investment.

One-size-fits all approach implementation may result in resources wastage and smart projects failure. Nowadays urban agglomerations may face many challenges as such: "traffic congestion, inadequate energy, lack of basic services, informal dwellings, poor management of natural hazards, crime, environmental degradation, climate change, poor governance, urban poverty, informal economy, and unplanned development" (World Economic Forum, 2016). These issues are common in many economies such as India, China, and Europe. However, there is no single and universal solution for intelligent cities. For instance, in one of the most agglomerate urban area from North Island, a big data traffic solution has been implemented, which allows to obtain real-time insights on traffic movements and support quick decision-making to improve mobility and traffic congestion (World Economic Forum, 2016). What may work in one country can prove not to be suitable in other. Every country has its own strategic vision of the city development based on the related context, culture, and economy. Therefore, developing smart models for urban areas should include specific requirements for each society. European Commission (2016) developed a five-step approach to city planning, which includes strategic vision of the city's development, SWOT analysis, defining strategic goals to develop the city, measurable indicators of city development, and smart city road map. All these steps must be completed to implement an adequate smart solution, from defining a coherent and shared strategic vision down to establishing the city needs, to initiative road map definition.

Smart cities development in general, and smart people in particular, requires the *integration of special digital skills and curriculum reforms* in all educational levels. Labor market driving shifts and industry disruption are affecting a great number of sectors and are causing changes in jobs and demand for highly competitive individuals. Highly trained workers capable to operate the infrastructure of smart cities are needed. The demand for information and communication technology (ICT) professionals "has constantly increased during the last decade, yet digital skills are lacking in Europe at all levels," and "by 2020 the number of vacancies in the ICT sector is expected to almost double" (European Commission, 2016). As more and more cities are trying to become "smart" it's critical that individuals get the skills and training they need to fill this gap. Smart cities workforce must have strong technological capabilities, be able to apply increasingly *sophisticated* techniques, and be able to develop new systems. Digital advances and technological trends have changed not only the learning behavior of individuals but also the teaching methods, to meet the requirements of the labor market. Individuals with adequate digital skills are vital for developing and using smart technologies. Constant improvements and reevaluations of the existing curriculum in all educational levels have to be implemented to respond to the continuous changes brought up by advances in technology (Hüsing et al., 2015).

Security and privacy problems are critical and very important challenges for several smart cities action fields. Smart cities are complex environments where billion of interconnected cyber-physical devices and processes generate huge quantities of data (Georgescu and Popescul, 2016). Much of these data have to be collected and manipulated in real time, which brings new threats regarding data confidentiality, integrity, accessibility, protection, and privacy. In the literature five major vulnerabilities of digital technologies in smart city have been identified: poor software security and data encryption, insecure legacy systems and poor maintenance, domino effect as a result of the interdependencies between smart city technologies and systems, many interdependencies and large and complex attack surfaces, and human error and deliberate malfeasance of disgruntled actual- or ex-employees (Kitchin and Dodge, 2017). These vulnerabilities are increased by some interrelated causes: lack of financial resources in the public sector, lack of ICT specialists who are more motivated to work in private companies, lack of cyberattack emergency plans (Cerruto, 2015), and lack of culture or vision in this field. The authorities must ensure the regulatory framework and inform providers and citizens about the obligations and risks associated with the technologies used.

Another challenge for implementing smart cities solutions is the *direct and active implication of all citizens.* Social inclusion programs are needed to make services accessible to all, to value people's needs equally, to have a representative voice in governance, and to improve the overall standard of living (affordable prices for housing and basic services, assistance of disabled citizens, etc.). The lack of implementation of social inclusion strategies may affect more than one action field as they are targeted toward attracting and retaining talented individuals, reducing barriers in social learning and participation, and allowing citizens to actively be involved in the decision-making processes, influencing public policies and programs in a way that impact more positively their social and economic lives (Khan, 2006; Visvizi et al., 2018). "Smart cities are not only about ICT, energy and transport infrastructures: Smart cities are about smart citizens, who participate in their city's daily governance, are concerned about increasing the quality of life of their fellow-citizens, and about protecting their environment" (Craglia and Granell, 2014). The technologies should be accessible for all citizens, including the poor, the disabled, the elderly, and other vulnerable people (Kharas and Remes, 2018). Citizens have to be motived and rewarded to get involved in all changes (Lytras and Visvizi, 2018) even if the final decisions remain with public authorities.

New or adapted regulations that fit with the changes in technologies are also an important challenge for smart cities success (smart governance) as they may help create an attractive environment for living (smart environment). The acceleration of technological innovation generates a constant need to review the regulatory framework. A huge quantity of data about citizens, institutions, services, and companies is captured, stored, and manipulated in virtual space. In this context, an important question is: "what kind of regulation is appropriate" (Kozlov et al., 2012) to protect citizens and to use these information for their benefit? Periodically, vulnerabilities are identified. The unauthorized surveillance and uncontrolled data generation and use are two aspects that must be corrected and regulated in the digital world and, implicitly, in smart city (Caron et al., 2016). The use of AI for a large number of activities and services in smart city creates also reasons for debate on legislation. The regulations have to consider rights and responsibilities both for users and developers, not just setting the limits but also removing legal and regulatory barriers that impede proper and easier implementation of smart city initiatives (Chourabi et al., 2012).

Achieving a *sustainable and efficient mobility system* available for all citizens, which permits the *reduction of traffic congestion*, represents another important challenge. Identifying the transportation challenges and addressing *the traffic congestion* issues in a smarter way implies the implementation of a multimodal public transport system, stimulates mobility alternatives that encourage CO_2 emission reduction, and creates a public transport reachable and accessible for all individuals (Monzon, 2015). Increased traffic flows represent an important challenge for most smart cities, and it requires physical infrastructures supplemented by creative thinking and the use of advanced technologies. To address the traffic congestion in a smarter way, a central control hub has been used to supervise the flow of the traffic and adjust the traffic lights accordingly to the movement of vehicle and automatically administer penalties for traffic violations and speeding (Dodge and Kitchin, 2007). Alongside adaptive traffic signals, other smart cities technologies (e.g., smart corridors, autonomous vehicle technology, real-time traffic feedback, etc.) can be utilized to combat the negative effects of traffic congestion, which may damage citizen's health and the environment.

Smart cities solutions implementation may lead to *increased pollution and energy consumption*. Although smart cities bring multiple social and economic benefits, these agglomerations may also generate negative externalities. Because of high urban concentration, cities are big centers of consumption, gas production, and emission of pollutants and waste, which puts an enormous pressure on the environment in terms of climate change, resource use, and protection of natural environment. For instance, city dwellers in developing countries have higher per capita energy use than those in rural areas. Also, "an urban dweller in New York consumes approximately three times more water and generates eight time more solid waste than a resident in Bombay" (Schubel and Levi, 2000). Smart cities solutions implementation must be directed toward pollution reduction and enhancement of the environmental quality.

3. Artificial intelligence: branches and applications

AI is a set of computational technologies that attempt to simulate, extend, and expand the human intelligence (Niu et al., 2016). It has been studied in academia and practice for over 6 decades. Significant advances have been made, especially from the early 21st century. Its progress is assigned to the improvement in the processing capacity, creation of new connections between AI and other fields with similar problems, massive data volume, diversification of the problems faced by society, and the need to find solutions to automate their solving (Niu et al., 2016; Lu et al., 2018). AI includes more branches with applicability in various fields (Table 12.2).

A smart application could use several AI technologies. They should be able to make quick decisions in real time and according to real situations. AI is considered to be divided in to two major types: weak AI and strong AI. The first type solves

Table 12.2 Branches of artificial intelligence (AI) and their applications.

Branches of AI	Applications	
Machine learning (deep learning, supervised and unsupervised)	• Virtual personal assisting • Traffic predictions • Online transportation networks • Videos surveillance • Automatic recognition of facial expressions	• Online customer support • Search engine result refining • Product recommendations • Online fraud detection • Email spam and malware filtering • Cancer prognosis and prediction, etc.
Robotics	• Students' education • Review cases and advice appropriate sentences • Patient care • Minimally invasive surgery • Wearable devices for mobility restoration	• Implantable devices to treat conditions following illness, trauma, surgery, or age-related degradation • Virtual reality devices that offer realistic tactile and physical interaction sensation, etc.
Natural language processing (content subtraction, classification, machine translation, question answering, and text generation)	• Machine translation • Automotive virtual assistant • Sentiment analysis • Part-of-speech tagging • Clinical document improvement	• Interactive interface • Text classification and categorization • Computer-assisted physician documentation • Customer service • Diagnostic assistance, etc.
Planning and scheduling	• Development of the transportation network • Economic planning	• Resources Planning • Traffic management • Autonomous industry transportation, etc.

Continued

Table 12.2 Branches of artificial intelligence (AI) and their applications.—*cont'd*

Branches of AI	Applications	
Expert systems	• Diagnosis and troubleshooting of devices and systems • Financial decision • Process monitoring and control	• Generate alternative solutions to problems • Productivity analysis • Control physical processes based on monitoring, etc.
Speech recognition (speech to text and text to speech)	• Translation of spoken language into text • Medical documentation process	• In-car systems • Fighter aircraft • Training air traffic controllers, etc.
Vision (image recognition, machine vision)	• Person identification • Audio-visual emotion recognition • Human actions in recognition • Visual object tracking	• Text recognition in scene images • Classify vehicles in traffic scene images • Facial expression analysis, etc.

Based on, Rossiter, J.M., Hauser, H., 2016. Soft robotics — the next industrial revolution? IEEE Robotics and Automation Magazine 23(3), 10–20; Medium Corporation, 2017. 9 Applications of Machine Learning from Day-To-Day Life. https://medium.com/app-affairs/9-applications-of-machine-learning-from-day-to-day-life-112a47a429d0; Asia Business Council, 2017. Artificial Intelligence in Asia: Preparedness and Resilience. http://www.asiabusinesscouncil.org/Research17_AI.html; Madhavan, R., 2018. Natural Language Processing — Current Applications and Future Possibilities. https://www.techemergence.com/nlp-current-applications-and-future-possibilities/; Król, A., 2016. The application of the artificial intelligence methods for planning of the development of the transportation network. In: Rafalski, L., Zofka, A. (Eds.), Transportation Research Procedia, vol. 14. Elsevier, pp. 4532–4541; Mills, M., 2016. Artificial Intelligence in Law: The State of Play 2016 (Part 1). http://www.legalexecutiveinstitute.com/artificial-intelligence-in-law-the-state-of-play-2016-part-1/; Peng, Y., Yin, H., 2018. Facial expression analysis and expression-invariant face recognition by manifold-based synthesis. Machine Vision and Applications 29(2), 263–284.

certain problems that could be solved previously only by the human mind (Wang et al., 2018). Strong AI or artificial general intelligence (AGI) is "the ability to achieve complex goals in complex environments using limited computational resources" (Goertzel, 2008). Smart applications and smart devices should have the following characteristics to transfer learning from one domain to another: autonomy, the ability to understand the problem not only solving problems posed explicitly by programmers, self-understanding ability and of others, and the capacity to solve problems unknown to the programmers (Goertzel, 2008; Muehlhauser, 2013). Complex environments, such as smart cities, with many heterogeneous interconnected objects need AGI because it offers a unified platform to support the fusion of objects.

4. How artificial intelligence can answer challenges at various levels of smart cities

4.1 Applications areas of artificial intelligence in smart cities

AI technologies have the potential to transform cities into sustainable smart cities. They play an important role in making cities and citizens safer, transport smarter, and urban planning optimal. AI allows to collect massive volume of data sets, using a variety of data sources and a high velocity for the purpose of supporting decision-making, forecasting possible future events, and making recommendations. AI can be used to provide a whole range of economic and social benefits from traffic congestions and parking up to energy, health care, and security, changing the way citizens interact on daily basis, how they work, and live. The most important areas of AI in smart cities are presented in Fig. 12.1.

1. *Smart home:* AI technologies could improve citizens' lives and optimize the resource allocation (energy-saving initiatives). There are several applications directed toward the development of energy efficient homes and intelligent building systems. Artificial neural networks (ANN) have been extensively utilized to predict building energy consumption and to reduce power consumption by studying human behavior patterns (Badlani and Bhanot, 2011). Ambient assisted living has been used to provide safe, high-quality, and independent lives for the frail and elderly (Caballero-Gil et al., 2018). Others examples of AI use in smart homes are intelligent vacuum cleaners, smart refrigerators, and smart systems for surveillance and monitoring.
2. *Health care:* In the health-care sector, AI may assist physicians with differential diagnosis of diseases, helps monitoring patients' vital signs at home, improves drug compliance, perform a rapid search within the patient medical records, and provides other possible treatment options (Dilsizian and Siegel, 2014). In addition, AI technologies can be used for automated image diagnosis, dosage error reduction, virtual nursing assistance, assisted surgery, improving data analysis in clinical trials and scenarios, etc. (Peek et al., 2015).
3. *Governance:* AI is used in governance to ensure the provision of intelligent services and a smart, more efficient, transparent, and inclusive public administration. AI can be applied in postdisaster reconnaissance and identification and prioritization of affected areas, for predictive maintenance of public infrastructure, to monitor weather and environment (smarter planning, prediction of safety measures), to assure a smart and wireless public transportation, to allow citizens to actively be involved in the decision-making processes, influencing public policies and programs by creating big data platforms, for classifying legal norms with rule-based technologies, etc (Abood and Feltenberger, 2018; Waltl et al., 2017).
4. *Education:* AI is used to enhance education at all levels by making classrooms smart, widening the access to educational system, increasing the diversity of learners, and providing personalization at scale (Popenici and Kerr, 2017). Some examples are intelligent tutoring systems, virtual human-like characters facilitators, personalized learning, etc.

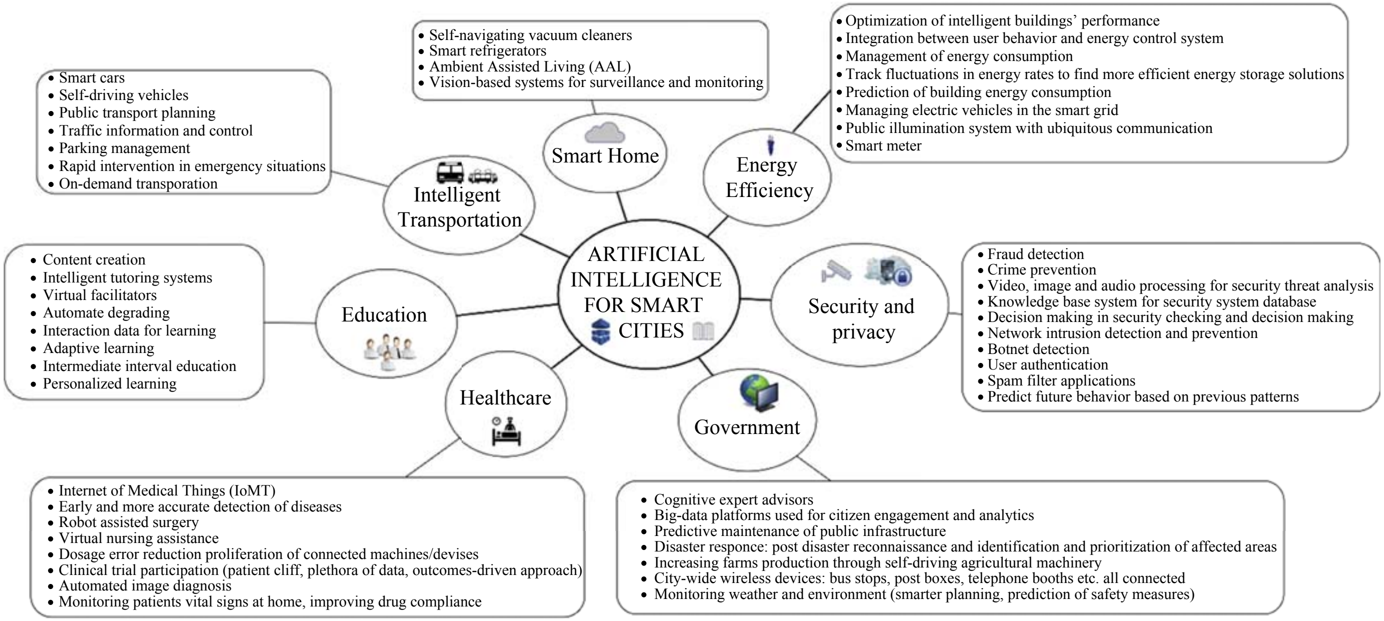

FIGURE 12.1

Artificial intelligence for smart cities.

Source: Authors' elaboration.

5. *Security and privacy:* AI can play an important role in improving security and privacy in smart cities. Some application may include fraud detection, crime prevention, video, image, and audio processing for security threat analysis, secure user authentication, botnet detection, and so further (Alauthaman et al., 2018).
6. *Intelligent transport:* Several authors show that AI can play a significant role in developing a more efficient intelligent transport system in smart cities (Agarwal et al., 2015). AI is used for design, construction, maintenance, and time scheduling of transport system, on-demand transportation, for resolving transport problems faster and more efficient (e.g., huge amount of data processing, provide real-time reports on traffic accidents, to predict traffic conditions, to provide rapid intervention in emergency situations, etc.) (Voda and Radu, 2018).
7. *Energy efficiency:* AI offers several opportunities to improve energy efficiency, reduce energy costs, and enhance sustainability. For instance, hybridized algorithm and network-based fuzzy inference system have been used to enhance accuracy in predicting, improving, and managing energy consumptions in buildings (Li et al., 2011). Among others, AI can also be used to track fluctuations in energy rates to find more efficient energy storage solutions, for the public illumination system with ubiquitous communication, optimization of intelligent buildings' performance, and managing electric vehicles in the smart grid.

4.2 The role of artificial intelligence in effectively addressing the challenges of smart cities

Nowadays, smart cities are confronted with important challenges in implementing smart solutions namely budget constraints, finding the appropriate solutions and developing their own strategic vision of the city development based on the related context, culture and economy (*one-size-fits-all)*, security and data protection, citizens' inclusion, regulatory framework, lack of digital skilled labor force, increased traffic congestion, and pollution. To solve these urban problems and provide an intelligent infrastructure, smart cities need cutting-edge techniques such as ML, deep learning, NLP, and other AI technologies that enhance the quality of the services provided, assure a more optimal resources allocation, and enhance the overall quality of life for its citizens. AI can be used to overcome the main challenges associated with smart solutions implementation as such:

> *First, AI can help low-resource communities and increase GDP level worldwide.* Beyond education, AI can be used to assist communities with low resources by means of providing mitigations and solutions to a diversity of social problems. For instance, ML and data mining have been used by public agencies to increase distribution of food efficiency (Stanford University, 2016). Additionally, AI has the potential to transform productivity and enhance GDP worldwide through (1) productivity gains from businesses automating process generated by the use of latest augmented intelligence technologies and (2) increased consumption, due to highly qualitative, tailor-made, and more affordable products (PwC, 2017). McKinsey Global Institute report (2017) analysis reveals that "automation could help serve as a new productivity engine for the global economy, bridging that economic growth gap."

Second, some AI technologies could be used in all smart cities. One unified model of a smart city development does not exist. Each country and culture has its own methods and models of success. But the same AI technologies could be used to solve similar problems in all smart cities. Examples of these technologies are robots or applications to help people with medical problems, some applications for environmental monitoring and for prevention of natural disasters, technologies for smart home, etc. But while some technologies can just be implemented, other AI techniques need to be adapted (e.g., predictive models to address problems such as lead poisoning are necessary in the cities where public health is threatened by this) (Stanford University, 2016).

Third, the use of AI in the educational sector may close the educational gap. AI implementation in education brings an enormous potential for widening access to educational system and increases the diversity of the learners' population. Through the utilization of NLP, ML, and crowdsourcing, AI enhanced education at all levels, especially by allowing the participation of an enlarged number of learners and by providing personalization at scale. This flexibility can facilitate a better integration for nontraditional learners and provide a more diverse training portfolio. For instance, human—AI interaction has been used to help individuals with disabilities and to augment the implication of learners and teachers in a more engaging process (Popenici and Kerr, 2017). Robots can effectively interact with humans as having the potential to retain learner attention and to deliver tailor-made teaching experiences for the users, which in turn generate lasting learning (Timms, 2016). For instance, MOOCs (massive open online courses) represent an important educational outcome, resulted through the use of AI and data mining. Data mining was used to improve "the understanding of MOOC ecosystem and enable practitioners to deliver better courses, while AI, supported by data mining, improved student experience and learning outcomes" (Fauvel and Yu, 2016).

Fourth, the use of AI can improve security and privacy problems. "If we detect 90% attacks today, new methods will be invented tomorrow" (Polyakov, 2017). The necessary time to solve a cybersecurity problem is still quite long: The companies take roughly 146 days to fix critical vulnerabilities that hackers exploit on a few minutes of their appearance according to industry research (Talwar and Koury, 2017). In this context, the need to find the best solutions in the shortest time becomes imperative. ML, image recognition, or NLP have been used to improve the cybersecurity in smart cities. They are used for spam filter applications (Awad & ELseuofi, 2011), fraud detection (Necula, 2017), network intrusion detection and prevention (Roy et al., 2017), botnet detection (Alauthaman et al., 2018), secure user authentication (Patel et al., 2016), etc. AI is very effective because patterns and anomalies have to be identified in vast amounts of data in the case of smart cities. Nevertheless, AI technologies are used not only in the virtual environment but also for crime solving and preventing illegal acts. ML, for example, enhances the ability to predict the place and the moment where crimes are more likely to happen and who may commit them (Stanford University, 2016). The existence of this huge volume of data in smart cities is also an advantage for AI. The main characteristic of these applications is their capacity to learn. The more the information they receive, the smarter they become. AI technologies not only solve the security and privacy problems in smart city but also improve the existing solutions or may offer new ones.

Fifth, AI technologies have the potential to make smart cities more inclusive and friendly. Both, AI and smart cities should be inclusive (Tyagarajan, 2018). To ensure this, technologies should facilitate a smooth interaction between all categories of citizens and their environment. AI techniques, virtual reality, multimodal interfaces, and digital nets could help people with disabilities or older people to have a normal life and to be independent (Fiol-Roig et al., 2009). The intelligent devices are embedded into the home environment and provide movement assistance and 24/7 health monitoring (Stefanov et al., 2004). There are AI applications that help people with disabilities to expand their use of computers to hear, see, and reason. In smart cities, these technologies should be equally accessible for all citizens who need them.

Moreover, AI can improve some aspects regarding regulatory framework. The use of AI technologies in justice and law brings an enormous potential for regulation analysis and interpretation. Nowadays, these technologies help attorneys in the following areas: "(1) document review in e-discovery ("predictive coding" or technology-assisted review), (2) contract due diligence review in corporate transactions, (3) third-party legal research products in multiple practice areas, and (4) time entry and matter analysis" (Ferose and Pratt, 2018). Active ML can be used for classifying legal norms with rule-based technologies (Waltl et al., 2017). The applications developed with these techniques together with data mining recognize patterns that will be used to predict decisions in other new cases and for automated patent landscaping (Abood and Feltenberger, 2018). The knowledge-based systems have been used in large-scale processing of administrative law (Prakken, 2016). Expert systems are suitable for supporting decision-making activities based on previous records and legal requirements stored in various databases (Islam and Governatori, 2018). AI will not replace the human decisions in justice but will help clients and specialists to solve cases faster and easier.

AI can help assure a more sustainable and efficient mobility system that reduces traffic congestions and other problems associated with it. Integrating AI in smart cities mobility systems helps provide real-time reports on traffic congestions and accidents (Hawi et al., 2015), predicts traffic conditions, and solves complex issues at a faster rate (Agarwal et al., 2015). For instance, ANN have been used to predict the most suitable solutions in solving traffic congestions and supervising urban traffic (Hawi et al., 2015). IBM developed Twende Twende project, which allows citizens to receive information on the use of an alternate route to bypass all the heavy traffic and avoid toll roads, details which can be sent directly on the user's phones (Hawi et al., 2015).

Lastly, AI can be considered as a helpful tool in internalizing smart cities negative externalities: generated pollution and high energy consumption. Several technics such as ANN, support vector machines (SVM), and fuzzy logic have been used to detect urban air pollution sources (Olvera-García et al., 2016; Ghaemi et al., 2015). ANN and SVMs have been used in building energy saving "in a variety of conditions, such as heating/cooling load, electricity consumption, sublevel components operation and optimization, and estimation of usage parameters" (Zhao and Magoulès, 2012). These techniques proved to be better and more effective in solving complex applications and nonlinear problems.

5. Conclusions

Population increase, digital revolution, and rapid urbanization create complex pressures on infrastructures, environment, economy, and citizens and accentuate the need to find efficient solutions to solve complex issues. Budgetary constraints, one-size-fits-all approach, digital skills and curriculum reforms, security and privacy problems, pollution, traffic congestion, citizens' inclusion, governance, and regulatory framework represent important challenges facing smart cities development. Smart urban technologies, as part of the smart and sustainable city agenda alongside with ML, NLP, vision, speech, expert systems, robotics, and other AI techniques, are increasingly used to provide solutions to ever-changing problems/issues. AI can be used in different areas from security purposes, education, to rescue management and transportation, and have the potential to transform cities into sustainable smart cities. For instance, AI can be used to assist communities with low resources by means of providing mitigations and solutions to a diversity of social problems (e.g., can be used by public agencies to prevent poisoning with toxic substances in the case of vulnerable population and distribution of food efficiently), can have the potential to reduce or even to eliminate the economic and social gap between different communities and people, can bring an enormous potential for widening access to educational system and increase the diversity of the learners' population (e.g., by allowing the participation of an enlarged number of learners and by providing personalization at scale), can improve security and privacy problems (e.g., crime solving and preventing illegal acts), have the potential to make smart cites more inclusive, by facilitating a smooth interaction between all categories of citizens and their environment (e.g., AI helps disabled persons to expand their use of computers to hear, see, and reason), and can improve some aspects regarding regulatory framework (e.g., ML can be used to recognize patterns in the decisions, etc.) and reduce traffic congestion and pollution.

To maximize the benefits of using AI for smart cities development, we have the following recommendations that should be applied before and/after smart cities implementation:

- Close collaborations between public and private sectors, between governmental organizations and citizens, and between universities and companies to ensure both the development of the necessary AI technologies and their acceptance in a natural manner.

- Programs to inform citizens about the benefits and risks of using ICT, including AI, according to the level of education, age, and interests.
- Clear delimitation through regulations of the responsibilities of developers and users of AI technologies.
- Conducting rigorous research on the side effects of the ubiquitous sensors on human health and dissemination of results to the general public.

Overall, AI technologies could solve many problems in smart cities. They are already presented in some devices and applications, but their maximum potential is still far from being achieved.

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PART 4

Global contexts

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CHAPTER

13 A framework of essential requirements for the development of smart cities: Riyadh city as an example

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Chapter outline

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00013-2

1. Introduction

This introductory section has two main purposes. The first is concerned with highlighting the increasing importance of cities around the world and with emphasizing the increasing interest in promoting the quality of life in these cities and enhancing its sustainability. The second purpose is associated with introducing the objectives of the work presented in this chapter.

1.1 Cities and the world

In 2016, the United Nations (UN) published documents presenting its targeted "Sustainable Development Goals (SDG)" toward the year 2030 (UN, 2015; UN, 2016). Seventeen different goals were specified, and the titles of these goals are given in Table 13.1. It is noticed that "goal number 11" is concerned with "sustainable cities and communities"; therefore, this issue is considered one of the main future development requirements at the world level.

Around "half" of the world's population live in cities and that this figure is expected to become "6/10" in the year 2030 and "2/3" by the year 2050. Cities usually enjoy various advantages over rural areas. For example, they become centers of various important activities, associated with "culture, knowledge, innovation, and business," and consequently, they become drivers of sustainable development. In addition, they offer more efficient "economies of scale" with regard to the provisioning of goods, transportation, and other important services.

In the meantime, cities also suffer from disadvantages that need to be dealt with. They develop slum settlements, with extreme poverty that lead to social problems, and they cause environmental problems, including air pollution, that affect health (cf. Visvizi and Lytras, 2018).

Table 13.1 The United Nations "sustainable development goals" (UN, 2015).

No.	Goal	No.	Goal
1.	No poverty	2.	Zero hunger
3.	Good health and well-being	4.	Quality education
5.	Gender equality	6.	Clean water and sanitation
7.	Affordable and clean energy	8.	Decent work and economic growth
9.	Industry, innovation, and infrastructure	10.	Reduced inequalities
11.	Sustainable cities and communities	12.	Responsible consumption and production
13.	Climate action	14.	Life below water
15.	Life on land	16.	Peace, justice, and strong institutions
17.	Partnerships for the goals.		

Cities need to maximize the benefits of their advantages and minimize the suffering of their disadvantages. The UN document (UN, 2015) has four suggestions for making cities more sustainable, and these are emphasizing urban planning; building affordable public housing; upgrading slums settlements; and the creation of green spaces.

Development toward better cities has brought up trends for making cities smarter; and this trend is addressed in the following section.

1.2 Trends toward smart cities

Making cities smart is becoming a trend toward achieving sustainability and enabling high quality lifestyle (Lytras et al. 2019). Various national and international organizations have attempted to define what smart cities are and have addressed their various requirements. These organizations include those associated with the technologies that enable the establishment of smart cities on the one hand and those concerned with managing the practical utilization of these technologies for the benefits of the state of the cities and the quality lifestyle of their inhabitants on the other (Visvizi et al., 2017). Table 13.2 lists some of the key organizations concerned and refers to important documents they produced on smart cities.

1.3 The presented work

The work presented here has four main objectives.

