

Exploring the Nature of the Smart Cities Research Landscape

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Abstract As a research domain, Smart Cities is only emerging. This is evident from the number of publications, books, and other scholarly articles on smart cities indexed in Google scholar and Elsevier's Scopus—an abstract and citation database. However, significant literature is available on related topics like intelligent city, digital city, and intelligent community based on search results research repositories such as Elsevier's Scopus, ACM Digital Library, and Google Scholar. This chapter maps the research work in the smart cities' domain, based on the available scholarly publications. The aim is to synthesize an emerging understanding of the smart city concept, determine major research themes, types, and gaps in the current research landscape.

Keywords Smart cities · Intelligent cities · Smart city research · Research mapping · Bibliometrics · Scientometrics

1 Introduction

The unprecedented level of urbanization and consequent growth in size and numbers of cities in different parts of the world present both challenges and opportunities. On the one hand, phenomenal growth (~tenfold) in the urban population

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(from 250 million at the beginning of the 20th century to 2.8 billion at the beginning of the 21st century, with an expected rise to about 9 billion in 2050 (DiChristina 2011)) challenges the traditional approaches to city management and urban lifestyle. For instance, the traditional approach to the management of transportation systems, water resources, waste, energy, and natural environment in the cities must be fundamentally rethought to cope in a sustainable manner with the pressure induced by growth in demand for these resources. On the other hand, given that cities constitute the social nexus (Ratti and Townsend 2011) of the larger society providing the much needed intellectual and social capital for growth, and that bigger cities appear to be able to do more with less (Bettencourt and West 2011), city growth may offer opportunities for more optimal city management and innovation. The collaborative creativity resulting from proximity and constant interchange of ideas offered by cities has helped many cities, particularly in the developing world to get out of poverty and integrate with the wider world economy (Glaeser 2011).

In responding to challenges and opportunities of rapid urbanization and city growth, many governments at different levels—international, regional, national, and local—have initiated some programs on digital and intelligent cities and lately smart cities. Digital, intelligent, and smart cities are related concepts all involving the information and communication technology (ICT)-enabled transformation of the city, city management, as well as city inhabitants and actors. While the difference between the three concepts remain fuzzy (Hollands 2008), differences have been noted in the changing focus and consequently the required capabilities in implementing initiatives associated with the three concepts.

Smart cities as urban innovation and transformation initiatives aim to harness physical infrastructures, ICT, knowledge resources, and social infrastructure for economic regeneration, social cohesion, better city administration, and infrastructure management (Ojo et al. 2014). A distinguishing feature of the smart city concept is the centrality of people or the welfare of its residents in its essence. Specifically, smart cities are concerned with the transformation of life and work of city inhabitants (Hollands 2008). Smart cities also focus on harnessing human collaboration for generating ideas which are considered as the currency of the current age (Ratti and Townsend 2011). This extended scope and focus on integration of different aspects of city—administration, resource management, lifestyle, mobility, etc.—makes the smart cities' research more challenging and ambitious with respect to previous research on intelligent and digital cities which focused primarily on the technology dimension (e.g., ICT infrastructure and services) and its transformational effect on other dimensions of the city.

The research in urban transformation is fairly mature with over three decades of work, whereas the research in smart cities, intelligent cities, and related areas is relatively new. However, given the close link between smart cities and major issues of interest to policymakers such as sustainability and technology innovation in city governments, research interests and outputs have been growing at a more rapid rate lately. Currently there are over 800 papers in Scopus with “smart cities” in their titles, abstract, or keywords and over 7000 scholarly resources indexed in Google Scholar. We believe that this level of research outputs in the domain is sufficient to explore the emerging and future trends in smart city research.

This chapter examines the smart cities' research domain by analyzing scholarly publications on the subject matter based on data available on Elsevier's Scopus database—the largest abstract and citation database of peer-reviewed literature: scientific journals, books, and conference proceedings. The study complements existing research landscaping studies in the e-government domain (Grönlund 2004; Heeks and Bailur 2007; Yildiz 2007). The chapter is primarily targeted at researchers. Findings may also be of interest to practitioners to guide funding policies for research in the smart cities' domain.

