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Smart Cities – A Multidisciplinary Perspectives Model

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ABSTRACT

A prominent concern of urbanization is to address affiliated challenges and/or strive for sustainability in the long-term. Towards this end, three conspicuous city forms are being advanced in the literature body such as sustainable, smart and eco-friendly, but these disparate advances might confuse the concerned actors who are looking forward to steer urbanization through present-day realities and emerging threats. This study adopts smart form discourse as the overarching theme of its discussion. Smart cities represent a popular theme for research with extensive body of literature which is expanding over time. Conversely, this theme incorporates a wide range of (varying) perspectives which in turn give the impression of a poorly defined phenomenon. At this juncture, efforts towards consensus-building on defining smart cities need attention. To this end, this study provides an overview of such efforts in the past and features a systematic literature review to propose a comprehensive multidisciplinary perspectives model for defining smart cities. Findings of this study suggest convergence of the sustainable, smart and eco-friendly perspectives under the smart form discourse, which in turn lead to a coherent whole about propositions for urbanization. Accordingly, this study advances the notion that a city is truly smart when it can capitalize on its resources for desired ends, is risk-aware and strives for sustainability in the long-term.

Key Words: **Eco-friendly, Framework, Perspectives, Smart cities, Sustainability**

Introduction

The phenomenon of urban growth (or *urbanization*) has picked pace since the 1950s (ChuanTao, Zhang, Hui, JingYuan, Daven, & Bertrand, 2015), and 66% of global population is projected to urbanize by 2050 (United Nations, 2015); environmental and social implications are significant accordingly (ChuanTao et al., 2015; Bibri & Krogstie, 2017). In connection, city *form* is perceived as a source of environmental and/or social problems (Bibri & Krogstie, 2017) – air pollution, congestion, waste management and human health (OECD, 2012). Conversely, international organizations are urging shift towards eco-friendly practices (Bibri & Krogstie, 2017). Borne out of the desire to overcome challenges of urbanization, three conspicuous city forms are being advanced in the literature body such as ***sustainable*** (Fu & Zhang, 2016; Ahvenniemi, Houvila, Pinto-Seppä, & Airaksinen, 2017; Bibri & Krogstie, 2017), ***smart*** (ChuanTao et al., 2015; Fu & Zhang, 2016; Ahvenniemi et al., 2017; Bibri & Krogstie, 2017) and ***eco-friendly*** (Fu & Zhang, 2016; Bibri & Krogstie, 2017).

Sustainable form implies a city which strives for balance between its urbanization-related objectives and environmental preservation (Van der Ryn & Calthorpe, 1986; Hiremath, Balachandra, Kumar, Bansode, & Murali, 2013; Bibri & Krogstie, 2017). Unfortunately, this notion is plagued with multiple interpretations which in turn have triggered an explosion of diverse indicators to measure urban sustainability (Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010), with varying priorities (Ahvenniemi et al., 2017). Nonetheless, numerous authors are advocating integration of citizen-led, participatory, localized and procedural approaches pertaining to urban sustainability (Ahvenniemi et al., 2017); underlying argument is that the key to achieving urban sustainability is through the understanding of the relationships between people, their activities and the environment (Ahvenniemi et al., 2017).

Smart form implies a city which strives for urban efficiency through intelligent management of functions and/or systems with information and communication technologies (ICT) at its core (Bibri & Krogstie, 2017). Regrettably, this notion is also beset with varying perspectives (Gianni & Divitini, 2015; ChuanTao et al., 2015; Ahvenniemi et al., 2017). Nonetheless, urban sustainability is being increasingly viewed as an important component of the ***smart*** form (Giffinger, Fertner, Kramar, Kalasek, Pichler-Milanovic, & Meijers, 2007; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014; Ahvenniemi et al., 2017; Bibri & Krogstie, 2017); implying a perspective that strives for convergence of the two forms.

Eco-friendly form implies a city which strives for the low-carbon discourse in its urbanization trends and corresponding strategies (Fu & Zhang, 2016). This form is normally characterized by terms such as *eco-city*, *low-carbon city*, *sustainable city* and *green city* in the literature (Fu & Zhang, 2016). Argument in this context is to turn a “sustainable city” greener by addressing the issues of urban greening, heat island, and public transportation against the backdrop of global warming phenomenon (Fu & Zhang, 2016). Surprisingly, ***smart*** form discourse is not significant in these discussions (Fu & Zhang, 2016).