- The first objective is concerned with general exploration of the hypothesis and the requirements of smart cities, as suggested by the key documents of the organizations concerned, given in Table 13.2.
- The second objective is associated with developing a comprehensive, structured, and flexible core framework that can accommodate the requirements of smart cities and that can be used as a reference for their investigation and development.

Table 13.2 Key organizations concerned with the development of smart cities.

Organization		Key documents [References]
ITU	International Telecommunication Union	ITU (2016a,b)
ISO	International Standards Organization	ISO (2014)
IEC	International ElectroTechnical Commission	ISO-IEC (2014)
BSI	British Standards Institute	BSI-PAS (2014), BSI-PD (2015)
EU	European Union	EP (2014)

- The third objective is related to using the framework for highlighting Riyadh smart city strategy and the current development of the city toward becoming a smart city. Riyadh city can be viewed as an important reference for other cities in the Gulf Cooperation Council (GCC) countries and may be in other countries worldwide.
- The fourth objective is concerned with considering the contributions of the outcome of the work and discussing potential future work.

In sequence, each of the main sections below will be concerned with the achievement of one of the above four objectives.

2. Hypothesis and requirements of smart cities

This section is concerned with the achievement of the first objective. It explores the hypothesis and the requirements of smart cities, as considered by the ITU; ISO and IEC; BSI; and European Union (EU).

2.1 Smart cities according to ITU

ITU defines "A Smart Sustainable City" as follows (ITU, 2016a):

> *A smart sustainable city (SSC) is an innovative city that uses information and communication technologies (ICT) and other means to improve: quality of life, efficiency of urban operation and services, and competitiveness; while ensuring that it meets the needs of present and future generations, with respect to: economic, social, environmental, and cultural aspects.*

The ITU considers smart sustainable cities to be associated with six main dimensions, and these are the "Information and Communications Technology (ICT)" dimension; the "Environmental Sustainability" dimension; the "Productivity" dimension; the "Quality of Life" dimension; the "Equity and Social Inclusion" dimension; and the "Physical Infrastructure" dimension (ITU, 2016b). Table 13.3 gives these dimensions, together with their subdimensions, and the number of indicators associated with each one of them. These indicators represent the ITU requirements of smart cities.

2.2 Smart cities according to the ISO-IEC

ISO and IEC have a joint definition for "A Smart City," and this definition is as follows (ISO-IEC, 2014).

> *Smart Cities provide a new concept and a new model, which applies the new generation of information technologies, such as the internet of things, cloud computing, big data and space / geographical information integration, to facilitate the planning, construction, management and smart services of cities.*

Table 13.3 The International Telecommunication Union dimensions of a "Smart Sustainable City" (ITU, 2016b).

Dimensions	Subdimensions	Indicators
Information and Communications Technology (ICT)	Network and access	4
	Services and information platforms	1
	Information security and privacy	3
	Electromagnetic field	3
Environmental sustainability	Air quality	1
	CO_2 emissions	1
	Energy	2
	Indoor pollution	NA
	Water, soil, and noise	8
Productivity	Capital investment	3
	Employment	2
	Inflation	NA
	Trade	1
	Savings	1
	Exports/imports	1
	Household income/consumption	1
	Innovation	3
	Knowledge economy	4
Quality of life	Education	2
	Health	5
	Safety/security public place	3
	Convenience and comfort	NA
Equity and social inclusion	Inequity of income/consumption	1
	Social and gender inequity of access to services and infrastructure	1
	Openness and public participation	6
	Governance	2
Physical infrastructure	Infrastructure/connection to services—piped water	4
	Infrastructure/connection to services—sewage	3
	Infrastructure/connection to services—electricity	2
	Infrastructure/connection to services—waste	NA
	Connection to services—knowledge infrastructure	NA
	Infrastructure/connection to services—health	1
	Infrastructure/connection to services—transport	2
	Infrastructure/connection to services—roads	5
	Housing—building materials	NA
	Housing—living space	NA
	Building	2
"6 dimensions"	"37 SubDimensions": "78 indicators for 31"/"6 not available"	

Table 13.4 The ISO fields of a “Smart City” (ISO, 2014).

Field	Indicators	Field	Indicators
Economy	7	Education	7
Energy	7	Environment	8
Finance	4	Fire and emergency response	6
Governance	6	Health	7
Recreation	2	Safety	5
Shelter	3	Solid waste	10
Telecom. and innovation	3	Transportation	9
Urban planning	4	Wastewater	5
Water and sanitation			7
“17 Fields”		“100 Indicators”	

> *Developing Smart Cities can benefit synchronized development, industrialization, informationization, urbanization and agricultural modernization and sustainability of cities development.*

The two organizations emphasize that the main target for developing “Smart Cities” is to pursue the issues of convenience of the public services; delicacy of city management; liveability of living environment; smartness of infrastructures; and long-term effectiveness of network security.

ISO, on its own, issued a document concerned with “Sustainable Development of Communities” (ISO, 2014). The document addresses “17 fields” refined into “100 indicators” for “City Services and Quality of Life,” which represent the ISO requirements of smart cities. Table 13.4 lists these fields and the number of indicators concerned with each of them.

2.3 Smart cities according to BSI

BSI defines “A Smart City” as follows (BSI-PD, 2015):

> *A smart city is where there is effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens.*

For further explanation of its definition, BSI adds the following (BSI-PD, 2015).

> *The smartness of a city is therefore not about technology as such, but rather about how well technology is used in an integrated way to help the city function more effectively, both in its individual systems, and as a whole. That involves better engagement with its customers, and better mechanisms of governance. Becoming smarter allows a city to build on existing foundations within a city, and enables it to set a more engaging vision and follow a new and more effective path into the future.*

Table 13.5 BSI "Traditional City Operating Model" (BSI-PAS, 2014).

Customer	Citizen/Business											
Customer delivery	Energy	Waste	Water	Telecommunication	Policing and emergency	Education and Training	Transport	Health	Social Services	Housing	Environment services	Financial and economy
Services												
Data												
Technology and infrastructure	City operating functions											

BSI advocates development toward smart cities by comparing a "Traditional City Operating Model" with a "New Integrated Model," where it considers smart cities are moving (BSI-PAS, 2014). Table 13.5 illustrates the first model, while Table 13.6 illustrates the other, considering both to be providing services in "10 main fields." A comparison of impact between the two is given in Table 13.7.

The above hypothesis and the requirements of smart cities considered by different reputable organizations have common issues and have some differences. Integrating them together would provide a more ambitious target to work for. In addition, it should be noted that the core hypothesis of a smart city is of a flexible nature that can grow as technology grows and as human ambition drives humanity.

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2.4 Smart cities according to the EU

A European Parliament study (EP, 2014) provides around "10 definitions" for "A Smart City," and one key definition is taken from chapter (Schaffers et al., 2011) and it states the following.

> *"A city may be called 'Smart' 'when investments in human and social capital and traditional and modern communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance".*

Seeking simplicity, the EU study develops its own working definition, which says the following.

> *A Smart City is a city seeking to address public issues via ICT-based solutions on the basis of a multi-stakeholder, municipally based partnership.*

Table 13.6 BSI "New Integrated Model: *The Smart City Target*" (BIS-PAS, 2014).

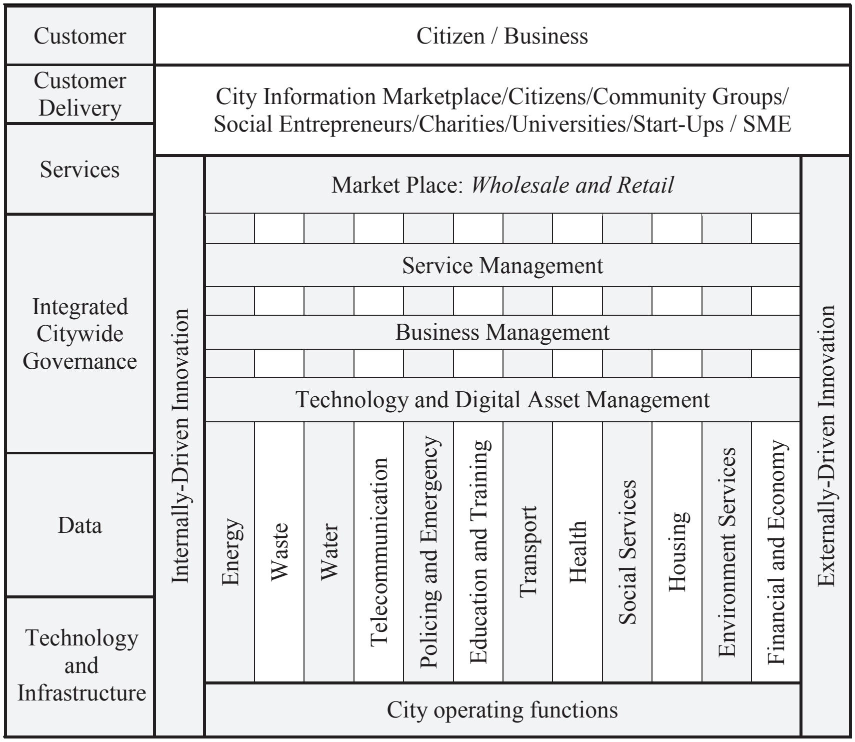

Table 13.7 BSI "Traditional City Operating Model" versus "New Integrated Model: *The Smart City Target*" (BIS-PAS, 2014).

Issue	Traditional model	New model
Integration	Unconnected: individual silos	Unlocking individual silos
	Not customer-focused	Integration of data; services; and customer delivery logical separation
	Inefficient	Efficient
External innovation	Closed system: not open to external-driven innovation	New market place for information and services
		Citizens, small and medium-sized enterprises (SMEs), and social entrepreneurs enabled to cocreate public services and new value with city data
Internal innovation	No ability to drive cross-section innovation	Improved and integrated service delivery Resource optimization
Change	No ability to drive citywide change at speed	Ability to drive citywide change at speed

Table 13.8 EU "Smart City Characteristics Dimensions" (EP, 2014).

Dimensions	Description	Riyadh terms
Smart living	❑ ICT-enabled life styles, behavior, and consumption. ❑ Healthy and safe living in a culturally vibrant city. ❑ Good quality housing.	Strategy: *vision*
Smart economy	❑ E-business and e-commerce and increased productivity. ❑ Advanced manufacturing and delivery of services. ❑ Local and global interconnectedness. ❑ ICT-enabled innovation: *products, services,* and *business.*	
Smart people	❑ E-skills: access to education and training. ❑ Human resources and capacity management. ❑ Improving creativity and innovation: *products* and *services.* ❑ Data analytic tools and dashboards: *making decisions.*	Mission
Smart mobility	❑ ICT-supported transport and logistics systems. ❑ Prioritizes to clean and often nonmotorized options. ❑ Costs and CO_2 savings. ❑ Data for long-term planning.	
Smart Governance	❑ Smart objectives: transparency; ICT open data; e-government in participatory decision making; and new services. ❑ ICT infrastructure, hardware, and software. ❑ Smart processes fueled by data.	
Smart environment	❑ Smart energy including renewables. ❑ ICT-enabled energy grids, metering, pollution controls. ❑ Buildings and amenities: green buildings and urban planning. ❑ Resource use efficiency.	Opportunistic
Smart ICT for SC		

According to the above, EU recognizes ICT as an essential enabler of a smart city. In addition, it addresses its characteristics considering six main dimensions. These dimensions are as follows: Smart Economy; Smart Living; Smart People; Smart Mobility; Smart Governance; and Smart Environment. They are described in Table 13.8.

3. The framework

This section describes the framework, which aims at providing a flexible structured tool for describing the state of a smart city. This tool would provide a common base for defining the current and targeted states of cities and for deriving plans toward development from the current state to the targeted one, in addition to monitoring the progress of development. The framework is presented in three steps. The first gives the basic principles on which the framework is based; the second describes its various components; and finally, the third addresses the practical use of the framework.

3.1 Framework principles

The framework is based on the following principles:

- The first principle considers that the framework should provide a "comprehensive view" of a smart city by identifying its "essential requirements" in a logically "structured manner" that can accommodate its various details. The accommodated details would be of "flexible nature" that can include those currently available and those which would be added or changed in the future.
- The second principle is concerned with the drive toward enabling "continuous development" of the city for achieving better performance and sustainability, through "strategy and plans" that can be both "reactive" in responding to forces of change and "proactive" in initiating innovative actions.
- The third principle is associated with the "use of technology" for delivering services and utilizing these services. The technology concerned includes ICT and other technologies associated with various other "city services."
- The fourth principle is related to "city services" provided by various "city organizations." These services include those addressed by ITU, ISO, BSI, and EU documents reviewed above and may include newer services in the future. Details of these services and their "enabling technology" would differ among cities. In this respect comes the need for the flexibility feature of the framework that accommodates the current state and supports future development toward the targeted state.
- The fifth principle is concerned with "people," that is, the "professionals," who are concerned with delivering the services on the one hand and the "public" who are making use of the services on the other. Awareness of the public would be needed for proper "use" of the services, and training and qualifications would be needed for the professionals for proper "delivery" of these services.
- The sixth principle is related to the "working environment" of the city, that is, the "regulatory framework" of the city, that is the rules, regulations, and practices associated with service delivery and service usage, in addition to continuous monitoring and performance evaluation.

3.2 Framework description

The targeted framework can be based on Bakry's structured STOPE view that consists of the five domains: "Strategy, Technology, Organization, People, and Environment." The view has been successfully used for the development of structured flexible and comprehensive frameworks concerned with different "technology and society" problems such as e-government (Bakry, 2004); grid computing (Arafah et al., 2007); and various others. It enabled these frameworks to accommodate the various issues of the problems concerned within its five structured domains. Using this view for our targeted *"smart city framework"* would comply with all *six principles* given above. A description of each of the five domains of the framework is given in the following:

Starting the framework description with the *first domain*, the "strategy" toward building a smart city would be concerned with the targeted continuous sustainable development of the issues associated with the other four domains. The development would be "reactive or proactive" depending on the issues considered, as required by the *second principle* above. The key strategic targets would include building suitable "technology infrastructure" that can respond to the various requirements; development of required integrated "services" delivered by the various specialized "organizations" of the city; training "professional people" to run the services; providing awareness courses to the "public" who are the users of the services and emphasizing life quality and prosperity for all; establishing suitable "working environment" that supports regulations and achieves "effectiveness and efficiency"; and finally providing "open opportunities" to support innovation associated with the above and to enable the realization of sustainability.

The *second domain* is concerned with the state of "technology" in the city that is the state of the enablement tools that support the smartness of the city. The technology of the smart city involves, as required by the *third principle* above ICT, including Internet of things, cloud computing, big data, geographic information systems, and others. These ICT tools would be useful to practically all services, providing them with intelligence and automation. In addition, the technology dimension also involves other technologies specialized in the various services delivered by the city.

The *third domain* is associated with the state of the "organizations" concerned with the city "services" and their management, as required by the *fourth principle*. Considering the above, ITU, ISO, BSI, and EU identified various services as main examples. It was emphasized that delivering each service should not be in isolation from the other services; some common ground should be established across the services as suggested by BSI and shown in Table 13.6. This would be associated with the regulatory framework of the city, which is associated with "environment" domain addressed below.

The *fourth domain* is related to the state of the "people" in the city including those who are running and delivering the services and those who are using them, as mentioned in the *fifth principle.* Awareness, qualifications, ethical behavior, and professional responsibility are important issues to consider.

The *fifth domain* is the "working environment" concerned with "regulatory framework" of the smart city, "performance," and "cooperation," which support innovation, continuous development, and sustainability, as required by the *sixth principle*. The state of the working environment would make or break the proper utilization of resources of the other domains.

The five domains of the STOPE view are illustrated in Table 13.9.

Table 13.9 An illustration of the five domains of the STOPE view.

<table>
<tr><td rowspan="3">Strategy: Considering all TOPE Domains:
Quality of Life / Sustainability / ...</td><td colspan="3">Information and Communication Technology (ICT):
Supporting Services / Providing Intelligence / ...</td><td rowspan="3">Environment: *Regulatory Framework / Performance / Cooperation: Internal and External / Innovation / ...*</td></tr>
<tr><td>People: The Public
Users of Delivered Services</td><td>Organizations Concerned /
City Services
e.g. Like Services addressed by the referenced ITU / ISO / BSI / EU Documents
Managing City Services
Considering Regulatory Framework / ...</td><td>People: Staff
Professionals Delivering Services</td></tr>
<tr><td colspan="3">Other Technologies:
For Delivering and Using the Different Services ...</td></tr>
</table>

3.3 Use of the framework

The framework described above provides a "tool" for describing the state of cities in a comprehensive, structured, and flexible manner using the STOPE domains. Therefore, the framework can be used in different ways including the following:

- It can be used as a base for "describing" the "current state" of a city, that is, as a "context establishment," that provides the "initial information base" of the city concerned for its future development toward becoming smarter.
- It can be used as a "description" of a "targeted state" toward which a city needs to drive its development. This targeted description would provide a "reference base" against which the "current state" can be assessed.
- Between the "current state" and the "targeted state" descriptions according to the STOPE view, a STOPE development path can be drawn, in incremental steps. This would enable well-directed and integrated development, based on a common approach, which provides development effectiveness with reduced cost.

In the coming section, the STOPE framework will be used as a base for highlighting Riyadh smart city strategy and illustrating the current development associated with it.

4. Riyadh city

This section is concerned with Riyadh smart city strategy and the development associated with it. It starts by introducing the city and emphasizing its importance. This is followed by considering the STOPE framework for highlighting the strategy of the city toward smartness and addressing its expected future achievements. In this respect, the section identifies the development base of the "strategy," its goals, and its essential elements. The strategy consideration of the "ICT technology" is then considered. In addition, the stakeholders, that is, the "organizations" and the "people" associated with the strategy, are identified. The results of an ADA (AlRiyadh Development Authority) study of the gap between the "current state" of key TOPE issues versus the corresponding "desired state" is then given, illustrating the smartness gap that need to be considered for the road ahead. The road ahead, with the targeted achievements is then highlighted considering short-, medium-, and long-term achievements that are related to combinations of TOPE domains.

4.1 Introducing Riyadh city

Riyadh city is the capital of the Kingdom of Saudi Arabia (KSA), which is the center of the GCC countries, the Arab world, the Islamic world, and the old world. KSA has an area of more than "2 million km^2" and has a population of around "30 million." It is a high-income country, and it enjoys holding the largest oil reserves in the world. Riyadh is located in the central region of the country as shown in Fig. 13.1 (ADA, 2017a).

The current area of the city of Riyadh is around "1400 km^2," and its current population is over "6 million"; its population density therefore is around "4300 people/km^2". Since the turn of the century in the year 2000, the population of the city doubled "3 times," with about similar increase in area. The city is becoming increasingly attractive to live and to work by both Saudis from other KSA locations and by non-Saudis from different parts of the world. The city is now highly ambitious to become a smart city and to be able to compete, in the near future, for a position among the top "10 ranking smart cities positions" at the world level.

4.2 Riyadh smart city strategy

Riyadh smart city strategy is described here in terms of its development base; targeted goals; and essential elements. The "development base" has three pillars: the KSA 2030 vision announced in 2016; the National Transformation Program associated with it; and the strategic plan of Riyadh city (ADA, 2017b; KSA Vision, 2016). The "targeted goals" are related to EU smart city characteristics, and they involve improving quality of life; providing sustainable living environment; enhancing economic development; and government enablement of city efficiency. The "essential elements" of the strategy involves focus areas; key stakeholders;

FIGURE 13.1

Map of the Kingdom of Saudi Arabia and the location of Riyadh city (ADA, 2017a).

Table 13.10 The base, the goals, and the elements of Riyadh smart city strategy (ADA, 2017b).

The development base of Riyadh smart city strategy	KSA (Kingdom of Saudi Arabia) vision 2030
	KSA-NTP (National Transformation Program) 2020
	Riyadh strategic plan
The goals of Riyadh smart city strategy	Improving quality of life
	Sustainable living environment
	Enhanced economic development: *business/jobs*
	Government-enabled efficient city
The elements involved in Riyadh smart city strategy	Key Stakeholders: *organizations involved*
	Dimensions and focus areas: *services*
	Criteria and benchmarking: *performance*

and criteria and benchmarks. Elaborations on these are considered throughout the following sections. Table 13.10 summarizes the development base, the targeted goals, and the essential elements of the strategy.

4.3 Riyadh smart city ICT

ICT is an essential enabler of smart cities. Riyadh city strategy considers ICT according to four main layers. The first is the core layer, and it is concerned with the "infrastructure" that manages the technical smart city functions. The second layer is that associated with the city "data"; such data provide important information that can support smart decisions. The third layer is smart city "platform" that provides the necessary base for smart services. The fourth layer is the one that implements "applications" and gives services to organizations and people, providing them with smart life.

Each layer enables the layer above. The "infrastructure" layer here is the base enabled by the increasing capabilities of ICT components, and the "application layer" is the provider of services to city residents and organizations. New and enhanced capabilities at the base layer would lead to smarter applications and services. Table 13.11 summarizes the four ICT layers.

Table 13.11 The ICT technology layers of Riyadh smart city strategy (ADA, 2017b).

Layer		Function
(1)	ICT infrastructure	Managing smart city functions
(2)	City data	Enabling smart decisions
(3)	Smart city platform	Facilitating smart services
(4)	Smart applications	Smart life residents

4.4 Riyadh smart city organizations and people

The players in the smart city are the "organizations" and the "people" concerned with delivering the services; using the services; or both. People may be individuals or they may be associated with organizations, and they are in many cases both. Smart cities of course are for all organizations and for all people. Riyadh smart city strategy identifies "12 stakeholders," which are key organizations concerned with smart cities; they include seven ministries including those of the Interior, Labor, Housing, Commerce and Investment, Economy and Planning, Education, and Health; two organizations concerned with Riyadh city: ADA and ArRiyadh Municipality; one organization concerned with research, that is, King Abdulaziz City for Science and Technology; one organization concerned with surveys, that is, the General Commission for Survey; and one organization concerned with e-government (YESSER). Table 13.12 lists the above organizations, which are the key stakeholders of Riyadh smart city strategy (ADA, 2017b).

4.5 Riyadh smart city environment

One of the main issues associated with the "environment" is monitoring and assessment. Gap analysis between the current state and a desired state requires assessment of the current state on the one hand and specification of the desired state on the other. The assessment and the specification should be concerned with certain state components that provide a good view of the state considered. In addition, assessing the components involved would need a measurement scale, with a range of specific values that measure them.

Riyadh smart city strategy identified six initial state components, provided measurement scale for their evaluation, assessed the current state, specified the desired state, and illustrated the gap that need to be crossed between the two states, with regard to the components considered. These components are related to the TOPE domains of the framework, and they include (ADA, 2017b) "resources," which are associated with "technology domain"; "governance practices," which are related to the "organization domain, as they coordinate and integrate the

Table 13.12 Key stakeholders of Riyadh smart city strategy (ADA, 2017b).

(1)	ADA: Alriyadh Development Authority	(7)	Ministry of Housing
(2)	AM: Alriyadh Municipality	(8)	MOCI: Ministry of Commerce and Investment
(3)	YESSER: E-Government	(9)	MOEP: Ministry of Economy and Planning
(4)	MOI: Ministry of Interior	(10)	MOE: Ministry of Education
(5)	KACST: King Abdulaziz City for Science and Technology	(11)	GCS: General Commission for Survey
(6)	MOL: Ministry of Labor	(12)	MOH: Ministry of Health

Table 13.13 Measurement scale of Riyadh smart city (ADA, 2017b).

0 Nonexistent	1 Minimal development	2 Some achievements	3 Adequate progress	4 Substantial achievement	5 Maturity level

Table 13.14 Assessment of the current state of Riyadh smart city (ADA, 2017b).

Domain		Current state: Grading 0–5	
TOPE	**Components**	**Current state**	**Measure**
Technology	Resources	Some efforts: open data and smart applications	2
Organization	Governance practice	No smart city office yet	0
People	User experience	Some feedback to smart applications	2
	Public participation	Some positive initiatives and some data crowdsourcing	3
Environment	Regulatory framework	Open data and e-government initiatives: national level	1
	Public–private participation	Mainly vendor/tactical solutions and services	1

activities of the smart city in a similar way to the horizontal layer, across the vertical layers, advocated by BSI (BSI-PAS, 2014); the "people" domain, which is concerned with the "user experience" on the one hand and with "public participation" on the other; and finally, the "environment domain," which is associated with the "regulatory framework" of the city, on the one hand, and with cooperation, that is, "public–private partnership (PPP)" on the other.

The measurement scale according to which the above components are measured is given in Table 13.13, the current state measurements are given in Table 13.14, and the gap between the current state and the desired state is illustrated in Fig. 13.2.

4.6 Future achievements

Riyadh smart city strategy provided an achievement plan identifying future expected achievements, with these achievements related to multiple TOPE domains. They are specified according to three future time frames: short term, which ranges from 1 to 2 years; medium term, which ranges from 2 to 3 years; and long term, which ranges from 3 to 5 years. The achievements were divided into four categories: the "governance" category, which is concerned with establishing "a smart city office" to take the governance responsibility; the "policy" category, which is concerned with the development of the "governance regulatory framework", the "smart district guidelines", and the

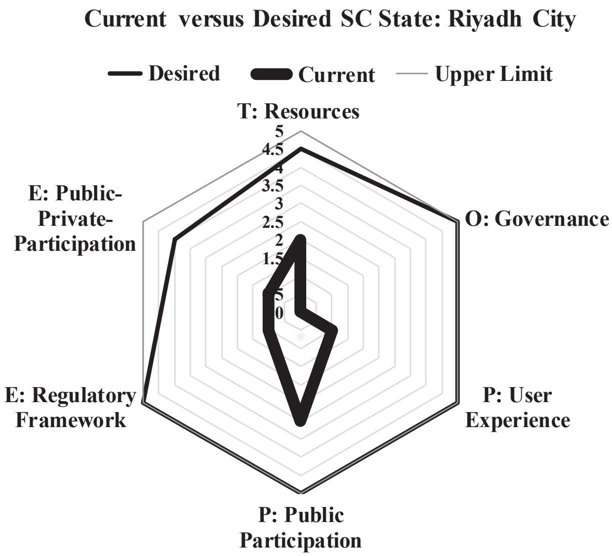

FIGURE 13.2

Riyadh smart city: Current state versus desired state according to city domains (ADA, 2017b).

"smart building guidelines"; the "initiative" category, which is associated with facilitating effective management; and finally the "service" category, which is concerned with providing smart services. Table 13.15 lists the expected future achievements, according to their time frame and by their category.

5. Contributions and future work

This chapter has provided three main contributions to the literature of the subject, and it has also opened various avenues for future work. These contributions and the future work avenues are discussed in the following.

5.1 Contributions

The work presented in this chapter involved three main contributions. One contribution is concerned with "exploring" the increasing importance of "smart cities" and with viewing "key literature" concerned with the best practices developed for their planning and implementation. In this respect, the chapter addressed the UN SDGs and their trends and reviewed the work of international organizations on smart cities, including the ITU, ISO, IEC, BSI, and EU.

Another contribution is associated with the development of a framework based on the Bakry's STOPE view for the planning and management of smart cities.

Table 13.15 The achievement plan of Riyadh smart city strategy (ADA, 2017b).

Time frame	Category	Achievements	
Short term: 1–2 years	Governance	Smart city office	
	Policies	Data governance: *law (regulatory framework)*	
	Initiatives	Smart city platform (1)	
	Services	Riyadh dashboard	Intelligent traffic management
		Citywide: Wi-Fi	Intelligent parking Systems
Midterm: 2–3 years	Policies	Smart district: *guidelines*	Smart building: *guidelines*
	Initiatives	Smart city platform (2)	Smart learning
		Smart health	Air quality and noise management
	Services	Open data portal	Smart water and waste management
		Smart public security	Smart metering
		Smart grid	
Long term: 3–5 years	Initiatives	Smart city platform (3)	Open innovation platform
		Paperless and cashless city	Innovation hubs
		Emergency response and management	
	Services	Disaster recovery	Driverless cars
		Government processes on blockchain	3D visualization

The STOPE view has proved, over years of use, that it has three useful features, with regard to its use for problems concerned with technology and society. The first is "comprehensiveness," that is, the ability to accommodate the various issues associated with such problems. The second is "modularity," that is, organizing the targeted issues according to a domain-based structure that divides the comprehensive view into easily managed and integrated components of the addressed problem. The third is its flexible "usability" for various planning and management requirements including change with time, state specifications, comparisons, gap analysis, and decision-making.

The third contribution is related to highlighting a real-life smart city strategy, using the STOPE-based framework, for one of the most important cities in the GCC countries, that is, the city of Riyadh, the capital of Saudi Arabia. This contribution has two main benefits. The first is its illustrative mapping of real-life smart city issues on the STOPE view, as this would enhance its future use in the field. The second is exploring, in a comprehensive and modular manner, what Riyadh city has done with regard to its drive toward becoming a smart city. This is beneficial to all cities in general, and to GCC cities in particular, as they enjoy similar features with Riyadh city.