2 Conceptual Framework

This section provides the conceptual underpinning for the study definitions of core concepts of a smart city. The term smart city (or smart cities) has been adopted by different governments, consulting organizations (IBM 2013), and research groups. Despite the wide use of the term, its meaning remains fuzzy (Caragliu et al. 2009; Nam and Pardo 2011). Smart city according to Giffinger et al. (2007) is “A city performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive independent and aware citizens.” This definition is based on the traditional, regional, and neoclassical theories of urban growth and development. In particular, the axes are based—respectively—on the theories of regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and participation of societies in cities. Based on Giffinger's definition, Caragliu et al. (2009) offer a similar definition of the concept as follows—“We believe a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.”

Smart cities are expected to dramatically improve their citizens' quality of life, encourage business to invest, and create a sustainable urban environment (Vasseur and Dunkels 2010). Interestingly, while the term *smart city* literally implies an outcome or a result, most consider the term as an “activator” of change through exploring relevant open innovation processes (Paskaleva 2011). Other conceptualizations, such as Nam and Pardo (2011) consider smart city as urban innovation involving technological, organizational, and policy innovations. Finally, smart city could be understood as a certain intellectual ability that addresses several innovative socio-technical and socioeconomic aspects of growth (Zygiaris 2012).

In Hollands (2008), three characteristic elements of the smart city concept were identified to include: (1) utilization of networked infrastructures to improve economic and political efficiency and enable social, cultural, and urban development infrastructures including ICT; (2) business-led urban development; and (3) social and environmental sustainability. Social sustainability implies social cohesion and a sense of belonging, whereas environmental sustainability refers to the ecological

and “green” implications of urban growth and development. In Komninos (2011), the concept of spatial intelligence of cities is presented as a composite capability enabling communities within the city to harness the intellectual capital, institutions, and material infrastructure in dealing with problems and challenges. Spatial intelligence is composed of three types of intelligence: (1) the inventiveness, creativity, and intellectual capital of the city; (2) the collective intelligence of the city’s institutions and social capital; (3) the artificial intelligence of public and citywide smart infrastructure, virtual environments, and intelligent agents. These three types of intelligence involve all dimensions of the city and maps to three types of spaces—physical, institutional, and digital. The “physical space” corresponds to the inventiveness and creativity of the city; the “institutional space” includes the social capital and collective intelligence of the city population; and “digital space” contains the artificial intelligence embedded into the physical environment, including public broadband communication infrastructure and digital technologies.

Focusing on the digital space, the following infrastructure networks for smart cities were identified in Vasseur and Dunkels (2010). Some of these networks are related to transport, public safety and security, public services, utilities, and social networking. In the physical space, skills and human capitals are considered as arguably the most important elements. For instance, it is argued that the greatest competitive advantages of the cities are qualities that attract the best and brightest from the world to a city (Bloomberg 2011). This is supported by the fact that educated cities grow more quickly than the less educated ones, since skilled cities are economically more productive and better at adapting to economic shocks (Glaeser and Saiz 2003).

We summarize the different elements of the definitions of the smart city concept below in Table 1. Further discussions on the conceptualizations and definitions of the smart city are provided in Hollands (2008), Caragliu et al. (2009), Chourabi et al. (2012), and Nam and Pardo (2011).

Table 1 Elements of “smart city” definitions

No	Description	Reference
Nature	Is a (1) forward-looking city in the areas of economy, people, governance, mobility, environment, and lifestyle; (2) form of urban innovation; and (3) intellectual capital profile of a city	Giffinger et al. (2007), Nam and Pardo (2011), Zygiaris (2012)
Essence	Means (1) information access, bridging digital divide, lifelong learning, social inclusion, and economic development; sustainable economic growth and urban development, higher quality of life; and wise management of natural resources; (2) innovative socio-technical and socioeconomic growth of a city	Hollands (2008), Vasseur and Dunkels (2010), Zygiaris (2012)
Approach	Involves (1) investments in human and social capital; (2) investment in traditional (transport) and modern (ICT) communication infrastructure; (3) promoting participatory governance and engagement of citizens; (4) technological, organizational, and policy innovation	Caragliu et al. (2009), Nam and Pardo (2011)

3 Methodology

3.1 Research Objectives and Questions

This study aims to capture the emerging understanding of the “smart city” concept, examining the nature of the smart city research and concluding on the overall research maturity and indications on areas where future research efforts could be targeted. Specific objectives for the study include:

1. Strengthening the conceptual foundations of smart cities’ research by: (a) developing an analytical definition for the “smart city” concept by integrating existing definitions in literature; (b) establishing conceptual similarities between “smart cities” and related concepts like intelligent cities, ubiquitous cities, digital cities, e-cities, etc.; and (c) determining the major dimensions of the smart city concept.
2. Determining the trend in “smart cities” research by identifying the major research themes and types in available smart cities’ publications and noting how these themes change over time.
3. Eliciting the research gaps by identifying research issues and questions from publications providing critical perspective, critique and lessons from planning, pilot development, and full-scale deployment of smart cities-related initiatives.

Guided by these objectives, the study answers the following questions:

- R1. How can the smart city concept be defined and what are the major dimensions of the concept?
- R2. Is there a discernible conceptual distinction among the three related concepts—smart city, intelligent city, and digital city? To what extent can previous studies in digital and intelligent cities fundamentally contribute to smart city research?
- R3. What trend can be observed in terms of theme, nature, and approach of research carried out in the smart city domain?
- R4. What are the areas of “smart city” research that are relatively uncovered and to what extent are the governance aspects of the smart cities studied?

3.2 Research Method

The research method adopted in the study combines research mapping and visualization technique with content analysis of scholarly publications used in scientometric or bibliometric studies. The main source of data was journal articles and conference papers related to smart cities or intelligent cities provided in the Scopus database—the largest abstract and citation database of peer-reviewed literature and quality web sources. Our decision to include publications on intelligent cities as a part of the publications on studies of smart cities is based on the results of preliminary analysis of the definitions of the three related concepts (digital, intelligent, and

smart city) presented in Sect. 2. *Our analysis showed that the concept of intelligent city is significantly closer to smart city when compared with the digital city concept.*

By taking publication as the unit of analysis, each publication is mapped to a number of dimensions—defining of key terms for the publication, the research theme addressed in the publication, the nature of research documented in the publication, the overall approach adopted in the research, and the aspects of the smart city concept addressed in the research. Microsoft Excel was used as an analysis tool, while “VOSviewer” and “Pajek”—Program for Large Network Analysis—were used for mapping and visualizing the research landscape. The details of our mapping and analysis are discussed in the subsections below.

Selecting Publications The source of data for our research is the Elsevier’s Scopus Abstract and Citation database. We considered all publications in the database with the terms—“smart city” or “intelligent city”—in their titles, abstracts, or keyword lists. The same query was run a number of times between the period October 2011 and March 2012, to track new articles. Given that over 70% of the available publications were published within the past 5 years, all available 209 publications were considered initially in analysis. After reviewing each publication for relevance and removing publications without abstracts, we were left with 170 publications. The 170 publications were exported from the Scopus to Microsoft Excel for further analysis.

Generating the Publication Map The mapping process entailed determining the nature of research contained in the publication, research approach adopted, aspects of the smart city concept addressed in the research, and the neoclassical dimensions of the smart city concept related to the publication. For all four dimensions, our strategy was to start off with an initial set of possible values or labels and extend the categories as they emerge from the publications. The initial set of values defined for the four dimensions are highlighted below:

- 1) *Nature of research*—describes the nature of research in the publication. A scheme combining the traditional classification of research in social science with the design-oriented research in computing and engineering was adopted. Publications were classified as (Heeks and Bailur 2007; Grönlund 2004): polemic, debate, position, conceptualization, theoretical, theory development, theory testing, survey, design, or simply descriptive.
- 2) *Research approach*—describes the methodological aspect of research publications including (Grönlund 2004): single and multiple case study approach, comparative analysis, empirical analysis, action research, modeling and simulation, experimentation were considered as options. When no specific approach is reported or implied in the abstract, the research approach was simply considered to be analytical.
- 3) *Research themes and subthemes*—the initial set of themes were related to the classical policy cycle for any major initiative, in addition specific themes related to improving current understanding of smart cities, policy and strategy, models and frameworks, technology, governance, organizational processes in smart city initiatives or projects.