The aforementioned strands and/or forms are rooted in distinct interests but seem to converge on the aspect of urban sustainability (Fu & Zhang, 2016); apparently a step towards consensus-building among scholars in the matters of urbanization. This study is intended to advance this consensus-building effort under the ***smart*** form discourse.

The *smart city* concept conundrum

The term 'smart cities' is synonymous with numerous nomenclatures in the literature such as virtual cities, cyber cities, digital cities, networked cities, intelligent cities, knowledge cities and real-time cities (Bibri & Krogstie, 2017); at the core of these themes is the use of ICT to facilitate relevant urbanization objectives. Although *smart cities* gained traction in the 1990s with Gibson, Kozmetsky and Smilor (1992) being cited as one of its earliest references (ChaunTao et al., 2015), an early proposition of "cybernetically planned cities" in the 1960s spurred the notion of smart cities as per Gabrys (2014).

A common complaint in the literature on *smart cities* is that this theme is beset with diverse perspectives and lacks a standard point-of-reference (Gianni & Divitini, 2015; ChuanTao et al., 2015; Ahvenniemi et al., 2017; Bibri & Krogstie, 2017). In-fact, Lom and Přibyl (2017) perceived *smart cities* as a non-deterministic environment with many variables. However, Giffinger et al. (2007) proposed a model that has served as a standard point-of-reference for this theme in some capacity **[1]**; this model characterize *European Smart City Classification Standard* (Zubizarreta, Seravalli, & Arrizabalaga, 2016) and its elements are being incorporated into other propositions over time such as in Vlacheas, Giaffreda, Stavroulaki, Kelaidonis, Foteinos, Poulios and Demestichas (2013), Neirotti et al. (2014), Nuaimi, Neyadi, Mohamed and Al-Jaroodi (2015), ChuanTao et al. (2015), Anthopoulos, Janssen and Weerakkody (2016), Ercoşkun (2016) and Lom and Přibyl (2017).

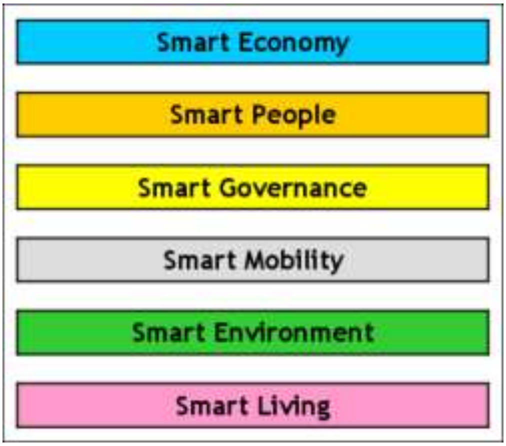

Figure 1
Characteristics of a smart city Giffinger et al (2007)

Diverse perspectives essentially highlight the multidisciplinary character of the *smart cities* theme (ChaunTao et al., 2015). Efforts have been made to reconcile varying perspectives in regards to the concept of *smart cities* for the benefit of concerned actors (ChaunTao et al., 2015; Anthopoulos, Janssen, &

Weerakkody, 2016) but this theme is continuously evolving (ChaunTao et al., 2015) – a conundrum.

ChaunTao et al. (2015) observed that smart city architectures **[2]** are largely data-centric, as in enabled and driven by data-processing technologies such as Big Data, Cloud Computing, Internet of Things (IoT), Mobile Computing and Data Vitalization. The end goal is to make city services more intelligent, interconnected and efficient by virtue of the overarching IoT infrastructure (Washburn, Sindhu, Balaouras, Dines, Hayes, & Nelson, 2009). The desired outcome of important service sectors is outlined in the model of Giffinger et al. (2007) – see figure 1. ChaunTao et al. (2015) attempted to reconcile varying perspectives into a coherent whole on the basis of commonalities and proposed a multidisciplinary data-centric architecture accordingly.