5.2 Future work

As the contributions of the chapter provide answers to various problems, they also raise questions to various others, and this opens avenues for future work. Three main possible future work avenues are addressed in the following:

- ❑ The work presented in this chapter is of broad scope, but with limited depth. This is of course the nature of the chapter, which aims at providing a wide view of all issues rather than a focused one on specific issues. One avenue for future work here is to divide the broad view of this chapter into several focused views and identify various problems for investigations. Examples of such focused views would include ICT, and each of the ICT layers presented in the chapter; the smart city "governance," its "regulatory framework," and other related plans; smart city "services"; and other problems.
- ❑ The gap analysis conducted by Riyadh smart city strategy has been useful as a broad assessment considering a broad view. Future work can consider the development of a "comprehensive smart city assessment framework" that provides more detailed metrics that can provide better understanding of the current state and better specifications to the desired state. Such a framework can be based on the STOPE view and can be refined in an incremental manner, in response to technology change and increasing requirements.
- ❑ The field of smart cities enjoys the features of modern fields, where innovation and competition are key issues. In this field, an important future work for any ambitious city concerned with smartness, including Riyadh city, is to establish a "research unit" that has three main tasks. The first task is concerned with keeping the city aware of the latest development and increasing requirements for improvements. The second task is related to monitoring the development of the state of city smartness, to respond to any problem. Finally, the third task is associated with creativity and innovation in the field that may be applied internally for improvement and may be invested internationally for contribution to economic development.

If this chapter has promoted the readers enthusiasm and positive drive toward smart cities and their continuous future development, it would have achieved its main goal. Smart cities need enthusiastic smart people to build them and to make use of their benefits.

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CHAPTER

14

Definition of public safety policies based on the characterization of criminal events using volunteered geographic information, case study: Mexico

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Chapter outline

1. Introduction

In Mexico, according to the Federal Public Prosecutors Office of the Attorney General's Office, the crimes are classified as common jurisdiction or federal jurisdiction crimes. The common jurisdiction crimes are related to crimes that directly affect people, that is, the person who is affected by the behavior of the offender,

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00014-4

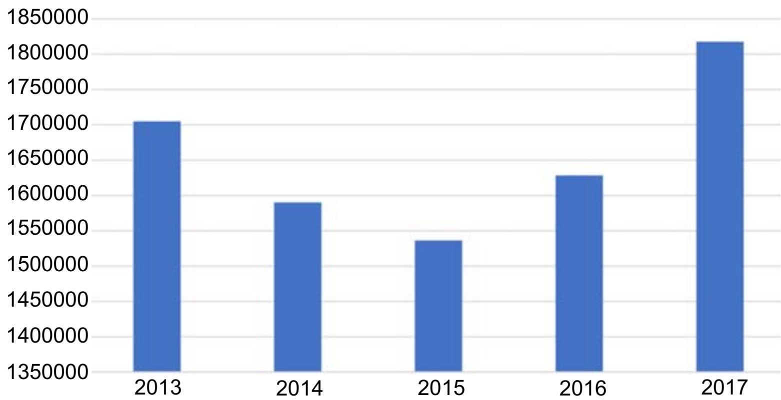

FIGURE 14.1

Crime rate in the last 5 years in Mexico.

for example, threats, property damage, sexual crimes, fraud and abuse of trust, homicide, injury, and robbery (home, business, bystanders, vehicles, etc.). These crimes are prosecuted by the Common Jurisdiction Public Prosecutor's Offices, investigated by the Attorney's Offices and judged by the Judicial Power of each of the states. The criminal incidence refers to the alleged occurrence of crimes recorded in preliminary investigations initiated and/or investigation files reported by the Attorney General's Offices and General Prosecutors of the 32 states in Mexico, who are responsible for the authenticity and updating of the data (National Information Center, 2016).

In recent years, Mexican Security Authorities use computer tools to generate statistical information at different levels of spatial granularity (by state, city, municipality or delegation, streets, among others). Yearly, the Executive Officer of the National System of Public Security gives an annual report on "Criminal Incidence of the Common Jurisdiction." This report has been generated from 1997 to date, where the police reports can be checked from public prosecutors' agencies, at national level, by state and by the sort of crime. In these reports, a substantial growth in the crime incidence rate can be seen, which affects the life quality of people (National Information Center, 2016). In Fig. 14.1, the crime rate for the last 5 years is described.

Annually, INEGI makes the Victimization and Perception of Public Safety National Survey (ENVIPE), whose purpose is to generate federal and local information on the phenomenon of criminal victimization, as well as the social perception regarding public safety and the efficiency of the authorities. Some of the most important results of this survey are described as follows (INEGI, 2015):

1. In 2014, the rate of criminal prevalence[1] per 100,000 citizens was 28,200, remaining at similar level to 2013 that registered 28,224.

[1] Criminal prevalence is a descendant sorted index that quantifies the criminal incidence, violence and perception of citizen insecurity by state.

2. In 2014, the rate of criminal incidence per 100,000 citizens was 41,655, also remaining at similar level to 2013 with 41,563 events.
3. Extortion was the second most frequent crime, accounting for 23.6% of the total crimes committed in 2014; however, the rescue payment amount decreased from 6.4% in 2013 to 5.4% in 2014.
4. In 2014, the unrecorded crime rate (number of not reported crimes or that did not result in formal investigation) was 92.8%, while in 2013, it was 93.8%.
5. The ENVIPE 2015 estimates that the main reasons to involve crime victims not to report an offense are circumstances attributable to the authority: 32.2% considered that impeachment process is pointless and 16.8% distrust in the authority.
6. The perception of insecurity in the states at the time of surveying (March—April 2015) reached 73.2% of the population aged 18 and over, staying at similar levels as in 2014.

According to this information, in Mexico, the unrecorded crime rate is very high. In consequence, considering 2015, the Executive Secretariat of the National Public Security System reported that the total number of common jurisdiction crimes was 1,511,292 crimes; the real crime number was higher than 15 million of offenses in that year.

For a long time, maps have been used to represent and describe information and events that have occurred on Earth. In consequence, several cartographic techniques and approaches have been developed focused on multiple problems. By this reason, the geographic information systems (GISs) are essential tools for studying and monitoring of spatial processes. In the scientific visualization era, GISs have increased the potential of analysis information and scientific research, compared to the use of traditional cartography, not just for the relationship between cartographic techniques, the computer science for the description, and analysis using a wide set of symbols, which has made possible the use of maps in different areas such as astronomy, application of remote sensors, geology, climatology, criminology, among others, which gives it a new field of potentialities (Gooodchild et al., 1994).

Frequently, maps are considered just like visualization tools. However, maps have an important role in the research process, analysis, and presentation of results related to geographic information in different application domains. In this restrictive interpretation, a map is more than an image or part of a database. MacEachren (1994), after the work of DiBase (DiBiase, 1990), pointed out the distinction between visual thinking and visual communication in the use of maps and graphics. A GIS is a particularly horizontal technology because it has a wide variety of uses in the industrial and intellectual environment; for this reason, it tends to resist a simplistic definition. It is important to understand of what is being talked about when we refer to GIS. A simple definition is not enough. To talk about GIS outside the context of any specific industry or use, a more flexible tool is required to explain it, for example, the Tomlinson model (Tomlinson, 2007).

To make an analysis of this model, the model must be studied part by part. The starting point represents the spatial data that have not been processed (raw information). These data have a geographical component and are represented by one of the three basic primitives (depending on the scale): points, lines, or polygons. These data have a description that characterizes them based on a location as descriptive information. These data can be captured in different ways, for example, using a GPS system or through map digitization; this process represents the second component of Tomlinson model, which is the databases and the digital data storage. The database contains relevant information for the case of study and represents the basis of information of the GIS. The final part of the model is represented by the application itself, which is described by a computing tool, and it is focused on particular objective. Finally, human experts are considered into the model, on which the efforts to interpret that information lie into to take advantage of the benefits offered by a GIS. GIS has been used to study the spatial aspects related to fear of crime in urban contexts, for which we can mention a specific case: the study of the fear of crime proposed by Vozmediano and Guillen (2006). From a set of surveys that were applied to a random sample of residents, the distribution of the target crime in the city was studied, based on judicial data and the distribution of the crime fear in three different urban regions.

In New Zealand, the first attempt to develop GISs and crime mapping tools started when the New Zealand (NZ) police decided, as part of a new record management system being developed during the mid-1990s, that a key reporting tool for this system would be based on GIS, allowing users to query police systems to ascertain patterns of crime, by specific areas in requested time frames. The NZ Police Information and Communication Technology staff developed the client-based GIS for an initial rollout of 19 analyst sites throughout NZ Police. The first version was delivered in early 1999. This approach ended in limited frontline interest due to two main factors. First, some members of the analyst staff could not understand the concept of what the application would potentially offer. Second, the package was to involve a local cost to each site or station receiving it.

In Argentina, an analysis of the criminal patterns based on data mining and statistical techniques was performed on a data set obtained from a spatial geoprocessing system. An iterative searching process of nontrivial information in large volume of data was implemented with the purpose of generating information as similar as possible to human analysis results, by means of patterns, identifying associations, changes, as well as anomalies and significant structures (Valenga et al., 2008a,b).

The crime study establishing a relation between crime events and delimited geographical areas has allowed to create the generation of crime maps, which is an essential tool for experts in analysis processes oriented to determine behavioral patterns and trends. A study based on the determination of patterns that allows a series of analytical studies of the problem, the behavioral and the available resources on the same system, and the criminal map was implemented to provide a guide for researchers when designing studies or applying for grants (Fritz and MacKinnon, 2007).

Over a decade and a half, some researchers have used GIS to represent and map out crime events, which has very specific characteristics such as incidence location, as well as an event type. In the case of human activities, they can be categorized geographically. Additionally, criminal activities are an anthropological aspect of the human being, which could be categorized in this type of applications (Goodchild, 2009).

Formally, any system that represents and analyzes with the basic and representative characteristics of geographic information processing is a GIS. For some authors, GIS is software oriented to the manipulation of geographic data. However, commercial applications are closed, expensive, and proprietary, which do not allow the comprehensive development of specific purpose applications. Considering the previous examples, these specific studies can be applied to different branches or sciences, which can be represented on events or phenomena with a spatiotemporal relationship, this is, the case of criminology.

Criminology is a multidisciplinary science that bases its foundations on sociology, psychology, and social anthropology knowledge, taking into account the conceptual framework that defines law. Criminology studies the crime causes and stands up approaches for the antisocial man behavior. Criminological research areas include the incidence, forms, possible causes, and consequences of crime events. They also gather social reactions and government regulations regarding crime. Because of its multidisciplinary nature, the integration and development of tools that allow people to get information for its investigation and study provide options for systems development to process information related to this phenomenon.

Environmental criminology, that is, a criminology specialty, is dedicated to studying criminal events as a result of the relationship between offenders and potential criminal objectives that occur in specific points of space and time (Brantingham and Cohmen, 1981). This specialty will be used within the case study proposed, due to its obvious relationship with GIS.

Although this phenomenon does not completely represent a continuous distribution, several criminalistics events can occur at several isolated points in a particular geographical space. Therefore, to generate criminal map of specific area, it is possible to estimate the values between a finite set of points that describe incidents locations, using several approaches, for example, Fritz and MacKinnon technique (Fritz and MacKinnon, 2007). Nowadays, criminal activities have always been a priority activity to be considered in different country areas, making it a problematic topic, not only in Mexico but also beyond our territorial limits.

In criminal investigation, the relevance of this phenomenon can be determined by a geographical profile, which is a technique for analyzing the spatial or geographic activity. With this technique, police and criminologist researchers have a profile that includes geographic movements; the main objective is to infer or to describe the behavior of criminal events to prevent the development of the same and determine the impact zones through a Geographic Information System (SIG) (Garrido and López, 2006).

These analyzes have generated studies on different influence zones for a specific crime event, particularly in the case of the study of criminology. Using these hotspots is easier to develop techniques to deduce patterns; in this way, the basic structure of new crime entities could be defined. This entity is related to particular events, allowing the development of a spatial thematic layer for the creation and acquisition of more enriched information. This information captured in thematic maps provides the following information:

- Integrate different types of information in a coherent and related way.
- Provide an intuitive event visualization and related cases and describe events and patterns to provide trails for researchers and criminologists.
- It generates the basis for spatial analysis and event relationships.
- It generates a perspective of the problem scope and can allow deploying resources more efficiently for its development.

An adequate identification of high crime locations is important because a quick growth in the population in urban regions demands the provision of services and infrastructure (Rathore et al., 2017). Using the definition of these hotspots and crime entities, there is the possibility of generating a neural network, to know the relationships that may exist between entities, whose value apparently is not linked but, applying detailed analysis approaches, relationships between two events can be determined (Grabosky et al., 2001), because we are able to transform massively the information produced by humans and machines into knowledge capable of supporting smart decision-making (Lytras et al., 2017).

2. Crime analysis case study: Mexico

We propose a methodology composed of the following stages: data acquisition, database connection, analysis, validation, and visualization. Each of these stages has a specific function, which is related to recovery and integration of criminal information process, connection to a spatial database for the extraction of data of interest, analysis of criminal information based on interpolation and classification methods, metrics to quantify the degree of reliability using pattern recognition techniques, and finally, a GIS application to display the generated results (Ruiz, 2013). Fig. 14.2 shows the proposed methodology.

In this figure, the process starts with the acquisition of related data; it is necessary to define the process to obtain the information, using a graphical interface that receives the user data. In this form, the number of classes that will be generated with respect to the criminal patterns should be specified.

Next, it is necessary to recover all the required criminal data for the analysis stage. All the information is stored in a PostGIS spatial database. Applying SQL statements, the connection stage proceeds to recover the information from the spatial database; when all the necessary criminal data are available, a classification algorithm based on Voronoi diagrams is applied in the analysis stage. In this process,

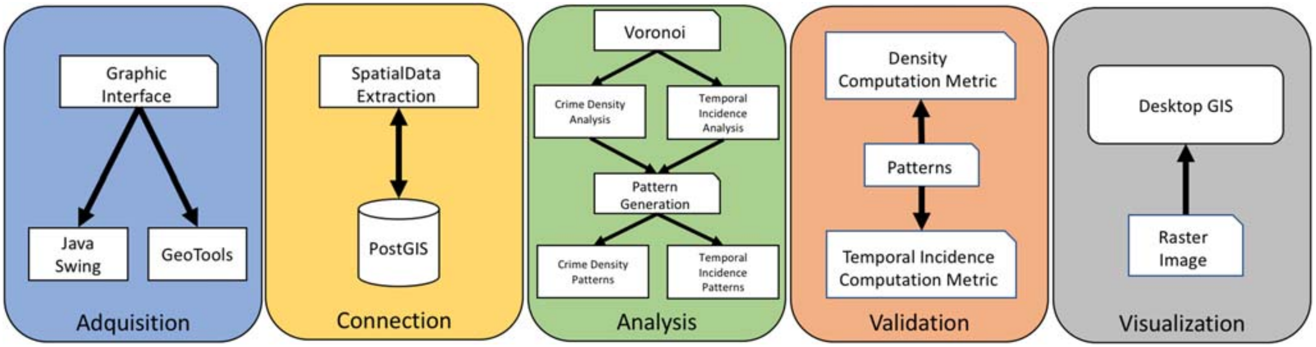

FIGURE 14.2

Architecture of the proposed methodology for crime analysis.

the areas with similar criminal incidence are grouped, by means of two analysis methods. The first one is focused on the criminal density, identifying the crimes frequency per unit of area. The second one is a temporal incidence method, and it is focused on quantifying the criminal incidence temporal pattern.

Additionally, in the validation stage, a validation process of the generated patterns in the classification process is carried out. It consists of analyzing the similarity of characteristics by means of two approaches: in the first approach, a density computation using a metric is applied, and in the second technique, a metric for the calculation of temporary incidents is performed.

Finally, in the visualization stage, the information generated in the analysis stage is represented by means of a raster image and displayed using a desktop GIS.

2.1 Acquisition stage

In this stage, the fundamental components for the capture of criminal information are defined and implemented. Therefore, these components provide the mechanism for the user interaction and recollection of criminal information. The interface is composed of two basic components: Java Swing and GeoTools.

2.2 Connection stage

The connection stage provides the operations for storing and recovering all required information related with criminal data in a spatial database. The data model used in the methodology is depicted in Fig. 14.3.

In the initial model, an analysis with more variables (entities) was proposed. Unfortunately, there is a lack of information related with items outside dashed box region. In consequence, we generated and used the information contained in the tables inside dashed box region. The data definition is given according to the information of the following tables:

DENUE: The DENUE provides updated information of all the economic activities that take place in the national territory; generally two versions per year are published. Outstanding descriptive information of those entities related to manufacturing industry, commerce, and private services, sectors in which there is the greatest number of economic units and employed personnel. The transport and construction activities are described by the company; therefore, in the spatial database, only the parent economic unit for the same company name is represented. In the proposed study, the DENUE information layer corresponds to the interest points; by using these points, the required analyzes are performed to calculate the criminal and temporal densities, which will be detailed later.

Crime: It contains the punctual information of the crime that will be analyzed, and a relation between the crime type, location, and date of occurrence are established. The witnesses and the accused information were considered in the initial design; however, in Mexico, it is not possible to obtain these data.

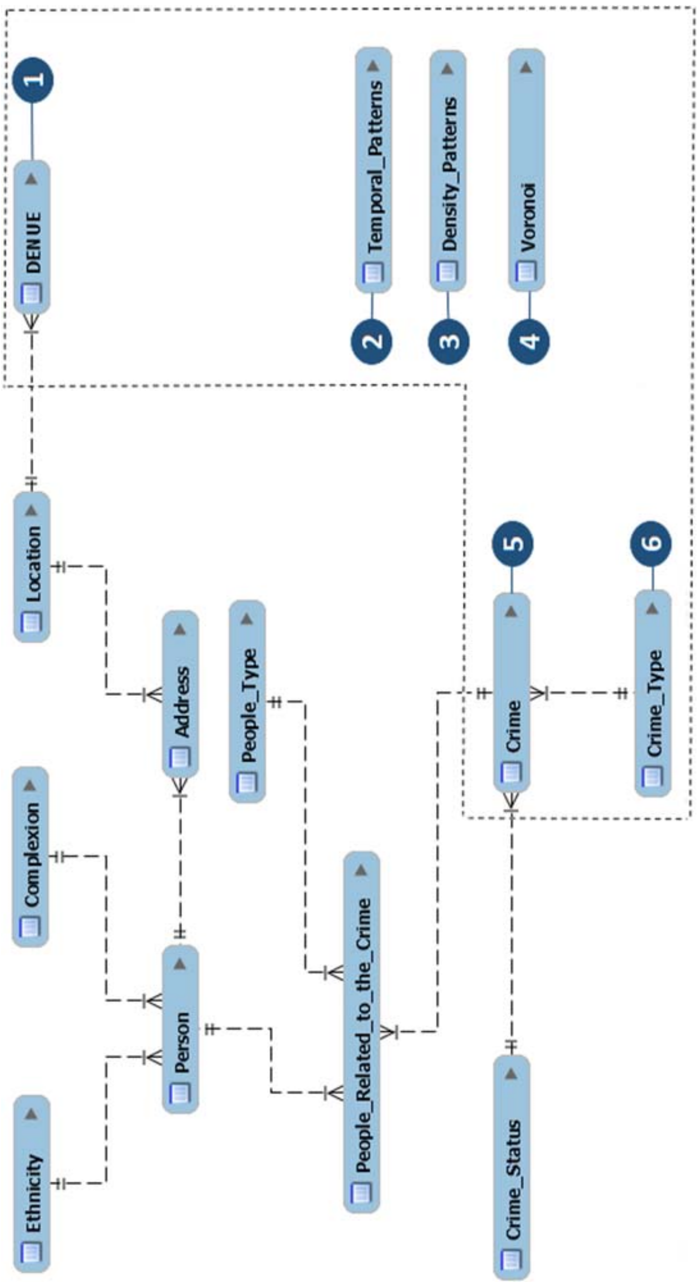

FIGURE 14.3
Spatial database model.

The data represented in ***crime*** and ***DENUE*** tables are used in the computation of criminal. One aspect to consider is that synthetic data were used for this case study because it is not possible to obtain information with real data.

Crime_type: The c*rime_type* table is a catalog of crime types. In this table, a relation of the type of crime with an identifier is presented; this identifier is generated and used to generate the patterns.

Temporal_patterns: These support table that stores the information of temporal patterns; the information of this table is generated when the analysis processes are executed.

Density_patterns: It is a table that contains information of crime density patterns by area; similar to the *temporal_patterns* table, this table receives specific information when analysis processes are running.

Voronoi: Support table helps to interpolate data through the information obtained, to generate a Voronoi triangulation. To calculate this table, a process generated in python is executed, which calculates the triangulation based on the geometric information obtained from a PostGIS table.

2.3 Analysis stage

In this stage, the analysis of the crimes is performed to determine homogeneous groups that can be classified based on similar characteristics. The Voronoi interpolation method was implemented to obtain common incidence areas, from a table of points that represents the crimes of a particular area. To calculate the Voronoi triangulation, a method based on the Fortune algorithm (Berg et al., 2008a,b) is executed. This algorithm was selected because it has linear propagation and *n log (n)* computational complexity, taking into account the source set contains a considerable number of points to generate the interpolation. There is a lot of documentation describing the implementations of this algorithm. Finally, the k-means algorithm is related to the classes clustering. Subsequently, to save the obtained results in the corresponding table, a connection with the spatial database is established. To do this, the following SQL statement is executed:

INSERT INTO voronoi(SELECT * FROM voronoi('denue', 'geom') AS (id integer, the_geom geometry));

Both, the generation of the necessary patterns and the calculation of the Voronoi triangulation, are processes that may take time to execute; thus, the obtained information is saved in the support tables to avoid constant computation of the Voronoi triangulation. However, this procedure can be performed manually. The Voronoi algorithm must be applied initially to be able to have a reference to the incidence polygon of each of the points that makes up the sample space. These polygons, which represent areas of affectation, are those that will be shown graphically with the purpose of describing the criminal map of the study area. Additionally, they are used in other calculations when original points are modified; the algorithm is applied again to be able to reflect the changes and update the information stored in the temporal tables.

On the other hand, the analysis stage also performs an analysis of crime patterns with the purpose of obtaining cartographic representations that allow analyzing and visualizing the spatial distribution of crimes. To do this, two methods aimed at generating this type of representations were proposed: the criminal density analysis method and the temporal incidence analysis method. Both methods were implemented in the Java language and performed a specific spatial analysis by means of a set of SQL statements in PostGIS. The criminal density analysis studies the frequency of criminal events in a determined buffer. The temporal incidence analysis inspects the frequency of criminal events in a given period of time.

Both analyzes can be applied in three types of levels: micro, meso, and macro; the difference is related to detail level that is selected from the sample set of the data analysis results. The *microanalysis* represents the highest detail level; for the analysis, a study area with a radius of less than 300 m is contemplated, which serves to locate nearby criminal events. The *mesoanalysis* represents a medium level of detail, which is calculated with a radius of affectation of crimes not greater than 700 m. Finally, the *macroanalysis* allows obtaining a general perspective of the analysis of crimes, contemplating a distance greater than a radius of 1500 m. The affect radius is the distance used by the analysis to retrieve data for the generation of patterns. The affectation radius can be interpreted as a measure close to the real value of the desired level of detail in meters.

As previously mentioned, the levels of analysis correspond to a specific detail level. An analogy can be made with the process of visually observing a painting. A *macrolevel* of analysis corresponds to appreciate the painting at a "far" distance, for example, 4 or 5 m, where only general features of the painting can be observed without being able to appreciate fine details of it. A *mesolevel* of analysis corresponds to approach the painting and observe it at a closer distance (2 m), at this distance the observer can appreciate new details of the same painting that could not be distinguished previously. Finally, a *microanalysis* would be the equivalent of appreciating the pint at a distance very close to the masterpiece, for example, 50 cm. In this position, the observer can even distinguish features of the strokes used to make the painting.

The analysis of criminal density and temporal incidence has a sequence of similar events, so they can be analyzed with the same use cases and the differences are related to the sequences that describe each type of analysis, the methods that are used to generate patterns, and the metrics necessary to quantify the obtained results. To generate the required results, two processes are applied: The first of them is to generate the patterns based on the stored information, and the second is a process that performs a shared analysis of the patterns generated in the first process. The pattern generation process consists of the following tasks:

1. The user selects the type of analysis and the level of detail, which are the input parameters.
2. The patterns are generated and a request is sent. Based on these parameters, the detail level and the type of patterns to be generated are decided. The information

of the DENUE is used as data input, searching for a relationship between this information and data contained in the *crime* table. Each punctual element of the DENUE table is compared with the punctual elements that describe a crime, taking into account the parameters of type of analysis and detail level.

3. The generated patterns are stored in the database, according to the type of analysis performed, there being one for each type of analysis.
4. The user is notified that the pattern generation process is completed successfully.

This pattern generation process is important because the results of the analysis processes are linked to the analysis developed in the process. This mechanism provides the advantage that if new data are captured into the database, they can be compared and displayed.

Criminal density patterns: The density patterns are composed by the set of points described in the *crime* table, which are distributed in a specific radius according to the detail level. The patterns are formed with the sum of incidences of the same type of crime as long as they are within the circumference formed by the radius of distance corresponding to each level of detail, which is denoted through the equation of the sum of the city block metric. Fig. 14.4 shows a spatial representation where a buffer of a specific radius is generated, which allows to estimate the crime density and their spatial distribution. In this figure, the general scheme of how these patterns are calculated can be identified. Additionally, a point of interest (white light color), depending on the desired detail level, generates a circle that surrounds the points (which describe the crimes), and the data contained

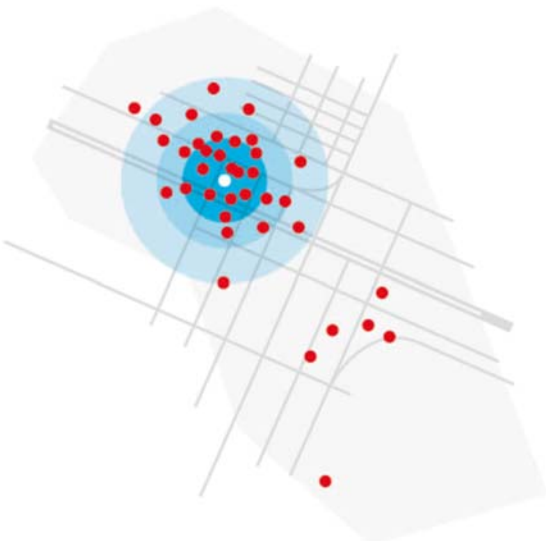

FIGURE 14.4

Spatial distribution of crime density.

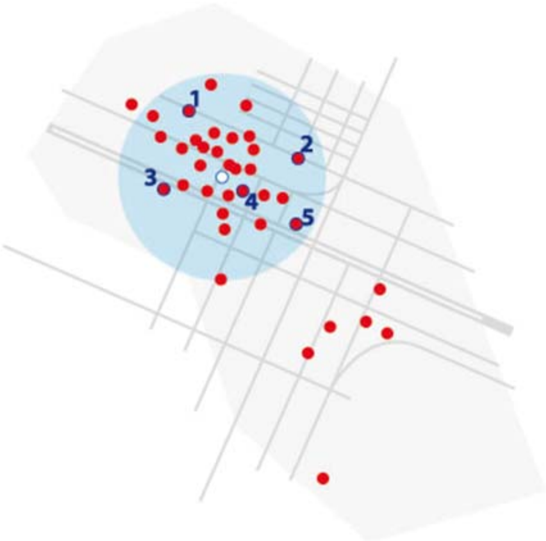

FIGURE 14.5

Spatial distribution of temporal density pattern.

within this circumference are considered in the analysis because they are within the affectation radius considered in this process.

Temporal incidence patterns: These patterns, such as the density pattern, are shown in a circle whose radius is based on the value of the selected analysis level. The differences of this type of patterns lie fundamentally in two aspects: The first one and possibly the most important is that the points are ordered with respect to the incidence date. The second refers to the input limit because it can be limited to a maximum number of points to consider for the analysis. By default, the value used in the ordering is equal to 10 points; in this way, the points are ordered and they are assigned into a temporal vector where the points are stored for later classification. It is important to mention that these points represent crimes spatially distributed in a given area, as shown in Fig. 14.5.

2.4 Pattern analysis process

To perform the analysis of the generated patterns, it is necessary that the support tables contain all the required data because the process is based directly on consulting and analyzing the results of the information contained in these tables. In consequence, the analysis process consists of the following tasks:

1. The DENUE point of interest is recovered (this point will be compared with the rest of point in the sample set). The objective is to map the crime according to the information of the point of interest to determine the related zones with similar pattern.

2. The analysis is started by recovering the information of the corresponding patterns (temporal or density according to the required analysis process).
3. The patterns are recovered, and the weighting process of the information is started based on the metrics; the obtained weight is generated with respect to the similarity of the points that are analyzed with respect to the point of interest.
4. These data are interpolated using the Voronoi triangulation method to obtain a layer of geographic data that represents the crime situation map.
5. The obtained Voronoi diagrams are displayed based on the weighted information that represents these areas. This information generates a series of sections with different colors according to their similarity.
6. This process is similar in the two analysis processes because the differences are related to the desired pattern and the metric used to quantify them.

2.5 Validation stage

In this stage, a validation process is carried out. It is based on a set of metrics that also corresponds to the criminal analysis. With these metrics, it is possible to correctly display the changes of the weighting process and, if it is necessary, to use the metrics in another report type.

Metric for density calculation: For the computation and weighting process of the criminal densities, the city block metric was used and consists on obtaining the values of each vector component by subtracting one against the same component of another vector, determining the absolute value of the operation and computing the sum of the obtained scalar values. This value represents the similarity of two vectors, where a result equal to zero represents equality between two vectors.

Metric for the calculation of temporal incidents: The Levenshtein distance was the selected metric to compute the similarity values of temporal patterns. This is an effective and widely used metric for the verification of patterns with hierarchical orderings. Finally, the pattern generated in the temporal chain that was previously determined is compared.