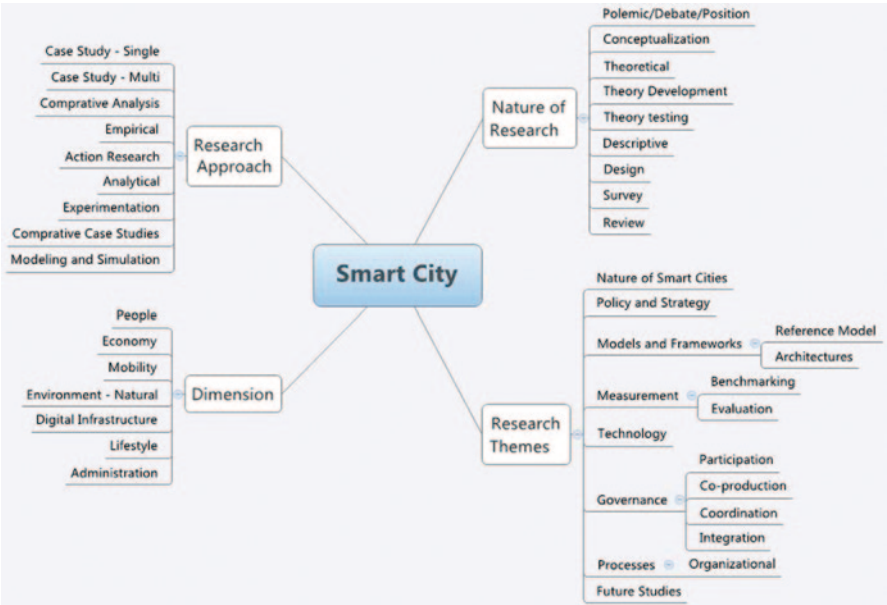


Fig. 1 Taxonomy for analysis dimensions

4) *Smart city dimension*—the initial set of dimensions specified for the smart city concept include people, economy, mobility, natural environment, ICT infrastructure, lifestyle, and public administration (or public governance).

Analyzing the Publication Map After mapping each publication along the four dimensions described above, pivot tables were generated to summarize the publications along each of these dimensions to produce corresponding tables and graphs showing frequency counts and trends over years. The second type of analysis involved organizing and visualizing the research domain based on the titles, keywords, generated research themes and subthemes, as well as abstracts of the publications. The typical workflow for domain visualization was adopted using the VOSviewer and Pajek tools. See Fig. 1 and Table 2 for the taxonomy and parameters for the analysis, respectively.

Table 2 Parameters for analysis

Parameter	Value
Unit of analysis	Individual publication
Measure	Counts of attributes—keywords, title, themes, and subthemes
Similarity measure	Co-term based using VOSviewer mapping and clustering algorithm
Visualization	Pajek “Draw” algorithm

4 Analysis

This section presents an analysis of the research publications based on the methodology described in Sect. 3 as the basis for answering the research questions. Section 4.1 examines the elements and dimensions of the smart city concept, Sect. 4.2 attempts to determine the similarities and differences between the smart, intelligent, and digital city concept. Section 4.3 explores the observed trends in smart city research, followed by analysis of research gaps in the domain in Sect. 4.4.

4.1 *Elements and Dimensions of the Smart City Concept*

This section analyzes the smart city definitions provided in Sect. 2.3 to obtain the nature of smart cities, the kind of goals they are built to support, and their elements.

From the definitions, we identify three basic attributes of the smart city concept as an “actual city, a form of urban innovation.” First, smart cities are characterized by the “high intellectual or human capital” needed to support continuous innovation and address problems or challenges. Second, in terms of goals, smart cities aim at social inclusion, significantly improved quality of life, and economic development. Third, smart city policies also target the development of human capital through lifelong learning, optimal management of natural resources, and sustainable urban development in general.

Aspects of the smart city concept include: participatory governance, human capital development, ICT infrastructure development, technological innovation, organizational innovation, policy innovation, integration of city endowments, and developing active self-decisive citizenry. Details are provided in Table 3 below.

4.2 *Conceptual Analysis of Smart Cities and Related Concepts*

In this section, we attempt to identify the similarities and differences between the smart city concept and intelligent and digital cities.

Digital cities by their nature are considered to be some form of an extension—a virtual extension of a real city. In a weak sense, it is synonymous to a label assigned to cities with good ICT infrastructure or that widely employ ICT applications. Similar to smart cities, digital cities are targeted at democratic participation, economic development, and social cohesion. Despite the wide applicability of digital city concept, its elements are limited to mainly ICT infrastructure or digital networks and software applications.