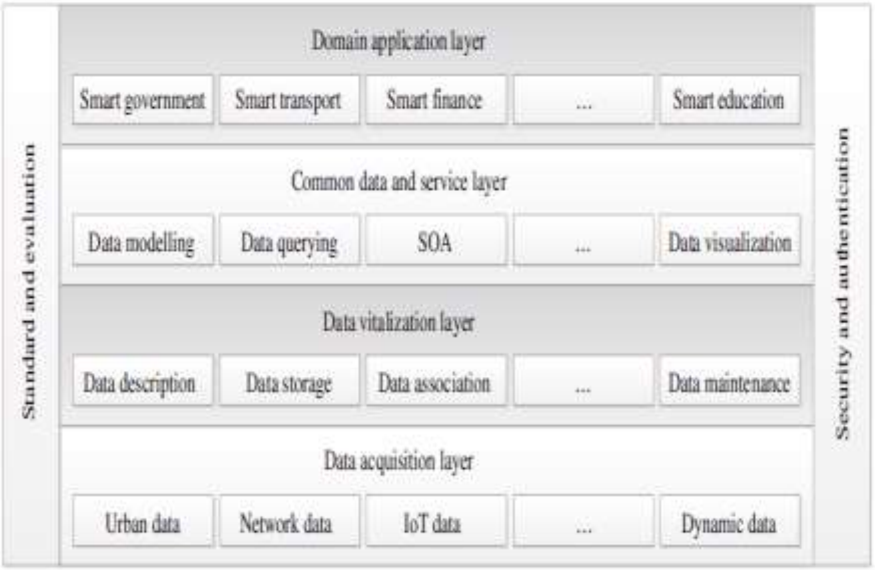

Figure 2
Data-centric smart city architecture proposition ChaunTao et al (2015)

The *domain application layer* feature important service sectors – adopted from Giffinger et al. (2007). This layer represents the desired outcome of a smart city environment but its prospects rest upon the overarching IoT infrastructure encompassing the interconnected data-centric layers beneath. The *data acquisition layer* represents the core IoT infrastructure which is utilized to collect relevant data in real-time. The *data vitalization layer* represents the stage in which the accumulated data are stored and refined for further processing. The *common data and service layer* represent the stage in which the vitalized data are classified and converted into meaningful information for the benefit of each service sector. Underlying argument is that all forms of urban data are collected, analyzed, vitalized and used to realize smartness in urban domains. Accordingly, ChaunTao et al. (2015) defined a smart city as:

> "a systematic integration of technological infrastructures that relies on advanced data processing, with the goals of making city governance more efficient, citizens happier, businesses more prosperous and the environment more sustainable."

Systematic review rationale and methodology

Smart cities represent a popular phenomenon for research with extensive body of literature which is expanding over time (Figure 3). In similar vein, ChaunTao et al. (2015) cautioned that new perspectives are likely to emerge for defining *smart cities* over time.

Field: Publication Years	Record Count	% of 1210	Bar Chart
2017	488	40.331 %	
2016	324	26.777 %	
2015	196	16.198 %	
2014	87	7.190 %	
2018	39	3.223 %	
2013	38	3.140 %	
2012	20	1.653 %	
2011	10	0.826 %	
2010	4	0.331 %	

Figure 3
Expansion of the literature body in relation to *smart cities* over time
Adopted from Web of Science

Aforementioned observations motivate a revisit to consensus-building effort in regard to the *smart city* concept for the benefit of concerned actors. Towards this end, a systematic approach to *literature review* was considered for this study; incorporating an organized literature search and screening strategy and subsequent **framework synthesis** of the accumulated literature body in relation to *smart cities* for the period (1975 – 2017). The objectives are as follows:-

A. Conduct a literature review to document various perspectives for defining *smart cities* **[3]**

B. Reconcile findings of **[A]** with the proposition of ChaunTao et al. (2015) to propose relatively enriched multidisciplinary smart city architecture.

Framework synthesis, or "best-fit" framework synthesis, is an augmentative and deductive approach to literature synthesis in which an existing conceptual model is adopted to guide the review and theory-building effort (Carroll, Booth & Cooper, 2011; Xiao and Watson, 2017). This approach is expected to yield a revised conceptual model which may include elements that were absent in the original conceptual model (Xiao and Watson, 2017).

Web of Science bibliographic database was considered for the initial *literature search* and subsequent filtration of results – details in Table 1. It shall be noted that Web of Science enables access to the Google Scholar bibliographic database for the purpose of accessing a publication (if necessary), making this access systematic as well.