2.6 Visualization stage

In this stage, the visualization of the data is performed. In particular, the information that is displayed is in raster format because it corresponds directly to the results of the interpolation and classification methods used. The obtained results are displayed in a desktop GIS, presenting raster maps that describe both the crime density and the temporal incidence.

The results are presented in a colored form, which depending on the analysis will have a possible interpretation. For density patterns, in a specific area, higher red color is related to high crime incidence. In the case of temporal patterns, they represent areas with a similar criminal behavior in terms of crimes types, and these events correspond to a specific time range. On the other hand, a particular area with a clear color represents an area with similar behavior; otherwise, the behavior is different.

2.7 Case study results

In this section, a case study in Mexico City for decision-making related to criminal incidences is analyzed. Firstly, the density patterns at a certain detail level should be generated, for which the detail level must be selected (*micro, macro, or meso*); in this case study, the microlevel will be used. It is not necessary to define the radius of interest because a predefined value for each detail level was proposed. Fig. 14.6 describes a portion of the generated values for the density patterns.

There are two possibilities after obtaining the patterns. In the first case, a general analysis could be performed, in which all the patterns are compared with an ideal

	clase integer	idDenue integer	patrones character(100)
1	812410	4333	3,10,9,5,0,4
2	811493	48317	2,3,5,5,5,3
3	434313	48318	14,19,11,15,18,16
4	461160	48319	11,12,7,8,10,5
5	461110	48320	10,12,8,8,11,5
6	811499	48321	12,21,11,16,16,16
7	463113	48322	14,20,9,13,14,16
8	722219	48323	14,21,12,13,16,16
9	464112	48324	1,1,1,1,2,3
10	465211	48325	3,3,6,4,5,2
11	811430	48326	12,17,9,11,14,14
12	812110	48327	10,19,10,15,12,17
13	463211	48328	11,17,9,11,15,15
14	931410	48329	3,7,6,6,4,3
15	811115	48330	1,4,4,2,0,2
16	465311	48331	3,9,7,3,5,5
17	332710	48332	1,2,3,2,2,3
18	311830	48333	12,20,11,16,16,16
19	464111	48334	14,20,9,13,14,16
20	461122	48335	14,20,12,16,18,17
21	461170	48336	12,20,10,17,16,17
22	722212	48337	6,14,7,10,7,12
23	561432	48338	10,10,7,7,10,2
24	461110	48339	5,5,5,3,5,4
25	316211	48340	0,1,1,1,1,2
26	465311	48341	11,16,8,10,11,7
27	812110	48342	11,16,9,11,11,9
28	531311	48343	8,20,10,14,11,15
29	461110	48344	12,19,9,13,15,15

FIGURE 14.6

Density patterns generated.

pattern; the second option is to select a point of interest to generate a behavior similarity map. For this example, the behavior similarity map will be generated. For the next step, it is necessary to select or capture the geographic coordinates of an interest point in the DENUE data set and perform a density analysis for which a comparison of patterns based on the city block metric is performed. This process generates a discrete value that represents the density calculation, as shown in Fig. 14.7.

Subsequently, the raster data layer representing the Voronoi diagrams is generated. This option generates a file that corresponds to the areas with the highest or

	idDenue integer	clase integer	nombre character(15	geom geometry	discretizador integer
1	37997	467111	TLAPALERIA	01010000001	45
2	38008	461190	EXPENDIO DE	01010000005	10
3	38010	811499	COMPOSTURAS	0101000000D	40
4	38020	722212	COCINA EL B	0101000000D	2
5	38022	722219	CARNICERIA	0101000000E	2
6	38024	465912	EL GRAN DET	01010000002	8
7	38036	461110	CASA FELIPE	01010000005	18
8	38044	461110	MISCELANEA	01010000007	13
9	38053	541330	DESPACHO DE	0101000000B	14
10	38055	463218	VENTA DE SC	01010000006	15
11	38057	624412	RES DE ESTA	0101000000F	13
12	38067	622112	HOSPITAL GE	01010000000	17
13	38080	467111	REFACCIONES	01010000002	18
14	38091	722212	COCINA ECON	01010000002	2
15	38093	461110	MISCELANEA	01010000004	9
16	38100	811121	TALLER DE R	0101000000C	5
17	38113	465914	VENTA DE AR	01010000002	7
18	38115	532291	ALQUILER DE	01010000000	19
19	38123	463212	ROPA PARA B	0101000000C	18
20	38128	461110	MISCELANEA	01010000000	8
21	38130	325510	FERRO MEXIC	01010000001	12
22	38150	811111	TALLER MECA	01010000006	42
23	38151	713943	GIMNASIO	0101000000D	25
24	38153	468212	AUTOPARTES	0101000000C	28

FIGURE 14.7

Values obtained in the density analysis.

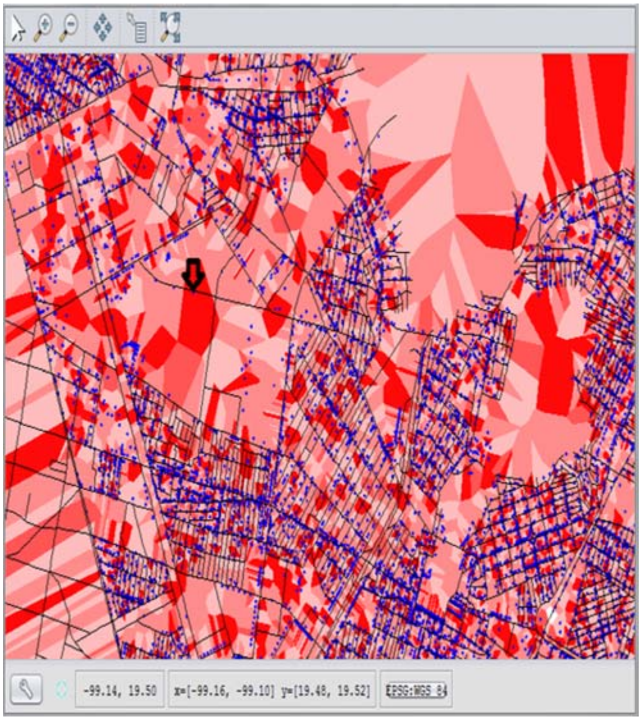

FIGURE 14.8

Example of crime density heat map.

lowest crime density index. To represent this information by means of a heat map, the values that are described by a high intense red color describe a greater criminal density, and the values with low red intensity represent areas with a lower criminal density. To make an adequate visualization and analysis of the obtained results, vector layers of complementary information corresponding to other thematic can be selected, such as the DENUE, the crime reports, and streets. In this example, the DENUE and street layers were used to observe and analyze the obtained information. Fig. 14.8 describes the system interface and depicts the results of the criminal density map, which is composed of the Voronoi diagram and vector data (DENUE and streets).

3. Density comparison

It is also possible to compare the obtained densities data with the purpose of identifying, from an interest point, the geographic regions that present similar criminal behavior. Similarly, as in the previous case, a raster heat map is generated, which is represented by a green intensities scale. Fig. 14.9 depicts the obtained result after a

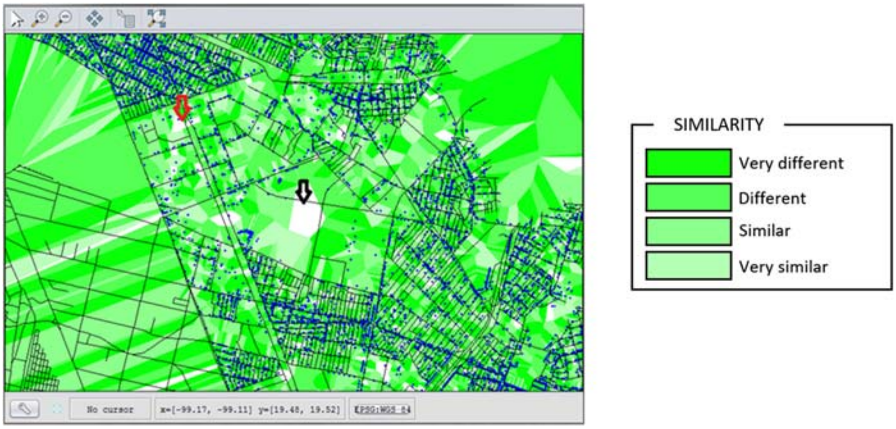

FIGURE 14.9

Example of density comparison heat map.

density comparison process using the same interest point in the previous section. In this figure, the interest area is represented by white color (the density difference of the origin zone with itself is equal to zero) and marked with a black arrow. Additionally, there is another white area, indicated in the figure with a red arrow. From this heat map, it can be concluded that these two white areas have almost identical characteristics, both in criminal activity and in crimes density. In other words, when two specific regions are represented with white color, these regions are more criminal related, otherwise, when the intensity is closer to an intense green, it indicates that the criminal behavior is different with respect to the interest area.

4. Different scale level analysis

In the previous section, we commented that using the proposed methodology an analysis in three levels of detail, micro, macro, and meso, can be performed. The use of different scales allows us to visualize the behavior of the criminal indices from a local to a regional perspective with the purpose of defining policies focused on reducing crime rates. Fig. 14.10 shows the obtained results in the three types of detail levels analysis using the same geographic object as interest point.

According to this figure, in Fig. 14.10A, the result of the analysis at a *micro*level is displayed, in Fig. 14.10B at a *meso*level, and in Fig. 14.10C at a *macro*level. These levels represent more to less detail, and it can be concluded that the values in the regions tend to "stabilize" On the other hand, areas that had already been evaluated in a specific category can change their similarity value. This change is due to the fact that when adding more calculation areas (greater detail level), the points that are closer to other point borders present a higher value because they contain more quantitative information for the density analysis. Another possible cause is that the range

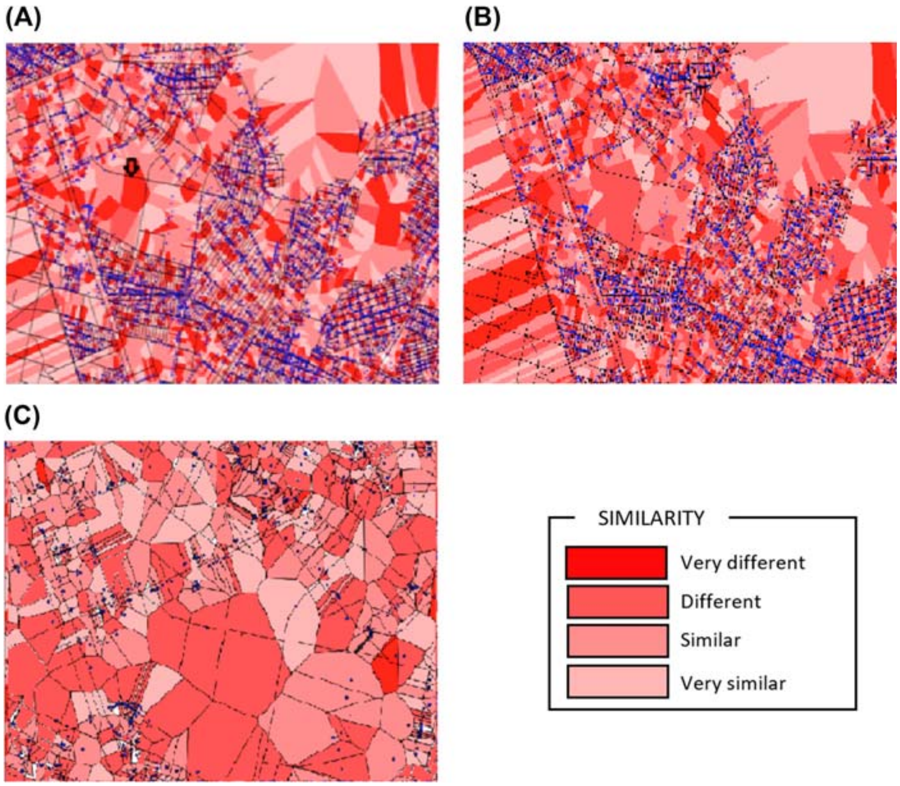

FIGURE 14.10

Example of density analysis using different detail level. (A) Using micro detail level. (B) Using meso detail level. (C) Using macro detail level.

of values is obtained from the maximum and minimum value of the interest points; if all the points increase their value, the ranges can also increase or decrease in quantities, generating a decrease or increase in the ranges according to the case study.

From this variation of distance ranges (detail level), it can be concluded that this "stabilization of values" represents the change of the statistical average of the sample data when the average is changed generally the values modified the panorama of the heat map since when the range of study is modified, the number of points that will be analyzed by pattern will also increase which produces an increase (or decrease) in the density average value.

5. Temporal patterns

For the study of temporal patterns, it is necessary to apply a sorting algorithm based on the occurrence date of a specific crime. Unlike the obtained result in the density

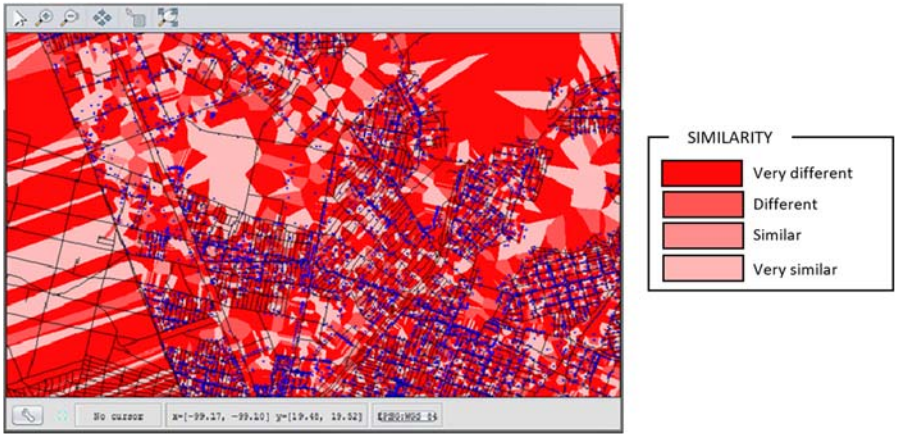

FIGURE 14.11

Results of temporal analysis.

analysis, this type of analysis requires the definition of an interest point to generate a heat map relating the point of interest with the rest of the points that define the sample data set, using the Levenshtein metric. Additionally, to calculate a temporal pattern, the number of maximum points for the definition of the string used in the *Levenshtein* metric must be specified.

Fig. 14.11 shows the results after applying the pattern analysis to a predetermined interest point, defining that the sample size is equal to a value of 10, using a microlevel of detail. The analysis is interpreted as follows: the data that present greater similarity are depicted by means of a light color, while those that have greater difference are described using dark tones in the heat map. Additionally, it stands out from the results that the use of a microlevel of detail allows the regions or zones to be clearly defined, compared to a meso or macro detail. Finally, as an order based on the crimes occurrence date is used, the analysis considers only the n-first closest criminal events by occurrence date. In consequence, the definition of regions is based on the temporal similarity of the criminal events.

6. Conclusions

The criminal phenomenon is complex and requires a deep analysis by specialists in this field, under the social context, because this phenomenon is continuous and presents diversified behaviors. Also, this phenomenon varies according to time and place because there are relations between the different entities involved in this problem. Similarly, it can be concluded that in larger area of study, the obtained analysis could be closer to the real behavior of crime incidence. This is due to the fact that when an analysis with a high detail level is performed, the obtained small areas present higher estimates of criminal indices with respect to the obtained results in larger areas analysis. Applying the analysis at *meso*level, the ranges of the area of study change and the values tend to stabilize. On the other hand, it is necessary to highlight that the studies at the three proposed levels of detail, *micro*, *meso,* and *macro,* correspond to diverse universes of interest, and based on the proposed approach, different tendencies with respect to the indices can be obtained.

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CHAPTER

15

An outlook of a future smart city in Taiwan from post–Internet of things to artificial intelligence Internet of things

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Chapter outline

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00015-6

1. Introduction

1.1 Smart cities

Usage and development of the Internet have rapidly increased since the beginning of the 21st century. Information and communication technology (ICT) has been widely used by governments, businesses, societies, and by people in their daily lives. In recent years, ICT has been a major consideration in urban development and management worldwide. In 2014, after the United Kingdom published standard specifications for smart cities (the PAS 180 and PAS 181 standards), governments of various countries also engaged in the planning and construction of smart cities and proposed smart city development plans. In recent years, Asian countries have used ICT policies to construct smart city development models and participated in ratings of smart city maturity in accordance with the measurement indicators of each international organization (Forum, 2017). Countries have also successively compiled blueprints for the construction of smart cities, such as SMART in China, the "u-City Smart City" in South Korea, the "i-Japan Smart City" plan in Japan, the "Multimedia Super Corridor" plan in Malaysia, the "Intelligent Nation iN2015 plan" in Singapore, and the "Intelligent Taiwan" plan in Taiwan. These blueprints have opened new windows for urban development in these countries.

Cities are continuously improving their digital infrastructure to solve problems in the daily lives of residents. These problems include those pertaining to food safety, disaster prevention, consumer shopping, environmental monitoring, home life, tourism, travel convenience, energy efficiency, care of senior citizens, and crime prevention. The objectives of these improvements are to achieve sustainable development, improve the quality of life, and enhance a city's competitiveness. The world is becoming increasingly data field, and the development of artificial intelligence (AI) and the Internet of things (IoT) have generated a wealth of data and smart applications that have played a crucial role in the feasibility of smart city initiatives. The future smart city ecosystem of Taiwan after ICT development is shown in Fig. 15.1. Using AI development, data collected from the IoT, data format exchange, big data, AI judgments and analyses, and automatic control devices such as robots, application services will be provided for people in all professions (METI, 2016) to improve living environments. Three major trends currently exist in business models: the IoT, big data, and AI (Tolentino, 2017). The maturation and commodification of AI in recent years have also increased the development of smart cities and accelerated digital city development. The relationship between these different aspects can be expressed as Smart City = digital city + IoT + cloud computing (Li et al., 2015).

The Industrial Economics and Knowledge Center (IEK) of Taiwan's Industrial Technology Research Institute expects that in the post-IoT era, AI smart devices will gradually enter our lives, and the industry's focus will be extended from the IoT to AI (Center (IEK), 2017). AI development has accelerated, with AI now used in image recognition, machine vision, voice assistance, and medical diagnosis.

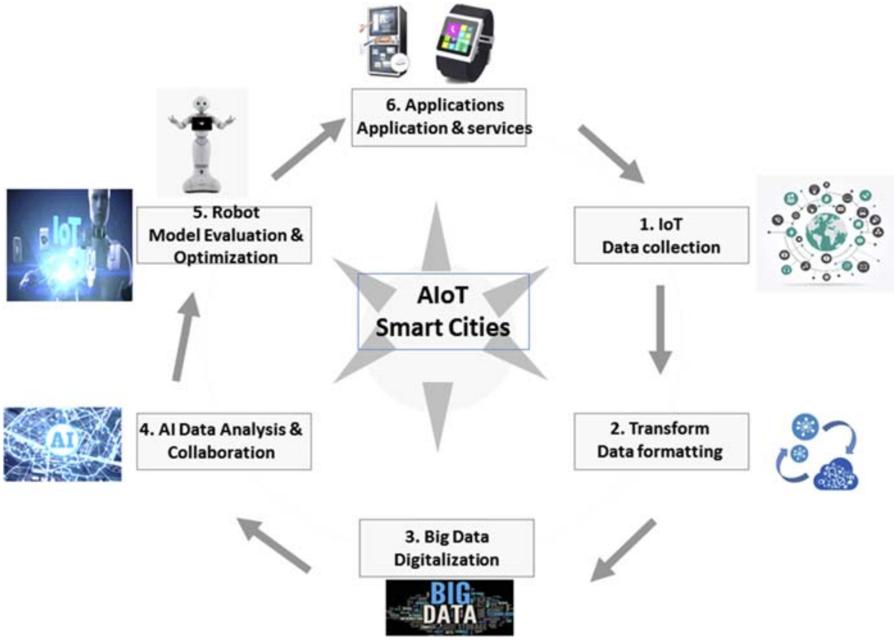

FIGURE 15.1

Ecosystem of artificial intelligence of things (AIoT) application in smart cities in Taiwan.

This has driven the restructuring of original industry chains; changes have occurred in integrated circuit design, terminal equipment, basic implementation, solutions, and application services. For examples, changes have occurred in deep learning algorithms required for various applications, processors suitable for neural computing, and sensor fusion used for machine vision. AI terminal devices will be increasingly designed and promote the future development of smart cities in Taiwan.

Ecosystem of artificial intelligence of things (AIoT) application in smart cities in Taiwan has linked people, data, and information together with urban problems. The previously untapped resources of cities have been released, and citizens, industries, and governments can develop new applications and services using these resources, improving infrastructures and applying automation to create new services for citizens. Smart cities employ technologies such as AI to change lives and enhance living environments and working methods. Technologies such as the media, the Internet, cloud computing, sensors, and mobile communications have been employed together to construct digital infrastructure (or the IoT). Innovation in this framework can be continued for new services such as communication, smart grid, traffic management, web conferencing, environment tracking, and public services. For cities facing recessions, the AIoT (AI + IoT) and digital infrastructure can offer opportunities for improvement and revitalization.

1.2 Artificial intelligence

AI is used in research and development-based simulations and extends and expands the theories, methods, techniques, and application systems of human intelligence. It is the driving force of technological development in the IoT era, and its research logic is based on reasoning, knowledge, and learning. AI is employed in knowledge representation, automated reasoning and search methods, machine learning and knowledge acquisition, knowledge management systems, natural language interpretation, computer vision, intelligence robots, automatic programming, and cognitive automation. Searle (Searle, 1980) classified AI as either strong or weak AI. An AI is strong if it has the same cognitive ability as humans, whereas it is weak if it does not have the same cognitive ability as humans and is designed only to appear as if it has intelligence. Intelligence gives an entity the ability to farsightedly and appropriately achieve functionality in its environment (Nilsson, 2009). AI theory and technology are becoming increasingly mature. For instance, the rapid development of ICTs such as big data and cloud computing has expanded the scope of AI application. The commercialization of technological products with AI has begun in recent years, and such products are entering our everyday lives; this trend is promoting a new round of research in AI. The structure of AI is illustrated in Fig. 15.2, and each component is individually explained in this chapter.

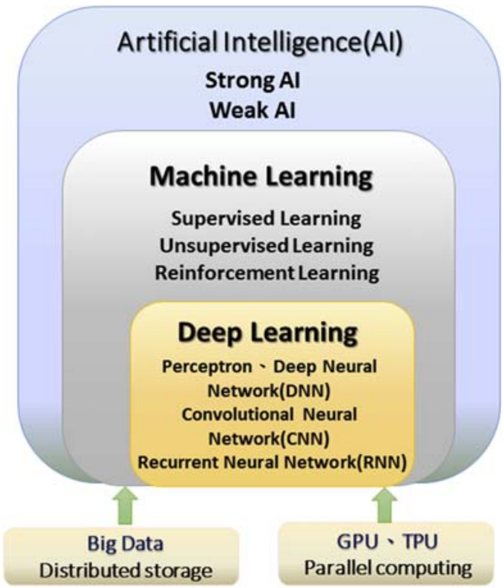

FIGURE 15.2

Structure of artificial intelligence.

1.2.1 Machine learning

Machine learning is a pathway to achieving AI. Using algorithms, a large volume of data is used for training, and machine learning is used for solving AI problems. After the training has been completed, a model that can be employed to make predictions is generated. Machine learning can be categorized as supervised learning, unsupervised learning, and reinforcement learning (Table 15.1). Given that traditional machine learning focuses primarily on pattern mining, reinforcement learning shifts the focus to decision-making, a technique that helps to promote AI further in depth into relevant fields of research and practice in the real world. The current research direction is to expand existing algorithms to a larger data set, followed by extensive application in fields such as data mining, natural language processing, biometric identification, search engines, medical diagnoses, detecting credit card fraud, DNA sequencing, voice and handwriting recognition, and robots.

1.2.2 Deep learning

Deep learning is the fastest-growing field of AI and is a mode of operation that simulates human neural networks. The common deep learning frameworks are multilayer perceptron's, deep neural networks, convolutional neural networks, and recurrent neural networks. Deep learning is employed in tasks such as visual recognition, speech recognition, natural language processing, and biomedicine and has obtained highly favorable results. To facilitate simulation, nodes (neurons) are allocated to multiple levels to simulate a neural network. Generally, there is one input layer and one output layer; in a deep learning network, there are also multiple hidden layers. Large volumes of IoT data are being generated because of the development of IoT applications. In combination with distributed storage and the parallel operation function of numerous servers, immense computing power is provided to promote the accelerated development of machine learning and deep learning. Deep learning uses several matrix operations to simulate the operation of neurons. Single computations in matrix operations are simple; however, when numerous computations are required, parallel operation is more appropriate. Graphics processing units (GPUs) were originally used for image pixel processing, and graphic processing is widely employed in the AIoT. The difference between central processing unit

Table 15.1 Different artificial intelligence categories.

Category	Subcategories
Supervised learning	Binary classification
	Multiclass classification
	Regression
Unsupervised learning	Clustering
Reinforcement learning	Q-learning
	Temporal difference

(CPU) and GPU frameworks is that CPUs have multiple cores to optimize sequential processing; by contrast, GPUs have thousands of small and high-efficiency cores that can be powerfully used in parallel computing.

1.2.3 Robots

Robots are one of the most obvious and powerful uses of AI. The use of deep learning increases the flexibility of robot functioning and can improve the accuracy of machine perception; much of computer vision and power and tactile perception are driven by machine learning and are crucial to advancing the capabilities of robots. According to a study by Stanford University, the most prominent places where AI is applied are in transportation, service robots, health care, education, low-resource communities, public safety and security, the workplace, and entertainment (Peter et al., 2016). According to observations made by the IEK of the Industrial Technology Research Institute, the AI industry has accelerated globally. In the future market, industries that integrate AI technology—for example, audio recognition, voice assistance, and medical diagnosis technologies—will experience substantial growth, and these technological innovations will eventually drive the restructuring of original industry chains (Research, 2018; Kyle, 2017). Current robots have the capabilities indicated in Fig. 15.3: data retrieval, data response, optical character recognition, natural speech recognition, multiple interface input and archiving, automated planning, report output, work assignment, and automated transmission to employees and customers.

In the current AI era, robots are gradually being used to perform a number of jobs that are traditionally performed by humans; the number of jobs that have been replaced varies according to the degree of automation of each country. By 2030, approximately 40% of jobs in the United States and 30% of jobs in the United Kingdom will be performed by robots (Hudson, 2017; Jenkins, 2017).

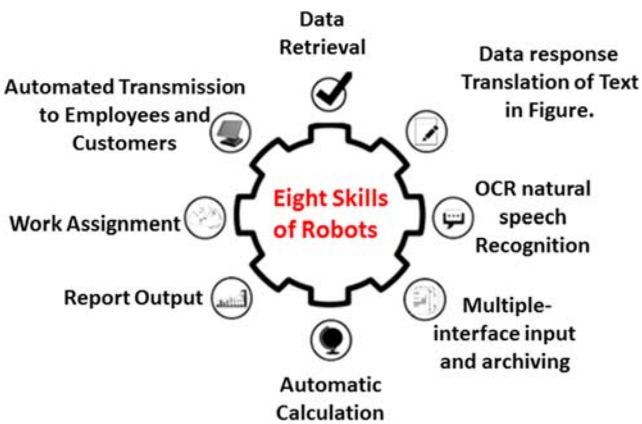

FIGURE 15.3

Eight skills of robots.

1.3 The Internet of things

The IoT uses technology to attach electronic labels to products that can receive information but were originally unable to connect to the Internet; users can then use the Internet to identify the location of the product and obtain information collected by the product. The centralized management of the computer, equipment, and even operating personnel can be employed to simultaneously position, remote control, and search for devices and automobiles in homes. IoT equipment has been developed and has a variety of applications such as in health care, conversion, agriculture, industry, market, smart homes, smart campuses, smart cities, and transportation (Al-Fuqaha et al., 2015; Nivetha et al., 2017).

IEEE P2413 states that the IoT comprises the following layers:

(1) Perception layer: The perception layer is also called the recognition layer (Suo et al., 2012). It is the lowest layer in the conventional IoT architecture. Components with sensor or recognition capabilities are embedded into various real objects. The sensing components are temperature, humidity, pressure, brightness, flow, distance, acceleration, pressure, gas, and other sensors or instruments that sense environmental changes. Each object has its own dedicated identification by means of a bar code, radio-frequency identification, or network name. Through identity recognition and feedback, the receiving equipment is informed of changes in the environment of each object or instrument.

(2) Networking and data communications layer: This layer is the brain of traditional IoT framework (Al-Fuqaha et al., 2015) and its primary responsibility is to help and ensure data transmission between the IoT framework application and perception layer (Suo et al., 2012). Using various low power consumption wired and wireless network protocols, wireless communication technologies upload data from various sensors to cloud servers. A new generation of networks comprising those of software and hardware component firms, network communication equipment suppliers, telecommunication operations service providers, Internet service providers, and cloud service suppliers have various wireless network protocols. As mentioned, all objects in the IoT possess networking capability and can transmit sensor data across the Internet; some components can also receive commands from and be controlled by remote users. To this end, the networking layer provides a service channel between objects and users, and transmission can be wired or wireless. Interconnection is enabled by common communications technologies such as 3G, Wi-Fi, NFC, Beacon, Zigbee, and Bluetooth, as well as the communication protocols commonly used in industrial networks such as Modbus, PROFIBUS, FieldBus, and CANopen.