Intelligent City as a Concept Appears to Lie Between the Smart City and Digital City Concept Intelligent city is conceived as a real city endowed with collaborative, learning, and innovation environments or spaces. The intelligent city concept is also considered as a transformational instrument in urban development. Core purposes

Table 3 Analysis of “smart cities” definitions in literature

No	Description	Summary
Nature	Is a forward-looking city in economy, people, governance, mobility, environment, and living	Forward-looking city
	Is urban innovation	Urban innovation
	Is intellectual capital of a city	Intellectual capital
Purpose	Means to information access	Information access
	Means to lifelong learning	Lifelong learning
	Means to bridging the digital divide	Bridging digital divide
	Means to social inclusion	Social inclusion (2)
	Means to economic development	Quality of life (2)
	Means to high quality of life	Economic development (4)
	Means to wise management of natural resources	Natural resources management
	Means to dramatically improve their citizens’ quality of life	Sustainable urban development
	Means to encourage business to invest	
	Means to creating a sustainable urban environment	
	Means to sustainable economic growth	
	Means to address innovative socio-technical and socioeconomic aspects of growth	
Elements	Includes participatory governance	Participatory governance
	Involves investments in human and social capital	Investment in human capital
	Involves investment in traditional (transport) and modern (ICT) communication infrastructure	Investment in social capital
	Includes technological, organizational, and policy innovation	Investment in communication infrastructure
	Involves smart combination of endowments	Technological innovation
	Involves activities of self-decisive independent and aware citizens	Organizational innovation
		Policy innovation
		Integration of endowments
		Activities of self-decisive citizens

for intelligent city initiatives center on transformation of lifestyle, work, and recreational activities in addition to sustainability of the associated cities. Similar to the smart city concept, an important objective of intelligent cities is developing the problem-solving capabilities of the cities.

Aspects of the intelligent city include the ICT infrastructure development, development of intelligence infrastructure, and services, in addition to building institutional leadership and organizational capacity of the cities. We summarize the similarities and differences among these concepts in the Tables 4 and 5 below.

Based on the analysis here, we note that the three terms—smart-, intelligent-, and digital city—are closely related concepts particularly in terms of their purpose.

Table 4 Similarity of smart city concept to intelligent- and digital city concepts

Similarities	Intelligent city	Digital city
Nature	<i>Like smart city, intelligent city concept:</i>	<i>Like smart city, digital cities are characterized by:</i>
	Serves as metaphor for real cities	High urban ICT adoption and usage
	Emphasizes on urban innovation	
	Is transformational	
Purpose	<i>Like in the smart city concept, intelligent cities also:</i>	<i>Like smart cities, digital cities support:</i>
	Focus on the urban sustainability	Socioeconomic development and other aspects of urban life
	Focus on the impact on different aspects of urban life	
Elements	<i>Like smart cities, intelligent cities also:</i>	<i>Like smart cities, digital cities also:</i>
	Involve ICT infrastructure development	Involve ICT infrastructure development
	Involve creativity and social capital development	

Table 5 Difference between smart city concept and digital- and intelligent city concepts

Difference	Intelligent city	Digital city
Nature	Smart city concept places relative emphasis on human aspect of urbanism, whereas intelligent focuses more on the technical supporting infrastructure and services	Digital cities appear to be virtual extensions of the real cities, whereas smart cities are conceptualized as “real cities”
Purpose	The scope of intelligent cities’ initiatives is relatively narrower than that of the smart cities	The scope of digital cities’ initiatives is even more limited or focused when compared with smart cities
Elements	Smart cities emphasize integration among elements, whereas elements of intelligent cities are more specialized and standalone	Digital cities are characterized largely by ICT infrastructure and services, whereas smart cities involve activities in all major aspects of the city development

When considering the constituent elements of the concepts, digital city is restricted to ICT infrastructure and services. The intelligent city concept in addition to the basic ICT infrastructure and services includes other specialized technical elements such as “intelligence” infrastructure to support acquisition of information (instrumentation) and learning. The intelligent city also includes elements that involve the development of innovation.

Smart city elements include those of the intelligent city in addition to socio-organizational and institutional infrastructure to support the specific policy domains and governance mechanisms for integrating the solutions to concerns in the different domain.

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