Table 1
Overview of *literature search*

Search terms	Web of Science based results	After screening	Accessible*	Authors
"Smart city concept"	33	18	18	Alizadeh and Sipe (2015); Anthopoulos et al. (2016); Annaswamy et al. (2016); Ahvenniemi et al. (2017); Alyoubi (2017); Bolívar and Meijer (2016); Bibri and Krogstie (2017); Basiri et al. (2017); Boukhechba et al. (2017); Caragliu et al. (2011); ChuanTao et al. (2015); Coletta and Kitchin (2017); Cerasoli, M. (2017); Castelli et al. (2017); Chiariotti et al. (2018); de Jong et al. (2015); Degbelo et al. (2016); Das (2017); Ercoşkun (2016); Fu and Zhang (2017); Georgescu et al. (2015); Garau et al. (2016); Garcia-Font et al. (2017); Gudowsky et al. (2017); Grossi and Pianezzi (2017); Hirš et al. (2016); Hoe and Hoe (2016); Hung and Peng (2017); Hoelscher (2016); Holotescu et al. (2017); Ianuale et al. (2016); Islam et al. (2017); Joss et al. (2017); Kylili and Fokaides (2015); Kitchin (2015); Khatoun and Zeadally (2016); Khatoun and Zeadally (2017); Khan et al. (2017); Kummitha and Crutzen (2017); Khan et al. (2017); Kao et al. (2017); Longworth and Osborne (2010); Lom and Přibyl (2017);
"Smart cities"	175 (refined)	81	66	
Total	**208**	**99**	**84**	

				Martínez-Ballesté et al. (2013); Markkula and Kune (2015); Mattoni et al. (2015); Maglaras et al. (2016); Menouar et al. (2017); Martelli (2017); Nuaimi et al. (2015); Niaros et al. (2017); Ogie (2016); Pérez González and Díaz Díaz (2015); Papa et al. (2015); Poslad et al. (2015); Pan et al. (2016); Paul et al. (2016); Petrolo et al. (2017); Puig-Pey et al. (2017); Rasouli et al. (2017); Sánchez et al. (2013); Schlingensiepen et al. (2015); Shahrokni et al. (2015); Stratigea et al. (2015); Staino et al. (2016); Semanjski et al. (2016); Sun et al. (2016); Scuotto et al. (2016); Sta (2016); Sarma and Sunny (2017); Thomas et al. (2016); Tsinganos et al. (2017); Taleb et al. (2017); Talari et al. (2017); Ueyama et al. (2017); Vlacheas et al. (2013); Vanolo, A. (2016) Vilar Guimaraes and Silva (2016); Viale Pereira et al. (2017); Wenge et al. (2014); White (2016); Zanella et al. (2014); Zubizarreta et al. (2016); Zhu et al. (2016); Zhang et al. (2017)

Featured in the framework synthesis segment of this study.

In relation to objective **[A]** of this study, two search terms namely 'Smart city concept' and 'Smart cities' were separately searched in Web of Science with inverted commas, to gain access to the desired data with a high degree of precision. Search term 'Smart city concept' yielded only 33 results for the period (1975 – 2017) and necessitated use of the other search term 'Smart cities' which yielded 1206 results (yearly breakdown in Figure 3) for the same period respectively. However, results obtained through the latter search term were refined **[5]** through the "search within results" option by inputting the word *concept* (without inverted commas) in this search box in order to make them relevant because 'smart cities' is a broad term in itself and can imply anything in relation to it, and the count was 175 after filtration. From among the search results in Web of Science (encompassing all search terms), 99 publications were shortlisted for framework synthesis on the grounds of featuring a meaningful discussion about the *smart city* concept after a thorough review. Among the shortlisted publications (N = 99), 15 were found to be inaccessible during the course of the review however **[4]**, reducing the count of shortlisted publications to 84 (n = 84) for framework synthesis accordingly. Table 2 discloses the classification of publications in accordance with the Web of Science discipline categories.

Table 2
Web of Science discipline-wise classification of publications (n = 84)

Web of Science discipline categories	Count	Percentage
Urban Studies	11	13.1
Construction & Building Technology	5	6.0
Information Science & Library Science	3	3.6
Engineering	8	9.5
Computer Science	21	25.0
Geography	2	2.4
Planning & Development	2	2.4
Chemistry	4	4.8
Green & Sustainable Science & Technology	7	8.3
Social Sciences	1	1.2
Business	2	2.4
Ethics	2	2.4
Automation & Control Systems	2	2.4
Architecture	1	1.2
Economics	3	3.6
Management	1	1.2
Neurosciences	1	1.2
Energy & Fuels	1	1.2
Education & Education Research	1	1.2
Multidisciplinary Sciences	1	1.2
Telecommunications	3	3.6
Environmental Sciences	1	1.2
International Relations	1	1.2

Computer Science (21), *Urban Studies* (11) and *Green & Sustainable Science & Technology* (7) represent 3 most prominent disciplines for defining *smart cities*, and subsequent drivers of discussion in relation to *Smart*, *Sustainable* and *Eco-friendly* city forms separately and/or in combination.