(3) Application layer: The application layer is considered the top layer in the traditional IoT architecture; it provides personalized services based on the relevant needs of users (Suo et al., 2012). The primary responsibility of this layer is to connect the major gaps between users and application programs and combine the industry to realize various advanced intelligent responsive solutions and handle the management of all smart applications.

From technological and social aspects, the IoT is crucial in many fields (Center (IEK), 2017). Available technologies and system architectures are utilized to effectively integrate the relevant signals, networks, and protocols of sensors and microcomponents in the bottom layer. The operating system, middleware, cloud solutions, application program interfaces, data management, and big data of the software architecture are employed to process signals transmitted by the perception layer for the use of various services and application systems in smart cities. For data management in the entire IoT, most equipment should have self-management and self-optimization functions (Silva et al., 2017); thus, automatic transmission of data can be maintained in the complex IoT system. This complex system is divided by the IEEE into seven modules and items, as shown in Table 15.2.

The IoT can be represented by the following formula: IoT = services + data + networks + sensors (Atzori et al., 2017; Bilal, 2017). The ubiquitous connectivity, system interoperability, and analysis of new IoT application programs are prompting the implementation of smart city concepts worldwide (Sun et al., 2016; Jayaraman et al., 2017). Through “perception” and “networking,” objects transmit data to the cloud or a database; analysis is then performed to develop a variety of applications or services.

The safety objectives of IoT equipment are confidentiality, integrity, and availability (Farooq et al., 2015; Lin et al., 2017). New technologies are used for managing the end-to-end security and privacy of next-generation IoT systems. These systems have a strong effect on performance evaluation techniques (Ngu et al., 2016) and feature security requirements that vary according to different applications (Lin et al., 2017) to protect user privacy and the data security of access control.

1.4 Big data of smart cities

1.4.1 Definition of big data

Garner analyst Laney (Laney, 2001) indicated that big data has three major challenges and opportunities; these challenges and opportunities are abbreviated as 3V: volume, velocity, and variety (Laney, 2001), which are combined with veracity and value to become 5V. Data sources are diverse, and data types vary widely; most data are unstructured and have a rapid update speed, which is a characteristic of big data. To use big data to create value, the data must be authentic (Beyer and Laney, 2014). Big data analysis is based on data science and mainly aims to find underlying meanings and potential relevance from a large amount of data (Sun et al., 2016). The theories and methods used in big data analysis may cover disciplines such as signal processing, probability and statistics, machine learning, statistical learning, and data mining.

Table 15.2 Technological and social aspects of the Internet of things (IoT).

Functional module	Items	Description
Management	• Touch management. • Auto- and self-organization of large IoT systems. • New processes and organizations.	All items operate in a fully automated and self-assembling manner and can join new processes and organizations with flexibility.
Enabling technologies and system architecture	• Sensors. • Gateways and MicroSystems. • Protocols. • Energy management. • Organization of sensors networks.	Protocols, energy management, the functions of various original components, and the organization of sensor networks are supported.
Software architecture	• Operating system. • Middleware. • Cloud solutions. • Application programming interfaces (APIs) and interfaces. • Data management and big data.	Software architecture supports the functions of all types of operating software, middleware, cloud computing solutions, APIs, data management methods, and big data interconnections.
Services and applications	• Trials. • Specific services (e.g., smart cities). • Applications	A wide range of smart city application services can be provided.
Business models and ecosystems	• New business models. • New value chains. • Creation of new ecosystems. • Application domains.	The IoT generates new business models, new value chains, and new ecosystems.
Social impacts of IoT	• Impacts and acceptance of users. • Change in the societal organization. • Democratization and control of the infrastructure.	New business models cause conflicts due to the nonacceptance of users and existing social organizations and also affect urban and social infrastructure needs, generating changes.
Security and privacy	• Management of personal data. • Privacy and security framework for IoT.	The basic confidentiality, integrity, and availability requirements must be met for the construction of personal data privacy and information security frameworks.

Source: IEEE Internet initiative, May 2015, organized by this study.

Although open data is a type of big data, big data is not the same as open data. Open data refers to the unconditional opening up of source data managed by private organizations or public sectors for use by anyone. In recent years, source data from the public sector have been widely discussed. Many nongovernmental organizations have advocated that public sector data be owned by the public. Unless personal privacy is involved, the public sector should make data unconditionally available, giving the public access and enabling individuals to use data for value-added applications in addition to browsing.

1.4.2 Data perception

Data perception is the realization of interconnection through the installation of sensors to connect data, systems, and humans using an unprecedented method. Interconnected and intercommunicating objects are cocreated such that the objects and people in any city framework system can communicate and coordinate with one another. For data used in the initial phase of edge computing, new models that have storage and higher computer power can convert voluminous data to provide a basis of analysis for actions. Because of the existence of these information and data, more accurate and objective intelligent decisions can be made. Following the rapid development of social networks and mobile devices, a large amount of data is produced in smart cities, particularly spatial information, video frequency, and other types of unstructured data. Big data poses analytical challenges, and data mining theory must be utilized to effectively store and manage Big data, rapidly retrieve and process data and information, and mine information and knowledge from big data, thereby extracting full value from it.

1.4.3 Data management

In big data analysis, problems are encountered such as identifying data format or presentation methods, and issues such as incomplete data, the presence of noise, and data inconsistency must be overcome before big data can be used effectively. Accordingly, data integration, cleaning, and conversion must be performed. Because of the massive amount of data and their rapid changes, distributed file systems (DFSs) are generally used in coordination with subsequent distributed analysis processing to enhance overall system efficiency. A DFS of big data allows files to be shared across multiple hosts using networks and enables multiple users on multiple machines to share files and storage space.

The most considerable risk to big data is its users. Big data users must be vigilant and not be overly dependent on data; big data should be controlled, rather than controlling its users. Three control strategies exist: first, to protect the privacy of personal information, users should not be asked to agree that their data be available for use. Instead, data users should be held responsible for their own actions. Because data reuse is becoming increasingly common, the burden of responsibility will be transferred from the public to the user. Second, instead of declaring guilt based on predictions, society must adjust their perception of justice, and the law must explicitly declare that people are only accountable for their own actions, but not their inclinations (Huang and Zhao, 2017). Third, the big data era will require a new type of professional to specially examine the legitimacy of data sources, analyze the suitability of tools (algorithms), and assess the reasonableness of result interpretations to ensure the accuracy and effectiveness of applications.

1.4.4 Data mining

Data mining is a continuous cycle of operations formed by a series of actions. Different scenarios are designed according to individual needs. Next, after evaluations are made using data mining engines, technology such as graphical interfaces is used to present the mined results concisely and clearly to users. Users then provide feedback on their usage experience to the system, facilitating continuous optimization; information that has undergone pattern evaluation is treated as new knowledge and stored in the knowledge database. Data mining is the use of statistics, AI, or other analysis techniques for in-depth search and discovery within historical big data for unknown and hidden relationships and rules, achieving the results of classification, estimation, prediction, affinity grouping, and clustering. The results are then presented to the user in the form of a report or web portal. This effectively completes a variety of business processes, enhances performance, and strengthens overall competitiveness. After data format conversion and edge computing of data generated by the IoT, data are large or complex, and challenges include data capture, data storage, data analysis, data management, searching, sharing, transmission, visualization, querying, updating, and information privacy (Faghmous and Kumar, 2014). However, data mining is more likely to be used for predictive analytics, user behavior analytics, advanced data methods (including AI), and not only for the size of data sets. Additionally, the increasing prevalence of data-as-a-service solutions will enable organizations to analyze data without the need to establish a data science department, which will be highly beneficial for small- and medium-sized firms with small budgets.

1.4.5 Data vitalization

The business models related to big data can be roughly divided into the following types. For the first type of data, realized from existing data, product or marketing strategies are formulated according to the data to enhance the products. For the second type of data, the data are used to enhance firm competitiveness; the effect of such big data projects cannot be directly linked to revenue, but instead it results in an enhancement of internal work efficiency or a reduction of decision-making costs. For the third type of data, data are used as the basis and core of services and are employed to overturn traditional industries; from the first day of operation, data are used as the core of business.

The retrieval, storage, management, mining, and analysis of big data may encounter different problems in different usage scenarios. Big data is no longer a tool; it is also a type of business thinking and a business model. Because of the rapid growth of data volumes, decreases in storage equipment costs, evolutions of software technologies, and maturation of cloud environments, a variety of objective conditions have been established to enable data analysis to evolve from understanding historical data to predicting the future and even defining new perspectives, creating a completely novel business model.

Big data analysis also has all the risks of traditional business analysis. Personal information security problems have always existed (Wu and Guo, 2016); however, with the increasing number of data sources and increasing volumes of data, the problem of information security appears more urgent. Another issue of concern is the "dictatorship of data problem" that big data may bring. According to Mayer-Schönberger and Cukier (2014), dictatorship of data is the use of data to control users to blindly accept the conditioning of analysis results, which results in a risk of abuse or misuse of data.

For a city seeking to attain smart status, data mining has become an effective approach to conducting big data scientific discovery and exploration to solve critical problems and satisfy actual needs. By mining the big data of smart cities, natural and social changes can be explored and discovered, including the changes in the lives, behaviors, and preferences of residents and trends in social thought and public opinion. The acquisition and transmission of big data depend on the Internet having wide coverage and rapid speeds; therefore, the spread and upgrade of Internet infrastructure is a crucial component of smart city construction. Data visualization technology can present complex city data to users in a concise and orderly manner, filling the understanding gap between technology and users. Driven by the application of city data, data visualization will inevitably become a crucial part of smart city technology systems.

1.5 Design of artificial intelligence business applications

The IoT and AI are currently changing the interactions between people, equipment, and data in every domain of life. Being more than just cutting-edge technology, they are causing a digital transformation of industries and reconstructing business. AI can make predictive insights based on a large volume of historical data and real-time observations. By simultaneously analyzing past and real-time data, AI easily identifies which data are exceptions and makes reasonable inferences; the importance of data in AI is self-evident. The IoT has a highly crucial mission: data collection (Mayer-Schönberger and Cukier, 2014; Ojinnaka, 2017; Yinyama, 2016). AI requires continuous data flow, and modular designs employ an open collaboration mechanism module for evaluation and continuous optimization. The more the data a system can process and learn from, the higher the accuracy of its predictions.

1.5.1 Artificial intelligence open collaboration mechanism

From the perspective of software design, the abilities to rapidly respond to market or customer needs and collaborate are an integral part of software development. The open collaboration mechanism plays a crucial role in AI, and businesses and organizations are beginning to use such mechanism as a means to obtain value from large volumes of numerical data. AI systems can rapidly consume voluminous structured and unstructured data and assign meaning to them through the creation of entities and conceptual models as well as the relationships between them. They generate assumptions, formulate answers to questions, and make predictions and recommendations that can be used to increase human intelligence and improve decision-making (Hupfer, 2016).

Developers can follow a variety of procedures and standards to ensure software quality and reliability and the compatibility of their programs with those created by others. Because of the growing popularity of the free software movement, much of the software that is being created is provided for public use. Naturally, the next step involves combining separate program components into a broader, coherent intelligence system. Because the software community has already created numerous components, the simplest integration method is to enable easy communication between components. A single developer can immediately integrate their modules into other projects by using common routing protocols. Each component becomes a module itself and can be employed in various setups and configurations of large system architectures to provide a variety of application services in smart cities (or within communities).

1.5.2 Model evaluation and optimization

The primary goal of machine learning is accurate prediction, and it is hoped that the service model we have constructed is as accurate as possible. When this model is employed during production, the resulting predictions are of high quality (Brink et al., 2016). The performance of a model should be evaluated to determine how it performs with new data, and after construction the model must be optimized according to changes in user needs. Brink et al. (2016) described the flow of machine learning model evaluations for unbiased estimations of model performance (Fig. 15.4).

AI uses data processing and algorithm operation to obtain meaningful information and to increase the intelligence of machines beyond that of humans (Hardoon and Shmueli, 2013). Machines can learn automatically, find rules among big data, and then make predictions. At present, research and innovation in the field of AI is still concentrated on new algorithms, model training techniques, and optimization methods. To maximize the potential of AI in practice, new abstractions must be implemented, and new interfaces, systems, and tools designed to help developers more easily develop and deploy smart applications. These tasks probably represent disruptive and fundamental changes (Mckendrick, 2017); design and development methods must change dramatically. Accordingly, new platforms and tools will appear at every level of the overall system in an attempt to optimize the normalization of AI development. Only a small portion of the code of AI systems is dedicated to learning and making predictions, and most of the code is used for preparing data, developing functions, and enabling the implementation of the distributed infrastructure. Modules must provide cyclical optimization, thereby scaling the implementation of various application needs of smart cities.

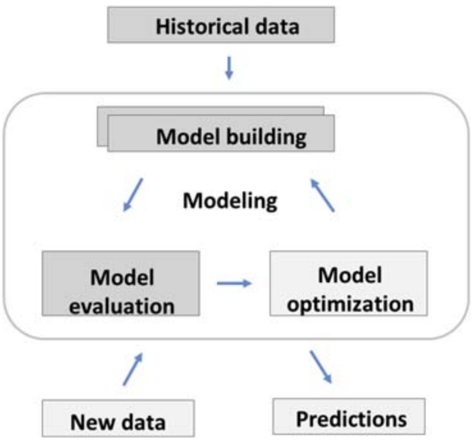

FIGURE 15.4

Model evaluation and optimization.

By Brink, H., Richards, J.W., Fetherolf, M., 2016. Real-World Machine Learning: Model Evaluation and Optimization. Developer. Available: https://www.developer.com/mgmt/real-world-machine-learning-model-evaluation-and-optimization.html.

To respond to trends in the future era of data, real and virtual spaces, IoT, big data, and AI technologies will be integrated to realize a future world driven by data. Strategic IoT plans will realize a new social pattern of robotization, customization, and a sharing economy through the technological innovations of IoT, big data, and AI, and the needs of a new type of smart city will be met.

2. Development of smart cities in Taiwan

2.1 Strategic planning

Smart city construction and urban planning must manage the relationships between cities, residents, technology, spaces, resources, and fairness (Dameri, 2017). In 2006, Taiwan proposed six major strategic development goals for the living technology industry. It intends to construct a vision of a future life of "smart living" and makes every effort to develop smart environments, smart cities, and smart spaces through the cooperation between industries, the government, and the academic sector. By using the concept of "new technology, new thinking, and new methods," it is hoped that the advantage of Taiwan's ICT industry can be fully utilized using the cross-disciplinary cooperation of industries such as the construction, interior design, industrial design, and cultural and creative lifestyle design industries to build smart cities in Taiwan that are green and environmentally friendly and have happy residents.

Based on the development of e-Taiwan and M-Taiwan, the establishment of a complete ICT environment through the development of an optical broadband network infrastructure enables designers to create a diversified environment for smart lifestyle application. The construction of digital housing, smart shopping malls, and other smart buildings, as well as the life applications of the Taipei EasyCard, all establish a technology application model of smart living.

2.2 Implementation of the value of smart cities in Taiwan

The government is obligated to use network infrastructure to make information available for public use. The coverage of the network must be dense without generating a digital divide, and even if the information is in place, its format should be open and easily accessible by the public. Previously, a gap existed between the public and private sectors. However, the promotion of smart cities requires cooperation between the public and private sectors; for the government to promote smart policies, they must use language that can be understood by industry and consumers to help industries understand where business opportunities exist and how consumers can benefit.

Governments and businesses use various types of interactive equipment to enable the public to experience digital innovation and establish a model of urban living with u-transportation, u-shopping, u-safety, u-convenience, and u-energy saving, realizing the vision of a smart life. The governments of each city in Taiwan each have their own planning and construction focuses. Taipei City promotes broadband coverage and smart government and has three major strategies—e-government, e-community, and digital life—to forge Taipei City as a green city with ubiquitous smart technology. To attract investment by innovative enterprises and manufacturers, Kaohsiung City provides incentives for the development of optical buildings (communities). New construction projects that cooperate with the digital construction policies of the Kaohsiung City government and introduce and construct buildings (communities) with fiber broadband networks can have higher floor area ratios if the change is deliberated and approved by the Kaohsiung City government.

The public sector uses urban design incentives to encourage the construction of smart buildings and communities and creates a ubiquitous and smart living environment and new urban aesthetics through the renovation of urban public places. Summarizing the opinions of expert scholars in all fields, the Corporate Synergy Development Center of Taiwan organized the 10 major application service trends and services of smart cities. The status of smart city implementation is detailed in Table 15.3.

Smart technology entails a considerable economic scope and scale. Telecommunications networks can be used to produce smart grids and manage tap water, gas, and traffic. Analyzing the data received from each system can produce useful information, provide insight into city operations, and enable high-level benefits such as economic stimulation, social innovation, and community participation.

In terms of economic stimulation, information technology brings innovation and business models to a city, linking individuals, industries, governments, and technology developers. Public data are employed to develop applications that solve new

Table 15.3 Summary of application services in six major cities in Taiwan.

Application service	Services
Smart governance	Weather forecasting system, open data platform, integrated disaster prevention system, waste management
Smart traffic	Internet of vehicles, smart traffic system, electronic toll collection applications, smart parking, traffic detection
Smart logistics	Logistics and warehouse management, logistics and vehicle cargo management, agricultural traceability, smart packaging
Smart finance	Payment, insurance, financing, fundraising, investment management, market supply
Smart health	Electronic health records, smart hospitals, personal health management
Smart energy	Demand response system, solar photovoltaics, wind power generation, smart meters
Smart security and safety	Smart policing, debris flow observation, water pollution monitoring, earthquake warning system, air quality monitoring
Smart campus	Smart learning, smart administration, smart green energy, smart management
Smart family	Smart home security, smart community, smart care, smart lighting
Smart life	Accessible services, smart guidance, smart tourism

Source: Corporate Synergy Development Center (2017).

problems in individual lives or activities. ICT also guides industrial development, initiates new services, and develops new systems.

In addition to increasing the efficiency of government services, the operation of smart cities also brings benefits to citizens in terms of social innovation. Regarding citizen participation, the opinions of the public can be obtained through mobile phones, computers, and telephones as 24-h public information, and residents can access general everyday life services. These types of data are highly valuable for the intellectualization of a city.

In recent years, some cities in Taiwan have begun to integrate ICT programs and policy objectives to promote smart city development. They have summarized the smart services that have been implemented or that are currently undergoing planning and implementation in major cities in Taiwan such as New Taipei, Taipei, Taoyuan, Hsinchu, Taichung, and Kaohsiung (Table 15.3).

3. Conclusions

Following the popularization of smart cities (Visvizi & Lytras, 2018a) and spread of a new generation of ICTs, smart communities are destined to prompt rapid development. To develop their city, government leaders should begin by understanding local development, needs, and actual conditions, define a vision according to the degree of urgency, and establish central guidelines and a direction to maintain. All departments of city governments must work in accordance with this guideline, the results must be quantifiable and evaluable, and the sequence of investment should be determined by the budget (Visvizi & Lytras, 2018b).

To transform or construct digital infrastructure, each city must render information transparent and coordinate cooperation between the internal organizations of the government. Smart cities are developed under the cooperation of the public and private sectors (government and enterprises); some aspects are controlled by the government, whereas others are controlled by enterprises and social organizations. Transformation can be viewed as "from the inside out" or "from the outside in." Using an open cooperation model to promote the construction of a smart city enables citizens and governments to both participate in the vision of a smart city and has transparency and inclusiveness (Neirotti et al., 2014). This chapter earnestly recommends that a city undergoing smart city development should heed the following recommendations.

First, to use digital industry to enliven the economy, smart city development must involve cooperation between the public and private sectors. The government must support the output of digital products and services, make a wide range of digital infrastructure investments, and establish a platform for building partnerships. A city is made smart through a nonlinear process. During the process, each region has a different degree of maturity and must adapt and learn as early as possible.

Second, the government should be prevented from employing nonopen methods of cooperation when signing strategic cooperation agreements with individual enterprises, which would covertly exclude other enterprises and restrict the healthy development of their smart city.

Third, "smart" integration in smart cities should be based on the applications of AI and big data, that is, the ability to summarize the past and predict trends. Big data analysis has benefits for the monitoring of a city's operational data and improves urban management and service optimization.

Fourth, regarding information security, which has the highest priority during smart city construction, the government should focus on the grading and classification of infrastructure and continue to deepen the data protection in the network infrastructure and information resources. Enterprises should strengthen industrial cooperation, working together to promote the development of the information security industry.

Under the competitive trend of globalization, the transformation of urban space has prompted new development thinking and strategies, and the construction of digital neural networks has established new working models for cities (Sta, 2017). The journey of innovation and exploration is continuing into the future. By employing pioneering design thinking and practice, designers can establish new design paradigms with intelligence and interaction, energy saving, environmental protection, and cultural innovation characteristics. Construction of an urban development concept and strategy that combines ecological sustainability, local cultural characteristics, and a smart environment enables local and global trends to advance together, creating an urban atmosphere with local characteristics. Additionally, such construction will accumulate competitive capital, create new urban competitiveness, result in a new city lifestyle with urban aesthetics and ideals, and increase the happiness of residents through the creation of a smart city.

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CHAPTER

Smart energy in smart cities: insights from the smart meter rollout in the United Kingdom

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Chapter outline

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00016-8

1. Introduction

Policy makers and the energy industry in the developed countries largely see smart metering as an integral part of the energy transition toward renewables and as an enabler for the smart city energy vision, including smart grids, large-scale integration of electric vehicles, decentralized power generation, and large-scale energy efficiency. The European Union (EU) and most of its member countries took major steps toward upgrading 80% of electricity and gas meters to smart meters within 2020 with the goal of achieving potential large-scale energy efficiency and digitalizing the energy grid.

As implementation of major infrastructure projects such as the smart meter rollout arguably depends on social acceptance to become a long-term success, this chapter first aims to showcase how commercial aspects might have been considered above the need of people in the rollout of smart meters by examining the interest in and the perception of these smart energy-enabling devices amongst the involved stakeholders. The chapter will begin by giving a thorough introduction to the topic of smart metering and its connection to smart energy cities, before going into the above-mentioned analysis of stakeholders.

2. The smart energy vision

Today's power system is becoming outdated. Many of the power plants supplying our electricity were built in the 1960–1980s, and the power grid was designed for these large, centralized fossil fuel power plants to provide power for many (Hodgson, 2017). Growing environmental concerns, a significant price decrease (Merchant, 2018), and the prospect of energy independence have resulted in a continuously greater amount of renewable energy generation in our power systems, thus transforming the power generation from large centralized plants to millions of decentralized power plants—located in households, commercial buildings, farms, and so on. This is a task for which the current transmission and distribution infrastructure is not well suited.

The intelligent grid or the so-called smart grid is in a sense the smart energy vision in practice; a power system connected to the Internet, where communication and energy can move power bidirectionally (Servatius et al., 2011), that is, not only from the grid to the house but also from the house back to the grid. Both energy and *data about the energy* are generated at different points in the grid. This is highly useful and will potentially make energy consumption and production more efficient than it is today, unlocking the so-called negawatts, as well as integration of electric vehicles and energy storage for today's power grid.

3. What is smart metering

Smart metering refers to a network of smart metering devices called *smart meters* or *intelligent meters* that have certain capabilities which traditional metering did not allow. Effectively, smart metering is connecting our energy and water consumption to the Internet. Table 16.1 shows some of the components that are present in such a system, although components may vary because of different standards and geography (Uribe-Pérez et al., 2016).

Smart meters are a result of the evolution of traditional energy meters for gas, electricity, water, and heat. Conventional meters are analog and do nothing but measure the electricity that passes through them. To read off the meter, the utility company has to be physically present, which is both inefficient and inaccurate, because of that single reading done per year. The smart meters' ability to send and receive data allow them to send of automated readings frequently (e.g., every 5 min), communicating prices to the customer in real-time and perform commands which enables demand response where a consumer can be rewarded for turning off appliances such as when the grid is reaches its capacity limit (Uribe-Pérez et al., 2016).

Table 16.1 Components and functions of a smart metering system.

Component	Function
Smart meters (smart metering device)	Measure the energy consumption of the end user and obtain data that are communicated to the utility or system operator.
Data-gathering device	Gathering of meter data from many smart meters and may or may not process these data before communicating them to the utility or system operator.
Centralized management system (AMM—advanced metering management system)	Collection, storing, and processing of meter data
Communication system	Enabling the flow of data in the advanced metering infrastructure using one or several different wired or wireless communication technologies such as ADSL, RF-Mesh, or GPRS.

4. Pros and cons

The capabilities of smart meters offer a whole lot of opportunities as well as challenges and issues regarding data management, and the possible outcomes if they end up in the wrong hands. As an example, collecting accurate readings of citizens' energy consumption over time makes it possible to create highly detailed profiles on how individuals live and their habits (Kovacs, 2017). This is personal and sensitive information and can possibly be used for marketing purposes or can cause harm (Buchanan et al., 2016). On the other hand, a smart meter makes it possible for the energy company to bill according to what is being consumed rather than an estimation from the year before, which is a normal procedure with conventional meters. This means putting an end to having to pay back at the end of the year if consumption has been more than estimated, or vice versa.

Another important argument for upgrading to smart meters is the gap between how people understand their energy consumption and the reality. Electricity is intangible and difficult to relate to in absolute numbers without experience. How many Wh(watt hours) does ones washing machine use? Smart meters will make it simpler for citizens to understand own consumption when the metering becomes more detailed (e.g., visualized in mobile apps, home display, etc.) and available (e.g., real time or as often as consumer would like), much like using a credit card that entitles the customer to a more detailed account statement at the end of the month (e.g., overview of spending for groceries and public transport) than if citizens only withdraw once and paid everything a month by cash.

5. The connection between smart metering and smart cities

Energy has a fundamental role in our society and our cities, for covering private, societal, and commercial needs such as heating, cooking, transportation, lighting,

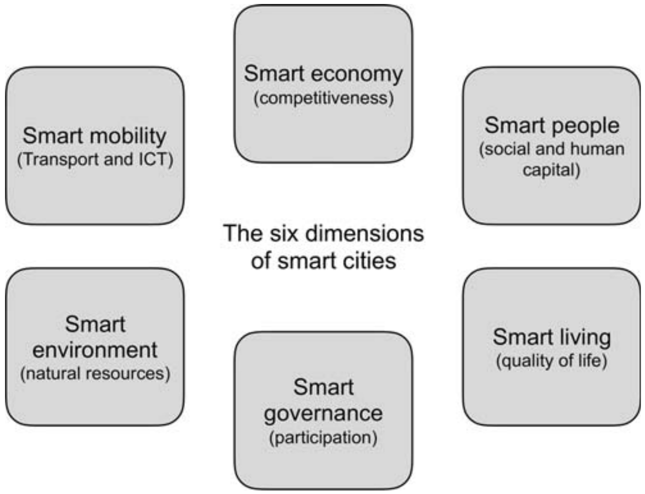

FIGURE 16.1

The six dimensions of smart cities (Giffinger, 2007).

entertainment, and for the production of goods and services. Hence, the transformation toward the smart energy vision touches all of the dimensions of a smart city (Giffinger, 2007) (Fig. 16.1), whether it is the reduction of air pollution, greenhouse gas emissions, improvement of the quality of living, the increase of mobility, or the competitiveness of our economy.

5.1 Smart people

Enabling better understanding of energy usage among people is important as it is intangible and transparent, by making it visible, accurate, and understandable with the help of smart meter data, mobile apps, and home displays. It is argued that citizens get encouraged to consume less energy when they become aware and receive feedback on their consumption (Darby, 2010) and in some cases even be motivated to save energy when compared with others, such as their neighbors (Fischer, 2008).

5.2 Smart governance

As a contrast to today's energy system, built up of large utilities and power plants, the smart energy vision has the prospect to increase transparency in the energy system when more actors are participating by generating electricity (e.g., prosumers with rooftop solar PV) and reducing consumption (participants in demand response). There will be a need for more transparency and cooperation between actors, often through a centralized data hub which is the case for example in Norway (Elhub, 2018).

5.3 Smart economy

In the light of the 2014 Paris agreement, there is a global consensus to move our global economy toward a resource efficient, low-carbon economy. The use of green growth indicators (Ekins, 2002) is becoming an increasingly important alternative to GDP for measuring economic and environmental performance. Smart meters play a major role in the realization of the smart grids. Furthermore, smart metering will allow energy markets to become freer, give energy companies a way to differentiate themselves and provide better services, and potentially drive down prices.

5.4 Smart mobility

Cleaner and smart mobility is key in future smart cities. An increasing number of electric vehicles demands more charging stations at even more places than before, whether at the workplace, in the city streets, at home, or on highways. For electric vehicles to be sustainable, the source of the power supply has to be from renewables. Electric vehicles can operate as a storage of electricity when not in use. When there is surplus of power in the grid and energy price is low, the electric vehicle can be charged and energy can stored for later use. The vehicle can also operate as a battery for home solar PV systems, connected in a smart metering system (Richardson, 2013).

5.5 Smart living

Smart homes, or home automation, want to provide comfort, security, and the most efficient use of energy and water using Internet of things technologies (Chui et al., 2018). It is estimated to be the future of living, and growth of the smart home market (Zion Market, 2018) might suggest that this is true. There are a large number of new appliances entering the market every year, which range from smart home stereos to smart thermostats, light bulbs, and electric vehicle home chargers.

5.6 Smart environment

The smart metering system will potentially reduce greenhouse gas emissions coming from our power use, through the realization of a number of different mechanisms (Pratt, 2010). The conservation effect of consumer information and feedback systems, the support of more electric vehicles and plug in hybrids, and penetration of more renewable energy generation are both central and decentralized. The accuracy of the data will allow proper measurement and verification of the impact of energy efficiency programs that is also of great benefit for the environment. More efficient water usage is also possible with smart water meters (Table 16.2). Table 16.2 summarizes the role of smart metering in smart cities.

6. The European Union smart meter market

Member states in the EU are required to ensure implementation of smart meters under the EU energy legislations The EU Directive, from 2009, is also referred to as *the*

Table 16.2 Smart metering in the six dimensions of smart cities. Authors' own illustration, based on characteristics and factors of a smart city (Giffinger, 2007).

Smart metering in the six dimensions of smart cities		
Smart economy (*Competitiveness*) Demand side management consumption reduction and low-carbon economy Peer-to-peer transactions Dynamic pricing	Smart mobility (*Transport and information and communications technology*) Better integration of electric vehicles (EVs) Effortless billing solutions for charging everywhere enabled by smart metering Exploit the storage capacity that is in EV batteries for grid stability	Smart living (*Quality of life*) Smart homes: Increased safety Remote control and automation of appliances Access the "negawatts"
Smart people (*Social and human capital*) Make energy visible Increase energy awareness Less consumption	Smart governance (*Participation*) More participation of people in the energy system, demand response, and as prosumers	Smart environment (*Natural resources*) Climate gas emission reduction Air pollution reduction Renewable energy integration

third energy package. Depending on whether a mandatory cost-benefit analysis (CBA) were positive or negative, EU member states would be obliged to conduct a large scale roll-out of smart meters reaching 80% of all smart electricity-meters by 2020 (Usmart Consumer, 2016). The member state would decide on whether the implementation of smart meters would be market driven or regulated. The cost—benefit analyses were done separately for gas and electricity.

The smart metering market in the EU is estimated to have reached early majority, and total sales will peak in 2019—20. Furthermore, it is stated that the EU rollout will reach 70% by 2020, failing to meet the 80% target set by the EU (Ryberg, 2017).

6.1 Rollout in the United Kingdom

The cost—benefit analysis in the United Kingdom showed positive results, and a large-scale market driven rollout strategy was approached. The aim of the smart metering program is to install 50 million gas and electricity meters across all domestic and smaller nondomestic sites in the United Kingdom. To this date, 10,036,200 million smart meters have been installed across the United Kingdom.

In the United Kingdom, the Department of Business, Energy and Industrial Strategy is leading and monitoring the rollout. The United Kingdom, as early as in 2014, set a standard of specific attributes and specifications for smart meters on the market. This was done to ensure a certain level of standardization and interoperability (Department of Energy and Climate Change, 2014). A code for installation of smart metering systems in households, called the Smart Meter Installation Code of Practice (SMICop), was also developed. This code specifies the minimum standards to follow in relation to the customer facing aspects of installation of a smart metering system.

7. Aim

The aim with this research is to better understand how different stakeholders in the smart meter rollout sphere have an influence on social acceptance, highly important for a successful rollout. This chapter puts emphasis on the citizen's needs (e.g., total number of customers make up the "social perception"), which the authors believe is not properly addressed in the UK rollout, as also might be the case for other countries, such as the Netherlands (Hoenkamp et al., 2011). This contribution wants to show that the findings from this research are applicable to other large-scale initiatives, such as smart city initiatives, as these might have similarities and touch some of the same worries related to data privacy, private data ownership, automatization, and behavioral change. A key question in this regard is what motivates citizens to participate in smart city solutions including the contribution of data (Abu-Tayeh et al, 2018) and what citizens hold up in the usage of smart city solutions.

8. Methodology

For the analysis, the different stakeholders' interest and perception were identified, and an estimation was to some extent made on what kind of influence these entities have on social perception by using business terminology, e.g., establish customer needs and measure customer satisfaction. Different methods have been applied in the research, which are described in further detail below.

8.1 Analysis of the customer

In the analysis of customers' interest, three theories were used to categorize and to create a hierarchy of the different aspects related to customer wants and needs. Firstly, the value proposition canvas methodology (Strategyzer, 2018) was used to categorize whether the aspects were positive or negative, or as it is called "pains and gains." These refer to the feelings that customers have in a situation related to buying a product. Secondly, Maslow's hierarchy of needs was used to rank these aspects (Frei, 2004). The aspects on the bottom are needs that have to be covered for people to enjoy the needs above, so removal or just the fear of removal will induce a negative feeling for the customer. Lastly, Kano's quality dimensions were applied to understand how these aspects affect customer satisfaction (Grigoroudis and Siskos, 2010). Central to the theory is that customer satisfaction on certain quality attributes

Table 16.3 Kano's quality dimensions (Grigoroudis and Siskos, 2010).

1. *Basic*: These are taken for granted, however, results in great dissatisfaction if not met.
   - *Performance quality:* These will equally contribute to satisfaction and dissatisfaction depending on to what extent these are met.
   - *Attractive quality*: These are surprising, which means they contribute to satisfaction if they are fully fulfilled. However, these will not lead to dissatisfaction if they are not fulfilled.
   - *Indifference:* These do not make any difference
   - *Reverse quality:* This quality dimension will lead to more dissatisfaction the more it appears.

is not proportional to the performance. For example, people are proportionally satisfied when a carton of milk lasts longer or shorter than the expiring date; however, people will become more dissatisfied if the carton is leaking than satisfied if it is not leaking. The following quality dimensions were used (Table 16.3):

8.2 Media analysis

For the analysis of media, five articles from eight different news outlets covering the entire political spectrum were sampled. The selected news outlets were chosen based on a survey of how left- or right-wing some news outlets are perceived among Brits (Smith, 2017), which were The Mirror, The Independent, The Guardian, The Times, The Telegraph, The Sun, Daily Mail, and Daily Express, mounting up to a total of 40 articles published in between 9.09.2014 and 15.04.2018. The articles were picked randomly from a pool of articles we had collected beforehand by using the search function on the newspapers website for articles containing "Smart meter." These were then read and characterized either as positive, negative, or neutral based on criteria set, see (Table 16.4) below. Furthermore, the articles were labeled with the subtopic.

8.3 Government analysis

For the analysis of the government, the authors have laid to grounds that this entity is the main driver of the smart meter rollout in the United Kingdom. Governmental

Table 16.4 Set of criteria for media analysis characteristics.

Positive: Main focus is on benefits and positive aspects.	Neutral: Could be focused on negative aspects and be critical, however, balanced with positive aspects or vice versa. These articles were generally just reporting on something that could not be interpreted as negative or positive.	Negative: Main focus is on negative aspects where you were left with an impression that smart meters, e.g., focus on the overexpenditure.

publications and quarterly updates on the rollout have been read at to identify interest and perception of the government. To identify the influence on customer, the general public perception, which have been based on research done by the Department of Energy and Climate Change (2017), has been the base.

8.4 Industry analysis

The analysis of the industry is done by looking at the benefits of smart metering and how they apply to the individual industry player. These benefits have been gathered through the European Smart Metering Industry Group (ESMIG), which is the entity that the authors see as the industry representative in promoting smart metering in Europe. To identify willingness and perception, observations on the visibility of information about smart meters on the websites of the big six energy suppliers in the United Kingdom have been made.

8.5 Analysis of academia

For the analysis of academia, *Google Scholar Advanced Search* was utilized to gather viable data on what kind of topics were of interest in the scientific community and how the interest for the topic has developed between 2010 and 2017. Only searches in titles were carried out to make the search viable, although this has excluded research about smart metering, not without smart meter in the title. Any articles with more than two of the words in the analysis might therefore have been counted twice. The topics in the analysis were chosen because they yielded most results out of a greater number of topics.

8.6 Social media

For the analysis of social media, the social sharing platform Twitter was used due to the availability of data and the sharing nature of the platform as well as the ability to make advanced searches. Sixty tweets were sampled from three different time periods: August 2016, November 2017, and April 2018. Only tweets from the United Kingdom were considered. The data were categorized based on what kind of person or entity was tweeting: private person, organization, industry, professional, or political. Furthermore, some attributes were added to categorize the tweets' message or wanted outcome and the topic of the tweet, e.g., educational, promotion, radiation, and more.

8.7 Critics

For the investigation of media, any filters on the website could have affected the initial collection of articles. Furthermore, in the investigation of industry, the focus has especially been on the interest of the energy supplier. The relationship between the supplier and the customer is observed as an important foundation for social acceptance, and it can therefore be mentioned that the interest of the suppliers might not be directly reflected at the interest of the industry as a whole.

9. Findings

In the following section, we will report on the findings from our analysis of the different stakeholders, focused on the following dimensions: interest, perception, and willingness, as well as what influence these entities have on social acceptance.

10. Customer

In the analysis, we define the consumer as a typical household that holds a contract with a utility and has or will receive a smart meter as part of the rollout.

10.1 Interests

We assume that customers' foremost interest in energy is to cover needs, related to Maslow's hierarchy (Frei, 2004):

- Physiological needs (comfort, convenience, etc.)
- Safety (data security, trust)
- Belonging (inclusion in the energy system)
- Esteem (contribute to society as a whole)
- Self-actualization (learning)

Because energy access and security are certainties in developed economies such as the United Kingdom, the status quo is already satisfactory for the regular customer.

10.2 Perception and willingness of customer

Two surveys conducted in 2017 showed signs of how Brits view smart meters. One survey conducted for Department for Business, Energy, and Industrial Strategy (Ipsos MORI, 2017) found that 66% of smart meter owners are likely to recommend smart meters to others, and that 80% are either very (50%) or fairly (30%) satisfied. 7% were dissatisfied (fairly 3% and very 4%). Another survey (Earl, 2018) showed that 21% would not have fitted a smart meter in their home if they were given the choice. This study did not specify whether the person owned or had any experience with smart meters at all. These surveys show that the overall satisfaction is positive, however, only slightly (Table 16.5).

Table 16.5 Customers' interests in the smart meter rollout.

Needs	Pains	Dimension	Gains	Dimension
Self-realization	*Forced* to learn about own energy usage	Reverse	Getting educated on energy usage	Attractive
Esteem	Ostrich problem: knowing you have to become aware of own consumption becomes a pain (Webb et al., 2013)	Reverse	Contribute to local, regional, national, and global emission reduction (better integration of renewable energies, energy efficiency, etc.)	Attractive
Belonging			Better insight and understanding of personal consumption makes you more connected to your own apartment or house Feeling of community spirit when contributing to energy efficiency	Attractive Attractive
Cost/convenience	"Someone has to pay for the smart meters, which will eventually be the citizens"	Reverse	Reduced energy bills through better efficiency, less energy theft, better billing Simpler communication with energy providers	Performance Attractive
Safety	Mistrust in power companies: marketing influx, personal data protection Fear of hacking or similar (Buchanan et al., 2016)	Reverse Reverse	Security of supply, shorter power outages because of more accurate data Better home security: get notified and detect break-ins or irregular user behavior (if someone forgot to turn of the oven)	Basic Attractive
Physiological needs	Health concerns: radiation Fear of being cut off (demand response) (Buchanan et al., 2016)	Reverse Reverse	Energy access	Basic

10.3 Influence on social acceptance

Customer influences social acceptance through social interactions, either through social media or offline. Thus, customers have a direct influence on social acceptance (Niamir et al., 2018).

11. Government

The UK government is the provider of framework and regulations for smart meters and the rollout, motivated by targets set from the EU, which involves rolling out at least 80% of smart meters of electricity within 2020 (Department for Business, Energy and Industrial Strategy, 2016).

11.1 Interest

A rapid rollout is cost beneficial to the United Kingdom. Smart meters will ensure a resilient and secure energy system, enabling demand side flexibility and optimizing the grid for integration of renewable energy sources (Department for Business, Energy and Industrial Strategy, 2016).

11.2 Perception

A strong willingness and positive perception can be observed from the government, as this is the stakeholder that has the legislative power and has given a framework that encourages the smart metering rollout. Quarterly reports about the progress of implementation and close follow-up on the suppliers show a strong willingness to reach the set targets from the government's side.

11.3 Influence on social acceptance

The customer knowledge about smart metering is relatively low (Department of Energy and Climate Change, 2017). A governmental entity, under the name "Smart Metering GB," functions as an informational source about smart meters (SmartGrids and Meters, 2018). After all, the only two benefits that are promoted on this website are

1. "No more estimated bills"
2. "See how much energy you're using in pounds and pence"

12. Industry

As the industry in this case, it is referred to the energy industry and the components of the electricity value chain. That would mean electricity generators, transmission system operators, distribution system operators, and smart meter suppliers.

Table 16.6 Summary of industry benefits of smart metering.

Industry entity	Benefit
Energy suppliers	• Provide a vast amount of consumption data that can be used to create more value for customer • Remove the cost of meter reading • Energy theft detection • Demand response
System operators (transmission system operators and distribution system operators)	• Rapid fault detection, location of fault, and diagnostics of the grid
Electricity generators	• Inclusion of smaller electricity generators • Decentralization of electricity generation
Entire energy industry	• Increased competitiveness of the energy market • Quality improvement

12.1 Interest

For the energy industry as a whole, development of technology through innovation and quality improvements may be results of a competitive market, which in the long run can drive industry forward.

For the supplier, which is the part of the industry with direct contact with the customer, smart metering will provide many advantages enabled by the available data, including proactive management of energy consumption to reduce the strain on the grid, also called demand response (Department for Business, Energy and Industrial Strategy, 2016) (Table 16.6). Table 16.6 provides an overview of benefits smart metering brings to different power industry entities.

12.2 Perception and willingness

For the industry, the smart meter will enable a new level of competitiveness (Ofgem, 2016). Suppliers may profit through customer satisfaction, product differentiation, and supplementary services. The rollout of smart meters is a necessary step toward the digitalization of the electricity grid and may also lead to cost reduction and simplification of work (Department for Business, Energy and Industrial Strategy, 2016).

12.3 Influence on social acceptance

Because the rollout in the United Kingdom is market driven and not regulated, meaning the installation is not mandatory for the customer, the customer acceptance is important for the success of fully rolling out smart meters over the United Kingdom. Considering the supplier is the party responsible for the installation, we can assume that this is the part of the industry that has the most direct influence on the customer. It will be necessary for the suppliers to differentiate themselves and focus on customer needs to gain competitive advantage and avoid being replaced by competitors. Standardization and requirements for interoperability lay ground for a seamless switch of energy supplier for the customer (Ofgem, 2012).

In contrast to the benefits, they might reap from the competitiveness of the market; the customers express mistrust toward profit-oriented energy suppliers (Buchanan et al., 2016). This mistrust in energy suppliers may lead to a resistance in willingness to shift to smart metering technologies (Balta-Ozkan et al., 2013).

13. Academia

In this analysis, academia is used as the term for the entire English-speaking scientific community that is working in the field of smart metering.

13.1 Interest

Arguably, the main interest of the scientific community is to ensure a high standard on scientific work and functioning as a whistle-blower to detect fraud and eliminate bias. Individual status and recognition are important drivers for the role of academia to function, e.g., getting recognition from the community, ideas adopted by industry, number of publications in scientific journals, and such. Research supported through government initiatives and industry-backed associations and organizations might affect the views in favor of smart metering, e.g., state greater benefits than in real life.

13.2 Perception and willingness

Assuming the academia is unbiased on the topic of smart metering, we can say that the view is neutral. Our picture is that articles are not pointing at the negatives, rather proposing solutions to the known negatives e.g., data privacy issues. Notably, it is the most cited article when searching on "smart metering" about privacy.

What can be observed in Fig. 16.3 is the annual number of articles that are listed about smart metering in the last 10 years. One can see that there has been an almost linear increase in the number of articles with smart metering every year until 2015, where it flattens out, peaks in 2016, and then drops by almost 4000 articles in 2017. This might suggest that the hype around smart metering is going down within the scientific community.

13.3 Influence on social acceptance

Academia's influence on the social acceptance may come indirectly through the influence it has on policy makers, industry, and even media. Measuring the influence

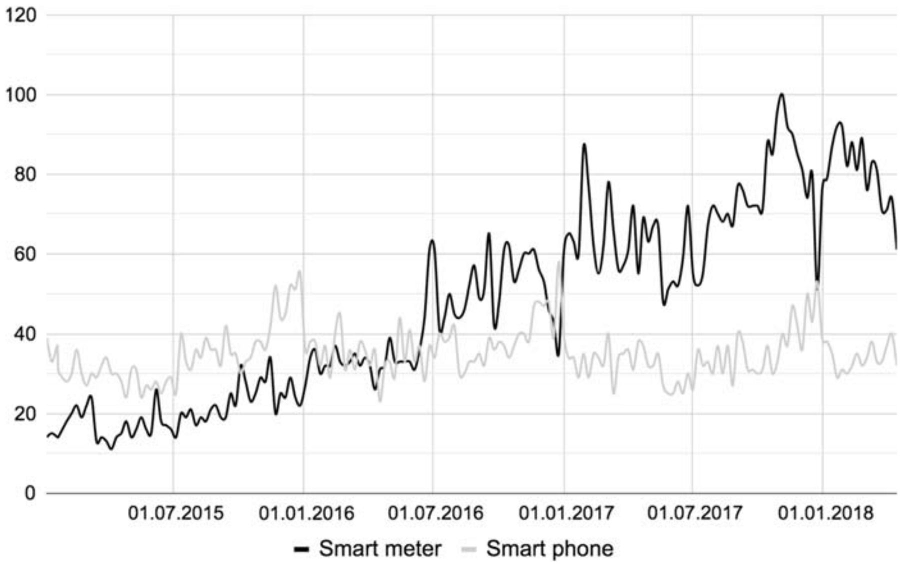

FIGURE 16.2

Google searches containing “smart meter” compared with “smart phone” from 01.01.15 to 22.04.18 in the United Kingdom.

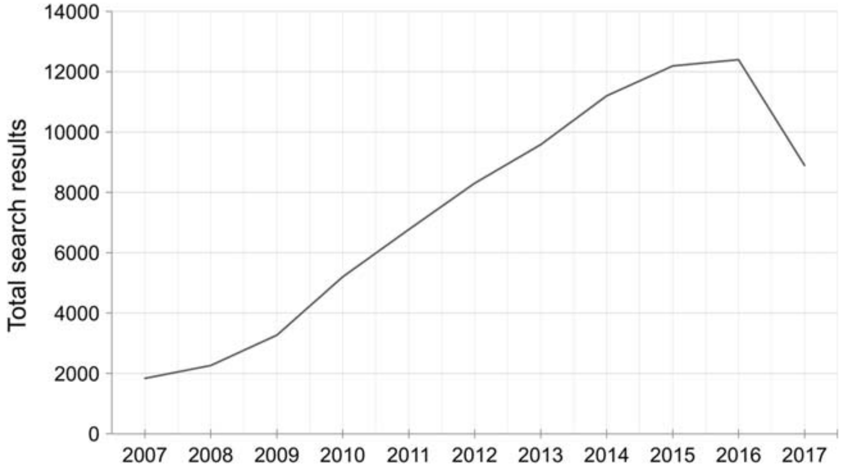

FIGURE 16.3

Google Scholar smart metering hype graph.

is difficult; however, a strong correlation between the results from popular research topics and what is written about in the media as well as being talked about in social media could indicate influence. Fig. 16.2 shows some of the most written-about topics within smart metering as of 14.12.17.

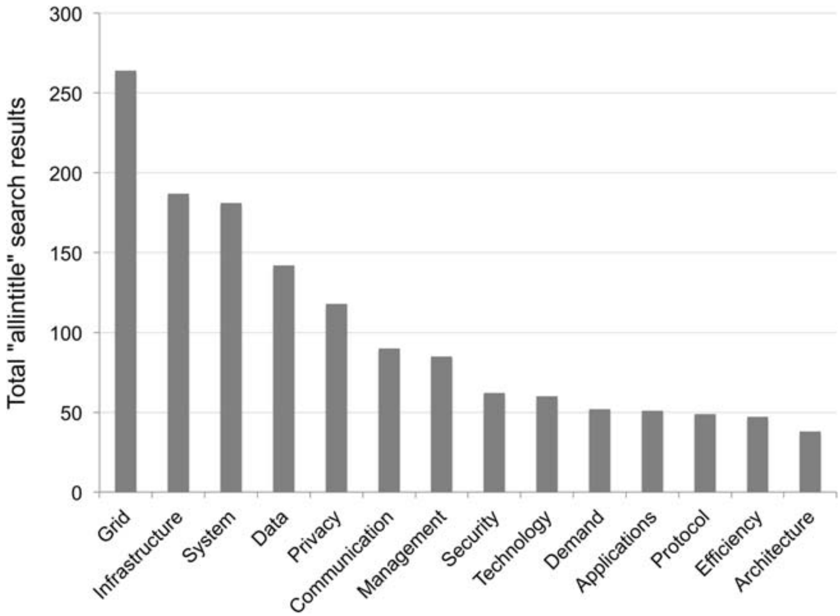

FIGURE 16.4

Various popular research topics in smart metering.

This is slightly true, as it is observable that privacy and security are relatively popular topics. However, most articles are not focused on "citizens interests," e.g., benefits for customers, or their concerns. Security and privacy are among the most written about topics. Search containing "rollout," "deployment," and "cost" yielded 29, 19, and 31, respectively (Fig. 16.4).

14. Media

In the analysis of media, only print media in the form of news articles has been taken into consideration.

14.1 Interest

Being a provider of information about current incidents and highlighting topics that is being discussed in society is arguably media's main role. Regarding the topic of smart meters, media's only interest is to gain readers and clicks by providing exactly what might generate the most attention.

14.2 Perception and willingness

For this analysis, to figure out print media's perception of smart metering, a sample of 40 articles was chosen randomly. After categorizing the articles based on criteria described in the methodology, the results showed that 20% had a positive view, 35% of the articles had a neutral opinion, and articles with a negative opinion were the most with 45%.

14.3 Influence on social acceptance

There is a direct influence on the general social acceptance. However, print media is dependent on the number of readers; hence, the topics written about reflect the interest of the public and vice versa. We found that most of the articles were about the status of the rollout, personal economy, and privacy and data security, which suggest a correlation to the customers' interests.

15. Social media

In the analysis of social media, the platforms Twitter and Facebook have been taken into consideration.

15.1 Interest

The social media's main interests are to increase the number of registered users and stimulate usage. Hence, it has shaped to be a platform, which is more user friendly with options to make it even more interesting in social interactions. One of the most used social media channels, Twitter, is driven by its users uploading content and thrives on people's urge to share things such as opinions, experiences, and news, motivated by gaining recognition in the shape of likes and shares.

15.2 Perception and willingness

The research revealed that there is a significant difference in the positive/negative message in the social media posts analyzed, depending on the entity that is posting. Posts originated from professionals and industry are almost strictly positive, substantiating the observation that the industry's interest is to promote smart meters in a positive sense. Posts originated from private persons, politicians (e.g., members of parliament), and organizations (e.g., an engineering organization) reflect an outcome that is more negatively skewed, see Fig. 16.5.

15.3 Influence on social acceptance

Rather than being an entity on its own, Twitter serves as a platform where all the stakeholders in our analysis are present and influence whoever is reading the content, although one-third of the tweets analyzed were from private Twitter users, see (Fig. 16.6).

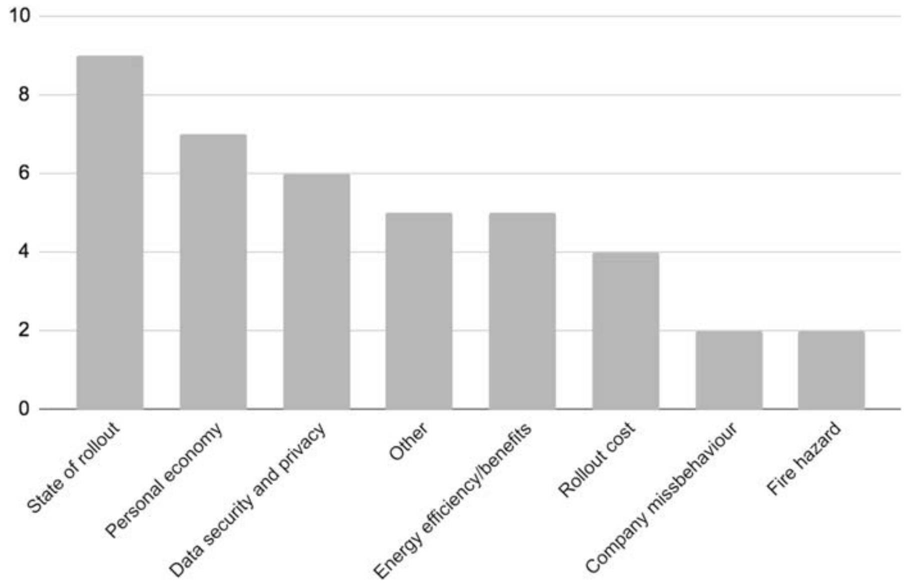

FIGURE 16.5

Most popular themes of UK news articles in authors analysis, 09.09.2014–26.03.2018.

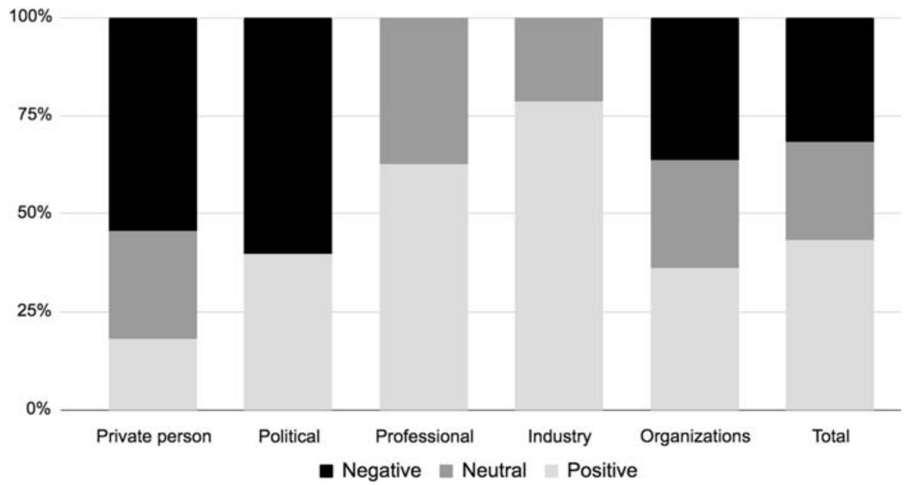

FIGURE 16.6

View of different UK entities' tweets containing "smart meter", 2016–18.

16. Summary of findings

The interest of *the customer* lies in convenience, comfort, security, and reduced costs. We established that most of the gains for the customer are new and not known, while the pains are known, thus skewing the interest negatively. However, we found that the perception of the customers is slightly in favor of the smart metering rollout and influences the social acceptance through social interactions, either through social media or offline. *The government's* main interest is based on development toward the smart city energy vision. Thus, the government's perception of the smart meter rollout is strongly in favor and influences the social acceptance through the governmental information channel "Smart Energy GB" and the power they have to make decisions that affect people. Digitalization of the energy value chain and potential increased future value creation are *the industry's* interests in the smart meter rollout. Its perception is strongly in favor and influences the general social acceptance through promoting smart meters and their benefits to their customers.

Academia's influence of public perception comes indirectly through the influence it has on policy makers, industry, and media. We found that the most publications included words such as *grid, infrastructure, system,* as well as *data, privacy,* and *security* in their titles. *Print media's* perception is slightly negative and no particularly differences were found in views in the different news outlets. This influences the general social acceptance directly when people read and talk about what they have read and heard. Similarly, *social media's* interest lies in gaining clicks and sharing views. It is made up of users who represent all stakeholders so that the interest is manifolded. The analysis shows an overall slightly negative perception of smart meters, although it revealed that stakeholders share very different views and opinions. The influence on general social acceptance is direct through content generated by its users, which is read, shared, and talked about.

17. Discussion

The negative view observed in media and social media, as well as the surveys on customer satisfaction, shows clear signs of negative public perception, which through the findings can be seen in relation to two main aspects:

Firstly, the investigation of the customers and their needs showed that most of the positive aspects of smart meters belong to the "attractive" quality dimension, which means they will not contribute positively before they become known. As a result, the pains, which solely contribute to negative satisfaction, outweigh the gains, thus leading to less social acceptance. The negative perception of smart meters thus indicate that the marketing campaigns initiated by state institutions and industry have been ineffective. Such as the single focus on only a few benefits such as long-term price decrease, which is the only benefit listed on smartenergy.gb.org. Furthermore, the findings show that the worries of the customers, which occurred in academic journals, media, and social media, such as data security and data privacy, did not occur in the analysis of government, indicating that these were not adequately addressed.

Secondly, as the rollout was a top-down decision and not bottom-up, e.g., not originating from public demand, it can be connected to the NIMBY effect (Not In My Backyard) (Kinder, 2016), which refers to the opposition, or resistance, in individuals to accept the construction of projects by governmental entities or large corporations that they otherwise would have supported if it was not occurring in their own nearby circumstances.

18. Conclusion

In this chapter, the different stakeholder's interest and influence on social acceptance have been showcased revealing some resistance among certain entities and UK energy customers, which happened as a result of poor change management and communication from industry and government who are responsible for the rollout. This has allowed customers to develop strong concerns regarding data security, health, marketing influx, and loss of control, which has been left unaddressed. Government is dispelling away the preconceived notions that people have developed about smart meters, and mostly addressing personal benefits such as savings, showing a mismatch between people's interest and what the government and industry were communicating, thus making it difficult for many people to see what "the bother" was good for.