Framework synthesis and findings

Framework synthesis is essentially framework-driven in large part and we used Microsoft Excel 2013 to accomplish it. Proposition of ChaunTao et al (2015) – see figure 2 – was utilized as the principle framework to guide and/or facilitate theory-building effort in relation to objective **[B]** of this study (Section 3). Each

publication was extensively reviewed (n = 84) in order to extract meaningful information from it (i.e. *elements* in relation to the *smart city* concept), which in turn were contrasted with the *elements* of figure 2 as per this research question:
Q: How the elements in relation to the concept of 'smart cities' correspond to the proposition of ChaunTao et al. (2015)?

If the *elements* matched (identical and/or homogeneous), then they were allotted to an appropriate overarching theme (Data acquisition layer; Data vitalization layer; Common data and service layer; Domain application layer; Standard and evaluation plane; and Security and authentication plane) as in figure 2. However, our synthesis effort yielded some perspectives for defining *smart cities* that were unaccounted for in the data-centric view of ChaunTao et al. (2015) in part due to pertaining to relatively new publications (Figure 3); *elements* in relation to these perspectives were allotted to one of the new overarching themes (Sustainability layer; Learning capacity layer; Anticipation layer; and Vision and strategy layer).

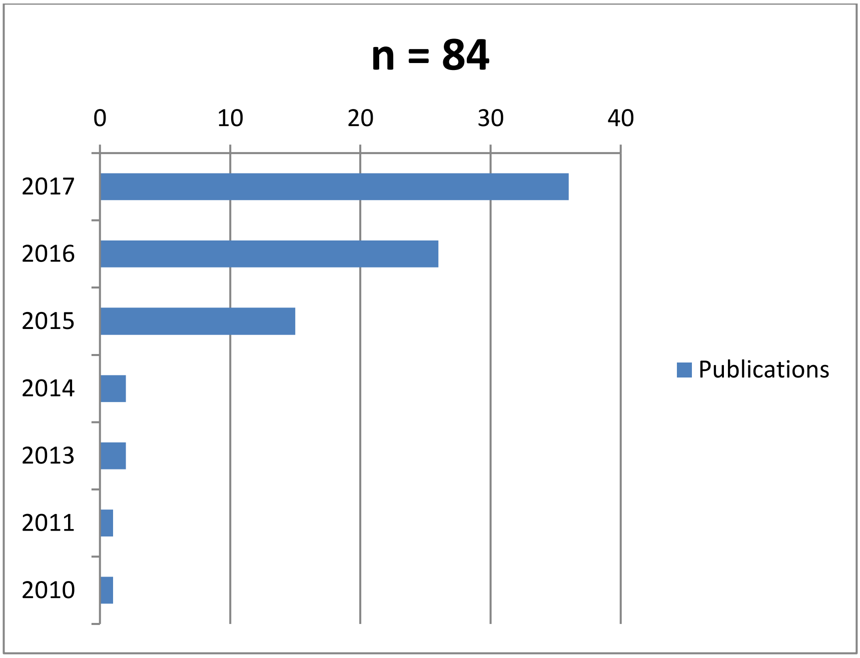

Figure 4
Year-wise classification of publications (n = 84)

Sustainability layer is grounded in the proposition of Ahvenniemi et al. (2017); *learning capacity layer* is grounded in the proposition of Papa, Galderisi, Majello, Cristina and Saretta (2015); *anticipation layer* is grounded in the proposition of White (2016); and *vision and strategy layer* is grounded in the proposition of Zubizarreta, Seravalli, & Arrizabalaga (2016) respectively. Table 3 unveils the outcome of the framework synthesis of this study.