19. Suggestions for future smart cities initiatives

Because of the personal data and the privacy problematics, its large-scale and top-down approach, the findings in this chapter suggest that there are two lessons to be learned:

1. *Transparent communication*: in the communication of smart metering benefits, short-term and personal factors such as savings and convenience have been promoted. This, in combination with a market-driven approach, may have made parts of the public skeptic, raising the belief that the smart meters are being promoted to the benefit of energy suppliers' profit. Changing the focus to long-term benefits for the consumer, such as energy security, involvement in energy grid, and the overall welfare of the society, may apply to more than the basic physiological needs in the consumer and rather trigger belonging, esteem, and self-realization.
2. *Address people's concerns*: bust the myths and concerns that are being conspired about on the same channel that they occur. A lower level of activity of

government and industry on social media platforms has been observed, making other sources of less viable information more accessible.

3. *Transition excellence:* both corporate reputation and customer trust will be harmed if the transition is not handled well; an increased level of coordination and planning will be needed; the industry will have to take care of this while continuing to achieve business goals of minimizing costs and maximizing operation efficiency.

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CHAPTER

Smart city vision and practices across the Kingdom of Saudi Arabia—a review

17

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Chapter outline

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00017-X

1. Introduction

Saudi Arabia is an Islamic Kingship of 33.5 million population, ruled by the descendants of founder Ibn Saud. The Kingdom of Saudi Arabia (KSA) has passed through several major transformations that affected Saudi economy and community. Before the discovery of petroleum oil in 1938, Saudi economic relied mainly on religious tourism for Hajj and Umrah. The Kingdom's economy at this time was good, life was simple, and development processes were limited (Alkhedeiri, 1998). After the oil discovery, the economy had shifted pivotally that the national income reached $26.000 per capita, which was reflected in all life aspects (Al-Ankary and El-Bushra, 1989). Since then, Saudi Arabia has experienced a strong economic performance, which enabled a sustained growth momentum in the last decade. This growth has been tempered by the economic crisis that has hit the Kingdom few years ago because of the low oil price decline. Despite some attempts at economic diversification, the Saudi economy remains heavily dependent on oil- and petroleum-related industries including petrochemicals and petroleum refining. To pass the recent crisis of oil price decline that has threatened the Saudi economy, Saudi Arabia resorted to implement major reforms in different aspects (Farag, 2019).

The oil boom has also a substantial impact on the urban population in Saudi cities that reached 75% in 1985 in return for only 10% in 1950 (Al-Ankary and El-Bushra, 1989). According to Saudi statistics, 82% of its population is living in cities today as the majority of the Saudi population is preferring the city living where it brings many advantages and amenities by providing higher standards of services and infrastructure (Siemens, 2016). However, living in the city resulted in many challenges that compelled Saudi authorities to offer new solutions for new problems. Accordingly, KSA aims to go beyond the current economic crisis to become an international leader by increasing investments in science and technology to compete in this field and to shift from an oil-dependent country toward a smart country, which adopts smart actions in all the aspects of development (Khorsheed, 2015). Smart city concept has emerged as a solution to the complex urban challenges driven by global technological companies. In this context, the Saudi Kingdom supports the initiative of the smart cities by all possible means (Aljoufie and Tiwari, 2017).

The objective of this chapter is to review and assess the smart city practices in Saudi Arabia with respect to the six dimensions of the smart city concept with a focus on the five cities that started the implementation. The chapter does not pose the question of how the Saudi cities can be transformed into smart cities but rather investigates if the Saudi vision reflects the smart city concept and dimensions. The main question to be answered is: to what extent did the transformation of the Saudi cities reflect the Kingdom's ambitious vision toward smart practice? Answering this question would be through a thorough insight in the literature of smart cities generally and Saudi Arabia vision and practices particularly.

After a brief introduction on recent development in the Kingdom, the following part provides a general overview of the Saudi Vision 2030 and its role in view of boosting the Kingdom's growth and development. The role assigned to cities/urban spaces in the vision is outlined. In the third part, the six dimensions of the assessment of the Saudi cities' smart practice are explained. Against this backdrop, the practice of the five targeted Saudi cities that started the implementation of smart city is examined. Conclusions and recommendation follow.

2. Kingdom of Saudi Arabia: future vision

2.1 Saudi Vision 2030

Reviewing Saudi Vision and its main goals—formed in 2016—illustrates the kingdom's elaboration of providing a better quality of life for its citizens and fulfills their needs, in addition to preserving the environment and natural resources that are considered one of the Islamic, human, and moral duties. The Saudi Vision 2030 has adopted and reflected the smart city concept by setting a series of specific goals for implementation. It sets out clear procedures to transform Saudi Arabia over the next 12 years. The KSA has a clear vision of its future, and Saudi cities are at the heart of achieving the government's vision of a smart Saudi Arabia in 2030 (Saudi Vision, 2017). The Saudi government has recently adopted and implemented an enduring strategy of development that shifts its focal point toward the formulation of knowledge-based society and directs a large proportion of economy for by knowledge-driven technological innovation (Aldusari, 2015). Saudi Arabia has the clear vision and the necessary resources to invest in technology and scientific field, while directing its resources to invest in people besides infrastructure.

2.2 Transforming Saudi cities into smart

While we are writing this chapter, KSA is going into a paradigm shift in which it transforms many cities into smart ones to boost investment away from oil dependency. In line with the Saudi Vision 2030 and the National Transformation Program of 2020 goals, the Ministry of Municipal and Rural Affairs (MMRA) announced the country's plan to build new economic cities and special zones, in addition to developing 10 new smart cities across the Kingdom (Arab News. a. 2017). The MMRA has launched the project of "application of smart city concepts" that aims to boost competitiveness of Saudi cities and urban sustainability, increase the level of citizens' satisfaction, improve efficiency of city management, minimize the negative environmental impact, attracting local and foreign investments, and create job opportunities (Al-Hindi, 2017). The ministry conducted a study in 2015 on 17 major Saudi cities to investigate the feasibility and eligibility to be transformed into smart cities based on the best smart practices in the world. The study has shown that there is a disparity in the Kingdom's cities preparedness to transform into smart cities (World Economic Forum, 2017). Moreover, the Minister of MMRA, Abdullatif Al-Asheikh, revealed the ministry plans to start implementation of smart city project in 10 cities across the Saudi Kingdom (Al-Arabiya economy, 2017).

The smart city initiative is targeting five Saudi cities by 2020 in sequenced phases. The first two cities, Makkah and Riyadh, are expected to be transformed by the end of 2018, followed by Jeddah and Al-Madinah, and finally Al-Ahsa by the end of 2020 (Arab News (a) 2017). However, the kingdom already allocated over $500 billion to invest across 285 municipalities for the implementation of smart cities to provide a better quality of life for its citizens by engaging them in developing Kingdom's future cities (World Economic Forum, 2017).

The objective of this chapter is to review and assess the smart city practices in Saudi Arabia as it is being implemented in five abovementioned cities with respect to the six dimensions of the smart city concept. However, speaking on smart city practices in Saudi Arabia, there are two projects that cannot be ignored: Yanbu Industrial Smart City dubbed "the first Saudi Arabia's smart city," and NEOM "the most recent smart city project in Saudi Arabia." These shall be discussed in brief in the next paragraphs.

2.2.1 Yanbu industrial city

Yanbu is an industry-based city that is located in a very strategic point on the coastal area of the Red Sea, and near Al-Madinah Region, with an area of 606 km^2. It has been established in 1975 and managed by the Royal Commission. It is a part of Yanbu city, and it is divided into two parts, the residential part in the north and the industrial part in the south. Yanbu is the third largest oil refinery center in the world (RCJY, 2018). Yanbu industrial city is a fast-growing city that focused on industrial growth since it was established. However, with the challenges the city is facing and in line with the vision 2030, the Royal Commission for Jubail and Yanbu (RCJY) decided to shift toward being a smart city by adopting more diversified sectors including entertainment, tourism, and science and technology, as announced by Dr. Alaa Nassif, the CEO of RCY (The Business Year, 2017). The chairman of RCJY, Prince Saud bin Abdullah bin Thunayyan, has inaugurated Yanbu Industrial City as Saudi Arabia's first smart city. In collaboration with specialized companies, they started building a unified telecom and IT network to improve the digital infrastructure and increase the efficiency of the IT environment to support all projects in the city. Also, to improve citizens' experience and city operations by using new technologies (Internet of things, IoT) and expand the variety of digital services, the RCJY started partnerships with international technology providers specialized in smart cities (Arab News (b) 2017). For better quality of life, the Smart Yanbu Industrial City has been planned for three stages: (1) the construction of city public infrastructure and information infrastructure (e.g., roads, buildings, water services, broadband networks, cloud computing); (2) the use of information and communications technology (ICT) applications (focusing on eight smart applications, e.g., heavy vehicle management, smart waste management, smart streetlight, smart parking, smart energy efficiency monitoring, crowd density analysis, smart manhole cover, and comprehensive performance assessment); and (3) covering the city management platform and smart community portal (e.g., big data analytics platform, IoT data platform, and communications integration platform). The construction of

Smart Yanbu Industrial City started in 2014, and in 2017, the first two phases have been completed, and its people started to enjoy the smart city experience. The third phase is being carried out to support municipal services, investment trend analysis, smart public facilities, emergency response, and smart police services, and build an integrated command center (Huawei, 2017).

2.2.2 NEOM city

Speaking about NEOM city, the Crown Prince Mohammed bin Salman announced the birth of the city of NEOM to be the first futuristic truly smart megacity in the Saudi Kingdom, in the conference on "Future Investment Initiative" in Riyadh, Saudi Arabia, October 2017. He announced the launch of NEOM to be a short gateway to the future where the dreamers can achieve new future and can live a new way of life. The Project's promoters brand NEOM as a smart city where development opportunities could contribute to make it a global hub for trade, innovation, and knowledge (Farag, 2019). The fundamental difference in NEOM city is that it will be built from scratch depending only on its comparative advantages of its unique location spanning across three countries—Egypt, Jordan, and Saudi Arabia—its picturesque nature and beautiful weather, and richness of natural resources. The point of building in a very new land is to avoid the common features of conventional cities that everything is new: fresh investments, young people, robotic population, new technology, and new regulations. NEOM location is blessed by the richness of mineral resources, oil, and gas, in addition to the natural resources such as the perennial solar resources (20 MJ/m^2) and the wind speed (an average of 10.3 m/s). In addition, silicon that could be extracted from the sand existed in abundance in the extended Saudi desert and was used in manufacturing the solar panels to be used in energy generating. NEOM is planned to be powered and developed by regenerative energy and fully generated by net zero carbon. The newest technology of today will be implemented to achieve an exceptional way of life, in transportation, health care, digital air, growing and processing food, net-zero carbon houses; online education; renewable energy; and robots industry. The plan is to start the construction of the infrastructure phase in 2017 and complete NEOM, the first phase, by 2025 (Farag, 2019).

3. Holistic approach to smart practice

3.1 Smart city concept

The term smart city was first used in the 1990s when the focus was on the importance of new ICT applications to modern infrastructures within cities and how a city could be designed to implement information technologies (Alawadhi et al., 2012). To recognize the national and global practices of "smart city," it is essential to understand the conceptual frame beyond these practices. Recently, there are many terms that seem to be analogous to the term "smart city" such as a digital, intelligent, virtual, or ubiquitous city. Actually, these terms are not inclusive because each term refers to and focuses on a specific aspect, while the concept of smart cities often includes them all (Caragliu et al., 2011). There are two main trends to define the term theoretically, the first one focuses on a set of definitions, which emphasizes only one urban aspect (technological, ecological, etc.), leaving apart the other aspects of the city. These monotopic trend descriptions misunderstand the main objective of a "smart city," which is to provide a comprehensive approach for urban management for all aspects of the city. Improving just one part of an urban system does not guarantee that the problems of the whole are being solved. The second trend emphasizes the main concept of the smart city, which focuses on the interconnection of all aspects of the city such as social, urban, institutional, etc. The last-mentioned trend is a comprehensive one, expresses the real concept of the "smart city", and reflects a holistic approach to handle the urban problems taking advantage of the new technologies. It shows a balance of the technological, economic, and social factors involved in an urban ecosystem (Correia, 2011), as the connection and integration of all systems is fundamental for a city to be truly smart (Nam and Pardo, 2011).

Maybe one of the reasons behind the absence of a general agreement about the term "smart city" is that the term has been applied to two different domains. First, it has been applied to "hard" domains such as buildings, energy grids, natural resources, water management, waste management, and mobility (Neirotti et al., 2014), where ICT can play a vital role in the functions of the systems. Second, the term has also been applied to "soft domains" such as education, culture, policy innovations, social inclusion, and government, where the applications of ICT are not usually decisive (Albino et al., 2015).

Accordingly, adopting the holistic approach of smart cities which considers the different aspects of the city, "people, physical environment, technology, etc.," is the most appropriate way, which is illustrating the conceptual frame for the different parts of this chapter.

3.2 Smart city dimensions—assessment criteria

In recent years, most documents that deal with the smart city concept used six basic dimensions as pillars for the smart city, which makes it the most accepted classification of the smart city concept (Giffinger et al., 2007). The six dimensions that will be discussed below are what the review of this study is based on to assess the smart city practice in the selected Saudi cities.

3.2.1 Smart governance

The aim of smart governance is to support and improve democratic processes, transparency in governance, citizen-centric development, and political strategies through the use of technology to facilitate the involvement of citizens (Kumar et al., 2016). It is also encouraged to benefit from the available advanced technology for coordination with other municipalities and other stakeholders to fulfill citizens' needs to improve both public services and confidence in the public institutions

(Giffinger et al., 2007). In the line of the previous definition, the third theme of Saudi Vision "Ambitious Nation" is built on developing an effective, transparent, accountable, enabling, and high-performing government. Saudi Arabia inspired to raise the Kingdom's ranking among the world countries on the e-Government Survey Index from the current position of 36 to be among the top five nations. To achieve the Saudi aspiration, many transformative programs have been launched. The Saudi Vision urges on expanding the variety of digital services to reduce delays and cut tedious bureaucracy, adopting a wide-ranging transparency and accountability reforms, measuring the government performance, and providing world-class government services to effectively and efficiently meet the citizens' needs. Effective E-Government is one of the major commitments to the vision to be achieved and is affiliated with the Ministry of Communications and Information Technology (MCIT). This will be achieved through coordination and integration between all government entities for providing online services and information for all citizens, residents, and businessmen. The online services have been already expanded over the last decade, including employment programs, online job searches, e-learning services, traffic, passports and civil affairs, online payment services, online issuance of commercial registers, etc., which improved Saudi ranking among several global indicators, such as UN E-Government Index (from 90/2004 to 36/2014). To achieve Saudi Vision 2030, the online services' scope will be expanded to include new areas such as geographic information, health care, education, and government agencies' applications such as cloud applications, data sharing platforms, and HR management systems (Saudi Vision, 2017).

3.2.2 Smart economy

It depends on innovation in increasing productivity to fulfill the market and workers' needs in order to enhance new business models which can compete locally and internationally (Giffinger et al., 2007). Having a strong economy has a high priority that could be recognized easily in the Saudi Vision when to find out that it occupies the second theme of the vision and the second pillar also. The second pillar of Saudi Vision is the determination to become a global investment powerhouse, while the second theme, "a thriving economy," is based on providing opportunities for all citizens, by building an education system aligned with market needs and creating economic opportunities for the entrepreneur, small enterprise, and the large corporation. This requires developing the investment tools, growing and diversifying the Saudi economy, creating job opportunities, and improving the quality of services. The plan is to privatize some government services, improve the business environment, support local investments in the telecommunications and information technology sectors, attract talented minds from Saudi and foreign people to contribute to economic development and attract foreign investments, leverage the unique strategic location in connecting three continents, and rehabilitate the economic cities especially those with comparative advantages (Saudi Vision, 2017).

3.2.3 Smart mobility

The smart mobility can offer efficient, clean, and equitable transport network for people, goods, and data. It benefits from the available technologies to provide users, planners, and transport managers with the needed information, allowing the enhancement of multimodality by improving the coordination and integration of different transportation modes (Giffinger et al., 2007). In respect to this definition, KSA strives to facilitate the movement of people and goods, in addition to adopting measures to ensure traffic safety and reduce traffic accidents and its tragic consequences. On the other hand, working on pilgrims' experience will be reinforced by a strong network of a transport system that could facilitate access and help pilgrims perform their visits with greater ease and convenience. This goal will greatly contribute to achieving the other dimensions of smart city concept, especially smart economy, smart environment, and smart living (Saudi Vision, 2017).

3.2.4 Smart environment

Smart environment uses a comprehensive database for all city aspects to guide urban planning process in creating efficient and sustainable urban environment, which serves and improves the citizens' quality of life (Giffinger et al., 2007). Achieving sustainable environment is one of the main goals of the Saudi Vision that is aspired to preserving the environment and natural resources. This goal is planned to be achieved by increasing the efficiency of waste management, establishing comprehensive recycling projects, reducing pollution, and fighting desertification. Additionally, there are several strategies that contribute to achieving a sustainable environment such as promoting the optimal use of water resources by reducing consumption and utilizing treated and renewable water. Protecting and rehabilitating Saudi's beautiful beaches, natural reserves, and islands and making them open to everyone is a suggested strategy to enhance the sustainability of the places and life quality of the people. Another strategy is creating a new city that is dedicated to energy, double gas production, and construct a national gas distribution network (Saudi Vision, 2017).

3.2.5 Smart people

The smart people concept lays in the wise participation of citizens in smart urban life, and their ability to adapt to new solutions providing creative solutions, innovation, and diversity to their communities is a crucial requirement for a city to be smart. Education is the main tool to improve this dimension (Giffinger et al., 2007). The deliberated objectives in the Saudi Vision reflect that the smart city concept concerns its people's values, talents, and capabilities and develops opportunities for everyone, especially the Saudi younger generations. It also reflects the true faith in the living with Islamic values and teachings as the right way to keep a society with its strong roots and the nation to be the core of the Islamic and Arab world. Moreover, social developments are promoted in the Saudi Vision to build a strong and productive community who are proud of their national identity and their ancient cultural heritage.

In terms of education, the vision aims to help Saudi students to reach the international averages in global education indicators and to have at least five Saudi universities among the top 200 universities in international rankings. It also shows the high priority in investment in education and training, starting of providing children the appropriate education, helping them to make careful career decisions, training them, and facilitating their transition between different educational pathways, so that young generations are equipped for the jobs of the future. In addition to building a strong well-educated intelligent society, this will contribute to closing the gap between the outputs of higher education and the requirements of the job market. The people with disabilities will receive a good education and job opportunities that adapt them for independence and effective integration in their society and put them on the path to commercial success (Saudi Vision, 2017).

3.2.6 Smart living

Smart living is defined as the wise management of facilities, public spaces, and services using ICT technologies to fulfill the citizens' needs and provide them with a high quality of life (Giffinger et al., 2007). In the light of this definition, the first theme of Saudi Vision—A Vibrant Society—aspires to spread the happiness and fulfillment among citizens and residents to live in a society in which all enjoy a good quality of life. Living healthy in a balanced lifestyle is an essential pole to achieve the high quality of life. A current lifestyle will be changed with a new one with opportunities for the regular practice of sports that have often been limited. Achieving attractive environment to live in is the other pole of the goal of high quality of life, which is planned to be achieved through ensuring high quality services such as water, electricity, public transport, and roads in addition to open areas and landscape for recreational purposes. Additionally, developing the telecommunications and information infrastructure especially high-speed broadband, expanding its coverage and capacity within and around cities, improving its quality, and developing buildings' standards contribute to achieving attractive environment to live in. The vision aims to have three cities be recognized in the top-ranked in the 100 cities in the world. The Vision also highlights the importance of developing the quality of the services offered to Umrah visitors that over 15 million Muslims per year perform Umrah, automating Umrah visa process and integrating e-services into the pilgrims' journey to make them completely satisfied with their pilgrimage experience (Saudi Vision, 2017).

Based on the above definitions, concepts, and dimensions of the smart city, it is found that the concept of smart cities varies widely. For any city to be "truly" smart it should implement all six dimensions. However, if not all the six dimensions are implemented, the city can be categorized under one or more of the following three categories depending on the dimensions implemented:

1. *The digital city* (technology-based), which refers to the instrumented city where the ICT connects, facilitates, and allows monitoring for services. The practices of *smart governance* and *smart living* dimensions may fall under this category.

2. *The intelligent city* (knowledge-based), where people are well-educated, creativity is encouraged, and knowledge is desired. The practice of *smart people* dimension may fall under this category.
3. *The environmental city* (community-based), where institutions and people work in partnership to promote the social capital to transform their environment for better quality of life and well-being. It is a community-driven city where citizens participate in the decision-making processes. The practices of *smart economy, smart mobility,* and *smart environment* dimensions may fall under this category.

Therefore, a smart city is a digital, an intelligent, and an environmental city. A city can be called smart if it integrates all three concepts together to serve people's growing and changeable needs and adapt the future challenges in a resilient, eco-friendly way to increase the quality of life of its citizens.

4. Smart city practices in Kingdom of Saudi Arabia

In the following part, the study illustrates the smart city practices of the five targeted cities that were announced to be completed by 2020, in the light of the six dimensions of the smart city.

4.1 Makkah smart city

Makkah city is considered the spiritual home for 1000 million Muslims and the destination of millions of pilgrims, where the most sacred place for the Muslims "*Kaaba*" is centered and Islamic rituals are practiced, *"Hajj*" or pilgrimage. The Hajj is one of the five pillars of Islam that every Muslim is obliged to travel to Makkah to perform Hajj once a lifetime when he/she can afford its cost. Makkah is spiritually considered a capital of the Islamic faith, which makes its development greatly important for all Muslims around the world, who are coming every year to Makkah for Hajj or Umrah in addition to its local residents (VenturesOnsite, 2014). Makkah city was a small and elegant town that was built with a unique Islamic style that unfortunately disappeared in the second half of the 20th century when the modern technology replaced the traditional one, and the old houses were replaced with towers (Peer, 2012). Saudi leadership has great ambitions to make the Holy city a role model for smart cities in the whole world in such few years (VenturesOnsite, 2014). Prince Khalid Al Faisal, the governor of the province of Makkah, had an important announcement: "*We will employ all kinds of modern technology to make Mecca smarter than any other smart city*," (Peer, 2012). Many initiations including forums, workshops, and several meetings have been held to develop the Holy city under the umbrella of the smart city concept. According to a study carried out under the auspices of the MMRA, Makkah city is one of the five feasible Saudi cities to move to a smart city in terms of availability of infrastructure and other services (Al-Hindi, 2017).

Because Saudi authorities called for participation to modernize the Holy city and transform it into a smart city, many private companies competed to participate in the released development projects to reach 300 billion SR planned investment. The project included new residential sites, upgrading the drainage system, central air conditioning, telecommunications services, health-care services, metro, etc (VenturesOnsite, 2014). Makkah regional authority has already implemented some of the initiations to transform the city considering different dimensions of the smart city concept. Regarding achieving Makkah's unique "*smart living*" dimension, the Saudi authorities recognized the importance of encouraging the investment in health, real estate, hospitality services, and infrastructure to satisfy the rising demand of today and beyond. Many initiations have been done such as redevelopment of informal areas to modern smart areas, in addition to establishment "Sumuw" a new area in the western suburb of Makkah that will be built according to specifications of the smart facilities and will provide accommodation for approximately 690,000 people. Design and operate a smart system to monitor and control the lighting network for more than 200,000 traffic lights in Makkah, and the holy places, through an integrated electronic system linked to Supervisory Control And Data Acquisition (SCADA) satellites.

Regarding the *smart mobility* dimension, more than 3000 smart cameras throughout Makkah, the Holy Mosque, and the holy places are installed to follow up and control Makkah streets and regulate the process of crowd management in addition to setting up a smart parking project, especially in the central area. The project includes the reorganization of the parking lots in the neighborhoods and the central area, in addition to operating an electronic payment system. The smart mobility projects include smart transportation of pilgrims and establishment of smart systems to follow up and control Hajj works and electronic identification bracelets. The *smart environment* dimension is targeted through the design and operation of a smart system that helps to follow up and monitor the cleanliness of Makkah city and holy places, using smart containers, smart cleaning equipment, and Automatic Vehicle Location (AVL) follow up system that is linked to the geographic information system (GIS) (Al-Hindi, 2017).

One of the promising projects in the process of transforming Makkah is the new Al-Faisaliah city, which is located on an area of 2450 km^2 in the western part of Makkah to be an extension to the old city rather than being an independent city. It is planned to mitigate the pressure on both of Makkah and Madinah cities, as it will provide 995,000 housing units, accommodate 6.5 million people by 2050, and provide one million jobs in different sectors including health, education, technology, and services. This project is planned and designed with a consideration of three dimensions of the smart city: mobility, economy, and environment. Considering the *smart mobility* dimension, multiple choices of transportation will be provided such as airport, sea port, train, metro, trams, and buses. *Smart economy* is considered in Al-Faisaliah city project in which the development strategies of pumping diverse economic investments will be set. Other strategies regarding the *smart environment* issue will be implemented such as reducing dependence on oil and gas and replacing them with the renewable energy and sustainable agriculture as it targets production of 9.5 GW of power from renewable energy sources. This project will be supervised by Makkah Region Development Authority, with an integrated effort from both government and private organizations (Muhammad, 2017).

4.2 Riyadh smart city

Riyadh is the Saudi Arabia's capital and main financial hub. It is a vibrant, forward-looking, 21st century city with a youthful population, which remains securely anchored to Islamic principles and the nation's heritage and traditions that embrace the promise of Saudi Arabia's Vision 2030 (Harrigan, 2017). The city adopted many initiatives in the field of smart cities with its variable dimensions in the context of Saudi Arabia vision, which will be illustrated later in this part.

The *smart people* dimension in Riyadh is targeted by the Kingdom's oldest university, King Saud University (KSU). KSU has an active role in setting up the new Riyadh's Smart City node through two notable projects: Riyadh Techno Valley (RTV) and Riyadh Knowledge Corridor (RKC). The RTV is a science and technology park project that represents a kind of public—private partnerships that are designed to foster knowledge flows and thus improve regional economic growth (Link and Scott, 2007). RTV aims to deliver an outstanding smart campus environment to enhance research and development, efficient operation, maintenance, and service delivery. Moreover, one of the main objectives of this project is to improve the interaction among all of these entities in a smart manner. It has been assessed that KSU is moving progressively toward knowledge society on a macro- and microscale in the kingdom by adopting innovations and entrepreneurial programs (Aldusari, 2015). The RTV and RKC projects illustrate the *smart economy* dimension as well; both are designed to be the gate for a knowledge-based economy. KSU established a partnership with RTV to convert the Saudi economy to a knowledge-based economy to facilitate research and investment in technology and communication (Aldusari, 2015; KSU News, 2018). The term "knowledge-based economy" refers to the environment that aims to convert knowledge into economic value through the transformation of technical developments into new services/products for economically investing into the market (Al-Filali and Gallarotti, 2012). There are many other projects in Riyadh which foster the *smart economy* dimension such as the King Abdullah Financial District, the City of Communication and Information Technology, the first and second industrial cities, and other centers that are all emerging, helping to provide growth and development opportunities in the city (Siemens, 2016).

Regarding the *smart governance* in Riyadh city, the smart applications that facilitate the governmental issues are widely used to emphasize citizen-centric development that enhances the quality of services provided by the government and reduces their costs (Pham, 2014). In addition, they facilitate the administrative processes and increase transparency, for example, "Riyadh Wiki Information and Complaining System," which is a free open-source smart tool that enables the citizens to engage in publishing Riyadh issues and data regarding the different sectors of the city such as health and education sectors. The citizens have the ability to add new sectors and new information to the system to support the government and improve the city. This tool used two models: the first one is codesign and the second one is crowdsourcing. In a codesign approach, the government opens its data to citizens to benefit from the different services (Castelnovo et al., 2015). On the other hand, in crowdsourcing approach citizens act as a source of data by using their mobile phones to collect data and images, provide feedback, and raise issues about their city to be used in policy formation and governance. Riyadh Wiki Information and Complaining System is developed as a web-based system, which can be used easily by the nonskilled citizens (Alexander, 2006) and at the same time allows skilled citizens to add new features and services (Helal and Mokhtar, 2018). The system helps in opening a connection between the people and the government. Such connections enhances transparency and trust between them, improves institutions' services through hearing the people concerns and fixing them, increases the level of satisfaction, saves time and money, guides decision-making, and fosters accountability as each governmental agency performance can be evaluated by citizens (Helal and Mokhtar, 2018). This system also strengthens the *smart people* concept because it encourages the wide participation of citizens in the urban life and their ability to adapt to new solutions.

In Riyadh, there are many projects that aim to facilitate the *smart mobility* through public transportation systems and efficient traffic management. Riyadh Metro project is one of the world's largest infrastructure projects. It consists of six lines with total length of 176 km. The metro has an automatic electrification and driverless train control system. The project systems optimize energy consumption, low maintenance costs, and high recyclability of the trains at the end of their service life. The trains are equipped with safety systems. Each train is provided by Wi-Fi service in the cars, LED lighting, and surveillance cameras (Riyadh Development Authority, 2015). Another example for smart mobility applications is the efficient traffic management system through the control and monitoring system installed in the center of Riyadh. The system provides sustainable solutions for the daily management of large traffic flows. A platform for the management of video stream from cameras placed along Riyadh's road network has been integrated into a video-monitoring system that supervises intersections set along the city's major traffic "corridors." Providing such smart public transportation enhances the quality of citizens' life and fosters the idea of the *smart living* as well because it facilitates their mobility, saves their time, and provides a safe and comfortable way of moving besides the different projects which target enhancing walkability and providing citizens' with livable public open spaces.

Regarding the *smart environment* dimension, the city of Riyadh has adopted many environmental practices to control the large amount of air pollution it experiences. The Natural Resources and Environmental Research Institute at King Abdulaziz City for Science and Technology (KACST) constructed a network for monitoring air quality. The first station was established at KACST premises in

1999, and then another four monitoring stations were constructed throughout the city. Another example is the Smart Water Meters and Hydrometer system, which has been installed in some regions in Riyadh and will be deployed in other cities in Riyadh Region for the next stages. Smart Water Meters are used for measuring the amount of water by ultrasound measurements besides other instruments and software programs for collecting, analyzing, and controlling data, which contribute to the efficient use of water (Abunayyan Trading, 2016).

4.3 Jeddah smart city

Jeddah city is the pride of the Red Sea and the tourism destination for Saudi and non-Saudi visitors, and it is located in the western region of Saudi Kingdom where 3.4 million persons live, which constitutes 14% of the Saudi Kingdom population (Jeddah Municipality, 2018). The Municipality of Jeddah seeks for shifting Jeddah city toward becoming a smart city and applying the newest technology to boost the city performance and the living quality and enhancing the business climate. Jeddah city will set the smart cities specifications for applying smart economic concept by reducing costs and resource consumption. The *smart governance* dimension will be reached by involving citizens more actively when they will be able to access government services easily, participate, and communicate efficiently from anywhere at any time. In this context, Jeddah Municipality already underwent the process by transforming all paper-based systems to e-service systems, replacing old equipment by high-tech infrastructure, and providing hundreds of terabytes of memory storage, in addition to an active network that connects all municipal branches. It is worth mentioning that the Jeddah Municipality received recently the Middle East Smart Government and Smart Cities Excellence Award in May 2015.

About *smart living* dimension and achieving the secure place to live, face recognition, computerized locks, and sensors in addition to multiple firewalls all will be applied in the smart homes. Regarding the *smart environment* dimension, adapting recycling system might be a good solution if integrated with people smart behaviors when they avoid consuming habits by the help of application that tells how green they are (Damanhouri, 2018). Collaboration between government and private sector would be a good indicator for a better future. Nokia and Zain, "Saudi Arabian mobile networks company," have signed an understanding memorandum to utilize advanced networking technologies in the IoT. Automating people lives and connecting each mobile to appliances, lights, and everything will shift Jeddah city and improve its living quality and efficiency and enable economic, social, and environmental sustainability (GoodNews, 2016).

In terms of *smart economy*, the King Abdullah Economic City (KAEC), which is located about a 1.5 h drive north of Jeddah, is the largest single investment to date in Saudi that is built as a free zone. It is designed as a multipurpose community, which includes schools and universities, an industrial zone, a central business district, a luxury resort, a deep sea port for both international shipping and passenger travel, and residential areas. The main purpose of building KAEC is to make a significant push toward diversification through economic liberalization beyond the oil industry, transform Saudi Arabia into a "nerve center" for global business, and to position Saudi Arabia to engage in the downstream sector through expanding petroleum-intensive industries such as petrochemicals, aluminum, and plastics. In addition, it is expected to address increasingly serious national problems such as housing shortage and high unemployment, in addition to providing a comparatively relaxed, liberal way of life (Moser et al., 2015).

King Abdullah University of Science and Technology (KAUST) is built in north Jeddah to be "*an enduring model for advanced education and scientific research*" *as* King Abdullah bin Abdulaziz Al Saud said. In the line of *smart people* concept, KAUST is created to be a knowledge destination, a catalyst for innovation, economic development, and social prosperity in Saudi Arabia and the world. The talented minds from Saudi Arabia and the whole world are invited to KAUST for education, research, and conferences, where innovative works that address the current global challenges are encouraged by the latest research methods and all available resources. It is also worth mentioning that KAUST Campus is built on green specifications and has earned Leadership in Energy and Environmental Design Platinum rating (KAUST, 2018).

4.4 Al-Madinah smart city

Al-Madinah province (Madina El Monawara) is the second holiest city in the Muslim world and an iconic part of the Hejaz region. It is located in the western side of the Kingdom and has a population of 1,300,000 and an area of 589 km^2. According to the 2030 vision, the expectations of the number of Umrah visitors in 2020 and 2030 is to increase up to 15 million and 30 million, respectively, and for Hajj pilgrims, the number is to reach 2.5 million in 2020 and 3.6 million in 2040. Because of the increasing number of Muslim visitors coming from all around the world, Al-Madinah City has seen major developments and expansions of both the mosque area and the airport.

Considering the smart city dimensions, the *smart mobility* is taking great attention due to the challenges that Al-Madinah face during Umrah and Hajj times including crowding, traffic congestion, and vehicles' environmental pollution. Therefore, and due to the criticality of having public transportation infrastructure, the Al-Madinah Al-Munawwarah Development Authority—the Saudi governmental organization responsible for implementing Al-Madinah region's comprehensive plan—is investing $100 million for the implementation of Al-Madinah Public Transportation Program (MPTP). The MPTP would endow Al-Madinah with an advanced public transportation system including metro and bus network to facilitate citizens and millions of pilgrims visiting each year. It would also provide other facilities, such as stations, park and ride lots, depots, and advanced intelligent transportation systems, which would allow seamless mobility, and provide safety to citizens and visitors (Louis Berger News, 2015). Along with that, the Haramain High-Speed Rail (HHR) project have been completed in 2016, but yet not opened for commercial services, and it is equipped with the latest signaling and communication systems and a very advanced automation technology. The HHR has the capacity to transport three million passengers every year between Jeddah and the cities of Makkah and Al-Madinah, with a speed of 360 km/h (Saudi Railway Organization, 2016). A study was conducted to assess the sufficiency and efficiency of the mobility performance (road classification, transportation means, and the use of nonmotorized traffic). The study found that Al-Madinah has a good radial street network within the city boundaries and beyond in terms of the streets' type, condition, width, and designated speed. It also has a good network of paved streets. In terms of traffic management, there is an automatic traffic system in the city that is connected to control centers covering all streets in the city. Also, there is a police unit monitoring roads traffic, security, and safety. However, regarding the nonmotorized traffic, there are no facilities for bicycles or pedestrians except for sidewalks (El Ela, 2016).

The second implemented dimension is *smart people*. Al-Madinah has launched in 2006 the Al-Madinah Knowledge Economic City (KEC) project with a budget of $7 billion, which is expected to be completed in 2025. It is one of four economic cities to be developed in the Kingdom. The KEC is a full city with an area of 4.8 km^2 and an expected population of 200,000 people. It contains all types of buildings including residential, commercial, educational, medical, and recreational (Driver, 2013). It is designed to be a smart city that aims to attract and develop talent and focuses on knowledge-based industries with an Islamic theme and Islamic tourism. The city is designed to be digital city, and it will provide a platform for the kingdom's small business entrepreneurs and IT industry (Ali, 2012). A study was conducted to look at e-learning, training, creativity, and knowledge. The study reported that government employees, employees in other jobs, and students attend training as part of their job requirements, and this training follows the local training courses in Al-Madinah. The study reported that the two universities in Al-Madinah are fully digitalized, and 259 schools in all level are partially digitalized and continuing to be fully digitalized, and some other schools need to be connected to technology (El Ela, 2016).

The third dimension that Al-Madinah started to implement is *smart living* through "Madinah as Smart City" project, which is supported and supervised by Prince Mugrin Bin Abdulaziz University. This project aims to converge different aspects of smart city such as connected people, connected IoT, connected vehicles, crowdsourcing, crowdsensing, human intelligence, semantic event viewer, cloud-based technologies, and more (Madinah the smart city, 2018). A study was conducted to assess the smart living of Al-Madinah based on three aspects of the quality of life: housing, health, and education. It was found that the three aspects are within the acceptable averages according to international standards (El Ela, 2016).

The fourth implemented dimension is *smart governance*. A study was conducted to assess the governance maturity level (e.g., strategies, visions and plans, and the technological tools and facilities that support decision-making) based on data from official authorities and public surveys. The results showed that there are points of both strength and weakness. The strength points are the use of technology by the city governance to facilitate planning and decision-making and the use of e-services in several sectors. While the weakness points are the top-down strategy is missing, the GIS application is not efficiently used, the smart city vision is applied on a case-by-case basis, feedback on governance performance is not yet in place, and although most of the departments stated clear roles of the smart city, there are no dedicated teams assigned for those roles (El Ela, 2016). The same study assessed the availability and effectiveness of services, networks, and ICT infrastructure in Al-Madinah. The results showed that the e-government transactions and services were provided since the issuance of the e-government program (Yasser) that was established as per Royal Decree no. 7/B/33181 in 2003, and there is an increasing demand every day. The MCIT is providing communication and ICT services for all sectors of the society all over the country (El Ela, 2016).

The fifth implemented dimension is the *smart environment.* A study was conducted to assess the situation in waste management and pollution rates. The Pollution Measurement Laboratory in Al-Madinah monitors the rates of pollutant in air and it is within the allowable rates according to the international standards. However, the central area of Al-Madinah has a high risk of the appearance of smog due to the tall buildings and heavy traffic. Regarding water in Al-Madinah, there are two supplies, the underground network of pipes that pumps water into tanks and the portable tanks or trucks that carry water to buildings off-grid. Both supplies could have the risk of contaminated reservoirs. Regarding sewerage, 56% of buildings are connected to the sewerage network and 46% are depending on underground reservoirs. The sixth dimension, *smart economy*, Al-Madinah has a rich Islamic cultural heritage and is surrounded with many archeological sites that attract millions of tourists every year. With regard to tourist, housing hotels in Al-Madinah are centered near to the Prophet's Mosque in the north-west part of the city, while guest houses and hotel apartments are covering the south-east part.

Another study confirms that Al-Madinah is deliberating three important steps toward transforming into smart city as follows: (1) after providing a broadband infrastructure, it included the e-government, intelligent city management applications, and safety control and security applications; (2) developing intelligent buildings and homes; and (3) providing intelligent applications for the visitors and pilgrims of the holy Madinah to mitigate emergencies and disasters and provide safety control and security (Ali, 2012).

4.5 Al-Ahsa smart city

Al-Ahsa is located in the eastern part of the kingdom with an area of 379,000 km (20% of the kingdom area) and a population of 1.3 million. The city is surrounded with Gulf countries, where Qatar and the UAE lie on the eastern side and Oman and Yemen on the southern side. It is one of the historical residential areas, where archeologist found discoveries older than 5000 years BC. Because of its very strategic location, it is known in the history as a center for exchanging commercial goods (Al-Ahsa Municipality, 2018).

According to the vision 2030, Al-Ahsa is the fifth city to be transformed to a smart city. With respect to the *smart economy* dimension, Al-Ahsa has two industrial cities; the first was inaugurated in 1981 and was established on the Dammam highway, north of Al-Ahsa on 1.5 million m^2, where all areas have been allocated to investors (Al-Barrak, 2011). The second industrial city was inaugurated in 2013 and was established on the Arabian Gulf 20 km away from the first industrial city. It extends on 300 million m^2, which makes it one of the largest industrial cities in the kingdom. It is in the size of 40 industrial existing cities, where it can accommodate over 10,000 new factories in heavy industries to become the economic pole for the kingdom and the Gulf. It is designed and planned to be based on environment-friendly systems and to become a developed center equipped with best services. The Saudi Industrial Property Authority (MODON)—the authority that is responsible for the development of industrial cities with integrated infrastructure and services in the Kingdom—and Al-Ahsa Municipality are supervising both cities and are responsible for developing and upgrading its security and smart city services and rehabilitating all roads and utilities (Saudi Industrial Property Authority, 2016). It is worth mentioning that Al-Ahsa Municipality was nominated in 2018 for the "Smart Economy & Government Administration Award" in Middle East Smart Government and Smart Cities Excellence Award (Manek, 2018). Along with that, Al-Ahsa has rich cultural heritage and natural resources that attract many tourists (Al-Ahsa Municipality, 2018). Regarding the *smart people* dimension, Al-Ahsa has established Al-Ahsa Creative City as part of the UNESCO Creative Cities Network to integrate culture and creativity into sustainable development plans (Al-Ahsa Municipality, 2018). As a practice for the *smart environment* dimension, Al-Ahsa started phase two for waste management, collection, and recycling using the latest high-tech equipment, an innovative waste sorting facility. New technology is used for a significant investment in optical sorting, which would improve recycling yield and increase overall productivity in Al-Ahsa waste sorting facility (Saudi Gazzete, 2017).

5. Conclusion

Responding to the earlier inquiry in this chapter that asks if the Saudi vision reflects the smart city concept and dimensions, after thoroughly reviewing the goals of the Saudi vision, it was found that the smart city concept and dimensions are deeply rooted in the Saudi vision despite that the "smart city" term is not mentioned literally.

Throughout this chapter, it is clear that Saudi Arabia strives to transform its cities into smart ones. It has the clear vision, willing, and the required resources to achieve its aspirations. After curious study, series of workshops, conferences, and meetings, the kingdom is determined to achieve the goal of transforming the first five feasible cities "Makkah, Riyadh, Jeddah, Al-Madinah, and Al-Ahsa" by 2020. The following part answers the second question in this chapter of knowing to what extent did the transformation of the Saudi cities reflected the Kingdom's ambitious vision toward smart practice. This study adopts the holistic approach of the smart city concept that is based on the six dimensions "*smart governance, smart economy, smart mobility, smart environment, smart people, and smart living*," which work collaboratively. Accordingly, the transformations of the five selected cities toward being smart are analyzed with respect to the six dimensions, and the conclusions are summarized in the following.

Based on the review of Makkah's smart city practice, it seems that Makkah has covered four out of six dimensions, *smart living*, *mobility*, *environment*, *and economy*, and missing two dimensions are missing, *smart governance and smart people*. This indicates that Makkah has transformed to a *digital city* by developing the infrastructure of the services provided to citizens (e.g., health, real estate, safety, security) using the advanced technology for more efficient performance and to an environmental city using technology to monitor the cleanliness of the city, smart cleaning equipment, and AVL follow-up system that is linked to GIS. However, there was no evidence found that indicates any practices toward smart people dimension. Although there is no available material or evidence that indicates to the smart governance practice, however, most of the government-related work has been digitized, electronic, and web-based throughout the kingdom.

Reviewing the Riyadh smart city practice, it appears that Riyadh is covering the six dimensions *smart governance, people, economy, living*, *mobility, and environment.* The *smart governance* practice is illustrated through the e-government program, the optimal usage of ICT, and the simplification of government procedures and systems. Clearly, the capital city focuses on the s*mart people* dimension, through many projects (e.g., the RTV, RKC). The *smart mobility* practice is very clear in having fully automatic trains and stations powered by renewable energy that will be a revolutionize transport not only in Riyadh but also in the region. The practice of *smart economy* is applied through the knowledge economic city that aims to transform technical developments into new services/products for economically investing into the market and through the industrial activities in Riyadh industrial cities.

Reviewing Jeddah smart city practice, there are five dimensions covered, s*mart governance, living, environment, people, and economy*, and one is missing, *mobility.* Jeddah's *smart governance* practice is similar to all other Saudi cities through e-governance that involves digital, electronic and web-based services and provides high-tech infrastructure. Regarding *smart living* dimension, Jeddah uses the newest technology to promote the city performance and the living quality (e.g., smart homes, face recognition facilities, networking technologies, IoT). The *smart environment* practice is through adapting recycling system, and the practice of *smart economy* is through many projects including KAEC, and finally, *smart people* is applied through KAUST, which provides great opportunities for education, research, and innovation for Saudi citizens and foreign students and researchers.

About the smart city practice of Al-Madinah, it apperance is covering the six dimensions. The *smart governance* practice is illustrated through the e-government program, the use of technology by the city governance, and the use of e-services in several sectors. The implementation of *smart people* in Al-Madinah is through Al-Madinah KEC project and the training provided by the city government for employees and students. Practicing *smart economy*, Al-Madinah is taking the advantage of its rich Islamic cultural heritage and the archeological sites around it to attract millions of tourists and is giving attention to tourist housing. Al-Madinah is providing a *smart living* to its citizens through "Madinah as Smart City" project that converges different aspects of the smart city. Al-Madinah is giving great attention to the *smart mobility* due to the mobility challenges during Umrah and Hajj times by providing a Public Transportation Program that would endow the city with an advanced public transportation system. Along with that, Al-Madinah has a good street network, a good network of paved streets, and an automatic traffic system. Al-Madinah monitors the rates of pollutants in the air and has a waste management system as a practice of the *smart environment* dimension.

About Al-Ahsa smart city practice, only four dimensions are covered, s*mart governance, economy, people, and environment,* and two are missing, *smart living and mobility*. Al-Ahsa's *smart governance* practice is similar to all other Saudi cities. The practice of *smart economy* dimension is applied through the establishment of two big industrial cities that are based on environment-friendly systems to become the economic pole for the kingdom and the Gulf and through benefiting from the rich cultural, the heritage, and natural resources that attract tourists. Al-Ahsa has established a creative city to integrate culture and creativity into sustainable development plans as a *smart people* practice. Al-Ahsa smart environment practice is illustrated through the innovative waste sorting facility for recycling and managing waste using the latest high-tech equipment. However, there was no available evidence that illustrates any practices for the missing dimensions.

Based on the above review, it is clear that the KSA has a clear vision and is moving fast toward fulfilling it, and it is striving to move away from oil dependency. The kingdom has directed its resources to invest in transforming its cities into smart cities through elaborate efforts on the six dimensions of the smart city. Riyadh the capital city and Al-Madinah are going faster toward achieving the Saudi Vision than Makkah, Jeddah, and Al-Ahsa. The review shows that there are lots of investments in the ICT infrastructure as a foundation of many other smart city dimensions and comparatively less efforts toward the mobility and smart people dimensions. It is important to put balanced and determined efforts in all dimensions. Because individuals are the building units of the society, thus smart individuals would potentially lead to smart communities and cities. Therefore, it is important to give more attention to the development of individuals in the city by emphasizing the smart people dimension to have a truly intelligent city that will lead to a full smart city.

6. Recommendations

Based on reviewing the practice of the five selected smart cities in Saudi Arabia, and according to the three main categories of the smart city developed by authors (end of part 3.2); ***digital city*** *(smart governance and smart living dimensions),* ***intelligent city*** *(smart people dimension), and* ***environmental city*** *(smart economy, smart mobility,* and *smart environment* dimensions), the following is recommended:

1. Makkah is a *digital* and an *environmental* city, but yet not an *intelligent city.* It is recommended to give more attention and elaboration to transform into an intelligent city so that Makkah can be a truly smart city. Also, continuous improvement and evolvement are important to maintain and refine the digital and environmental aspects of the city.
2. Riyadh has transformed into a *truly smart city* by implementing all six dimensions within the three categories (digital, intelligent, and environmental) of the smart city. Being the capital would keep Riyadh always under spot, which requires continuous improvement and a lot of hard work for excelling in the performance.
3. Jeddah is a *digital city* and an *environmental city*, but yet there is no clear evidence for being an *intelligent city.* It is recommended to give more attention and elaboration to transform into an intelligent city so that Jeddah can be called a smart city. Also, continuous improvement and evolvement is important to maintain and refine the digital and environmental aspects of the city.
4. Al-Medina is implementing all six dimensions of smart city, which indicates that the city has transformed into a truly *smart city.* However, further elaborate efforts are essential as the city faces many challenges.
5. Al-Ahsa started working toward being a *digital city* through implementing only the *smart governance* dimension but missing the *smart living* dimension, toward being an *environmental city* by implementing the *smart economy* and the *smart environment* dimensions but missing the *smart mobility* dimension, and toward being an *intelligent city* by implementing the *smart people* dimension. It seems that it covers the three categories of smart city concept, but yet requires lots of effort to work on the missing dimensions to be a truly smart city.

Overcoming the future challenges lies in the Kingdom human resources; thus, investing in people through emphasizing on the smart people dimension would result in having a truly intelligent city that will lead to a full smart city.

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CHAPTER

18 Reflecting on *oikos* and *agora* in smart cities context: concluding remarks

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Chapter outline

1. Introduction

Smart cities, seen as a concept and policy strategy, have firmly established themselves as the key tenet of contemporary academic and political debates. Smart cities research matures, and—increasingly—the so far distinct and distant communities examining smart cities through the lens of, for instance, computer science, engineering, urban geography, politics, sociology, communication studies, and many more engage in dialogue (Albino et el., 2015; Vanolo, 2016; Wiig and Wyly, 2016; Letaifa, 2015). Smart cities research is driven by the recognition that advances in information and communication technology (ICT) may be effectively employed in city/urban space to preempt, address, and/or mitigate nascent risks, threats, and challenges. Thereby, ICT-enhanced tools and approaches may contribute to well-being of cities' inhabitants (cf. Bibri, 2018; Wu et al., 2018). In this view, smart cities research locates itself in an area defined by issues as diverse as governance, mobility, economy, energy, living conditions/architecture, and environment. What brings these issues together is the recognition that—if used in socially and ethically sensitive ways—ICT-enhanced tools and approaches may allow addressing challenges cities face very effectively (Visvizi et al., 2017). This volume is very explicit in this regard.

Smart Cities: Issues and Challenges. https://doi.org/10.1016/B978-0-12-816639-0.00018-1

Central in the debate on smart cities is the concept of broadly understood sustainability. By upholding this issue in Goal 11, "sustainable cities and communities," of the United Nations Sustainable Development Agenda, a momentum was created to involve in the debate a variety of until-now-disengaged stakeholders (cf. Klopp and Petretta, 2017). By including them in the conversation, an implicit expectation has arisen that smart cities research will infuse the policy-making process with the very much needed conceptual zeal, methodological discipline, and evidence of multiple causal relations that unfold in the ecosystem of a (smart) city. This volume responds to this plea.

Measured by the frequency of its use across issues and domains, "smart cities" is a remarkably successful concept. The downside of this success is that at times its meaning is diluted, with smart cities becoming a sort of buzzword in academic and political narratives (cf. Kitchin, 2015; Visvizi and Lytras, 2018; Kitchin, 2019). Moreover, ICT—speaking to the "smart" part of smart cities—tends to be approached with great caution by many. Consequently, the concept of smart cities, the resultant debate, and policy strategies justifiably raise confusion among considerable part of the society members. From a different angle, the relative emphasis on ICT in smart cities research, followed by proposals of increasingly sophisticated ICT-enhanced solutions applicable in city space, effectively consolidated the already existing divide between research communities approaching smart cities from perspectives as diverse as those specific to social sciences, humanities, engineering, computer science, etc. Considering the amount of challenges cities are bound to face, these unnecessary divides ought to be bypassed. The objective of this volume was to do just that.

This edited volume gathers a unique selection of cutting-edge insights into developments that cities/urban areas confront on a daily basis. This book introduces the readers into key issues, developments, definitions, and conceptual frameworks necessary to understand the essence of the smart cities debate. The chapters included in the volume map nascent risks and threats and highlight drivers that may have substantial influence on city/urban landscape in the years to come. The balanced relationship between conceptual and empirical insights featured in this volume allows to bridge sound academic analysis with hands-on approaches and policy-making perspectives.

2. The context of this volume: beyond the information and communication technology—hype

The role of cities/urban areas in contemporary social, political, and economic processes evolves. Correspondingly, the variety of challenges cities are confronted with increases. Driven by processes of economic liberalization, the resultant increased movements of capital and labor, and finally by advances in ICT, gradually, cities and urban areas turn into powerful centers of power and influence. Becuase of their economic, political, and societal clout, in no time, several cities and urban areas will effectively challenge the established centers of state authority, thus adding a new, but very tangible, dimension to—by now classic—argument of globalization and shifting spheres of authority (Rosenau and Czempiel, 1992). With the onset of sophisticated ICT, the social reality seems to have become more complex than ever (Cardullo and Kitchin, 2018; Lytras and Visvizi, 2018). The city space attests to it. In other words, owing to advances in ICT, the traditional binary division between oikos (*οίκος*) and agora (*αγορά*) in city space has been challenged by the emergence of parallel channels of communication and consolidation of "virtual" public and private space. How in these circumstances to conceive of a city, conceptualize its fabric, and account for the mechanisms that govern its functioning? How to bridge the virtual and the tangible in the city space? How to enable civic participation? How to ensure the key imperatives of "freedom to" and "freedom from" in the evolving ICT-infused landscape of a city? How to embrace the key facets of sustainability in the city space, including social inclusion, resilience, environmental balance, safety and security, and well-being (cf. Arendt, 1958; Bauman, 2013; De Cauter and Dehaene, 2008; Martin, 2000; Castoriadis, 1997)? This volume was triggered by precisely these questions.

Throughout this volume, a case for ethically and socially sensitive perspective to, and the use of, ICT-enhanced tools and approaches was advocated (cf. Mazzucelli and Visvizi, 2017). In other words, even if sophisticated ICT is at the center of the debate on smart cities, this book reminds that it is the citizen/the individual and the society/the community that define the thrust, the concept, and corresponding policy-making considerations. Seen in this way, this volume rests on the recognition that ICT in context of smart city should be employed to and/or should fulfill the following prerequisites, even if critical issues remain (cf. Visvizi and Lytras, 2019; Boussios, 2019).

- It should be beneficial for the society and embrace the logic of social responsibility;
- It should be geared toward addressing a critical social issue and respond to a social problem;
- It should derive from the premises of equality and solidarity;
- It should embrace the logic of sustainability and so should promote considerate use of resources, be cost efficient, etc;
- It should promote social inclusion;
- It should be accessible and useable;
- It should be applied in a legitimate, accountable, and transparent manner;
- It should embrace critical legal and ethical considerations pertaining to privacy;
- It should flexible, open, and extendable;
- It should promote collaboration;
- It should capitalize on social diversity.

3. A few points on technology and smart cities

Smart cities research provides a framework for an inter- and multidisciplinary discussion related to the value added of several cutting-edge technologies, including immersive technology, virtual and augmented reality, wearable technology, cloud computing, social networking, web applications, and internet technology. The big data paradigm adds a yet another layer to that debate because it offers the prospect that we will acquire the capacity to manage and use data effectively, e.g., for data-driven decision-making processes in urban areas. The cases of natural disasters affecting cities/urban areas or one-off events, such as those related to the uncontrolled influx of migrants and refugees, illustrate well why the demand to use big data to provide services in a targeted manner cannot be underestimated. From a different vantage point, as advances in ICT pave the way toward more effective teaching and learning strategies and methods (Lytras et al., 2019a), the expectation is that the smart cities debate will incorporate these considerations as well.

Considerate research exists, which maps the existing ICT-enhanced tools and approaches that find their application in city space. In this sense, smart city becomes the embodiment of the encounter of society and technology. Fig. 18.1 offers an overview of technologies that play a role in smart city space.

The key point in this context is that a holistic approach to these technologies is needed to enable efficient and sustainable use of technology in the city space. Indeed, the chapters included in this volume showcase a variety of ICT-enabled tools that aim at making cities human-centered, resilient, and sustainable. The volume therefore diagnoses and proposes remedies to very specific problems, challenges, and concerns that define the smart cities debate. Successive contributions included in this volume, step by step, address very specific issues pertinent to the smart cities debate, including democracy, civic participation, well-being, safety, security, leisure, resilience, economic development, and talent management. Case studies embellish the discussion.

4. By means of conclusion

Consensus has emerged that sustainability and resilience of cities and, generally, urban spaces requires that advances in ICT are skillfully harnessed. Driven by academic research, policy makers' considerations, and civil society representatives, an effort is underway to design, develop, and implement ICT-enhanced tools aimed at addressing needs and challenges that inhabitants of urban spaces face (Deakin, 2013; Karvonen et al., 2018; Bibri, 2019). Smart cities, seen as a concept and policy strategy, serve as the embodiment of this effort. Paradoxically, even if the academic debate on smart cities matures and ever more sophisticated insights into the sphere of the technically possible in urban space are proposed, praxis suggests that for the

FIGURE 18.1

Smart cities—enabling technologies.

Source: Lytras, M.D., Visvizi, A., Sarirete, A. (2019) 'Clustering Smart City Services: Perceptions, Expectations, Responses'. Sustainability 11 (6), 1669. Reproduced under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited (CC BY 4.0). [https://www.mdpi.com/2071-1050/11/6/1669].

preponderant part of city dwellers, smart solutions remain a misunderstood, unrecognized, or feared product of "science fiction." From a different angle, many smart services have been embedded in the city space so seamlessly that their existence is a part of the daily routine.

This volume provides insights into a number of case studies and outlines policy recommendations geared toward boosting sustainability and resilience of cities and urban areas. From this perspective, this volume may be seen as a primer on smart cities. This volume considers the needs of a reader with no prior knowledge of the smart cities debate and allows him/her to understand what the debate is about, what potential it bears, and what is at stake. But this volume offers nevertheless enough of in-depth insight into more complex issues that shape the reality of smart cities. Therefore, it will be of interest of those who have been in the field for a while now. We hope that this volume will be of use for students, university teachers, executives, and policy makers.

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Smart Cities: Issues and Challenges

Mapping Political, Social and Economic Risks and Threats

- Combines conceptual and empirical insights to explore current developments pertinent to smart cities
- Applies inter- and multidisciplinary perspectives to examine case studies from all over the world
- Combines foundational information with sophisticated insights on smart cities that enable critical reflection and operationalization

Smart Cities: Issues and Challenges: Mapping Political, Social and Economic Risks and Threats is a primer on smart cities, providing readers with no prior knowledge on smart cities with an understanding of key debates and developments in this field. Featuring cutting-edge research and insights from academics, practitioners, and policymakers, the volume discusses nascent risks, threats, and challenges contemporary cities/urban areas face, highlighting how information and communications technology (ICT) can facilitate addressing them in an effective manner. Providing a blend of conceptual and empirical work, the book offers also a few recommendations on how to boost (smart) cities and urban areas resilience and sustainability.

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ISBN 978-0-12-816639-0

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