Table 3
Typology of the smart city concepts

Elements in relation to the *smart city* concept	Citations	Overarching themes	Description
Environmental sustainability	Ahvenniemi et al. (2017); de Jong et al. (2015); Fu and Zhang (2017); Garau et al. (2016); Hirš et al. (2016); Hung and Peng (2017); Kylili and Fokaides (2015); Khatoun and Zeadally (2016); Niaros et al. (2017); Rasouli et al. (2017); Shahrokni et al. (2015); Staino et al. (2016); Tsinganos et al. (2017); Zhu et al. (2016)	Sustainability layer [Proposed; grounded in Ahvenniemi et al. (2017)]	Notable indicators of 'environmental sustainability' include *energy efficiency** (Kylili & Fokaides, 2015; Hirš et al., 2016), *climate control* (Staino et al., 2016), *energy conservation* (Kylili & Fokaides, 2015), *intelligent energy management* (Kylili & Fokaides, 2015), *vertical greening** (Hung & Peng, 2017), *renewable technologies* (Khatoun & Zeadally, 2016), and *smart urban metabolism* (Shahrokni et al., 2015).
Economic sustainability	Annaswamy et al. (2016); Ahvenniemi et al. (2017); Alizadeh and Sipe (2015); Basiri et al. (2017); Garau et		Notable indicators of 'environmental sustainability' include *digital*

	al. (2016); Markkula and Kune (2015); Staino et al. (2016); Scuotto et al. (2016); Talari et al. (2017)		*economy* (Alizadeh & Sipe, 2015), *transactive control* (Annaswamy et al., 2016; Talari et al., 2017), *co-creating innovation* (Garau et al., 2016; Markkula & Kune, 2015; Scuotto et al., 2016), and *knowledge and innovation economy* (Basiri et al., 2017).
Social sustainability	Annaswamy et al. (2016); Ahvenniemi et al. (2017); Degbelo et al. (2016); Garau et al. (2016); Gudowsky et al. (2017); Hoe and Hoe (2016); Hoelscher (2016); Joss (2017); Khan et al. (2017); Sun et al. (2016); Sarma and Sunny (2017); Talari et al. (2017); Vanolo (2016)		Notable indicators of ‘social sustainability’ include *citizen engagement* (Hoe & Hoe, 2016; Niaros et al., 2017; Talari et al., 2017), *entrepreneurship* (Sarma & Sunny., 2017), *citizen participation* (Grossi & Pianezzi, 2017); Hoelscher, 2016; Joss, 2017; Khan et al., 2017), *co-creating solutions* (Hoe &

			Hoe, 2016), *citizen empowerment* (Annaswamy et al., 2016; Degbelo et al., 2016; Stratigea et al., 2015; Vanolo, 2016), *smart and connected communities* (Sun et al., 2016), and *human interrelations* (Gudowsky et al., 2017).
Integrated data acquisition	Hirš et al. (2016)	Data acquisition layer (ChaunTao et al., 2015)	This layer is concerned with *acquisition* (Wenge et al., 2014) and *transmission* (Wenge et al., 2014) of *urban data* (ChuanTao et al., 2015) and/or *IoT data* (ChaunTao et al., 2015). Hardware network for aforementioned practices might incorporate the *Internet of Underwater Things* (Kao et al., 2017),
Big Data	Ianuale et al. (2016); Nuaimi et al. (2015); Poslad et al. (2015); Pan et al. (2016); Paul et al. (2016); Semanjski et al. (2016); Sun et al. (2016); Vlacheas et al. (2013)		
Urban data	Alyoubi (2017); Castelli et al. (2017); Khan et al. (2017); Ballesté et al. (2013); Sta (2016); Wenge et al. (2014); Zhang et al. (2017)		
Internet of Things (IoT)	Coletta and Kitchin (2017); Khatoun and Zeadally (2016); Kao		

	et al. (2017); Lom and Přibyl (2017); Maglaras et al. (2016); Poslad et al. (2015); Paul et al. (2016); Petrolo et al. (2017); Sánchez et al. (2013); Sun et al. (2016); Scuotto et al. (2016); Taleb et al. (2017); Talari et al. (2017); Vlacheas et al. (2013); Zanella et al. (2014)		*mobile edge computing* (Taleb et al., 2017), *Social Internet of Things* (Paul et al., 2016), and *Social Internet of Vehicles* (Maglaras et al., 2016).
Facilities	Anthopoulos et al. (2016)		Notable indicators of 'facilities' include *Energy system* and *Internet of Things* (Anthopoulos et al., 2016).
ICT networks	Basiri et al. (2017); Bibri and Krogstie (2017); Ercoşkun (2016); Khatoun and Zeadally (2017)		Sensors and networks which characterize *Internet of Things* and/or are concerned with acquisition and transmission of urban data.
Mobile Crowdsensing	Ogie (2016)		
Robotics	Puig-Pey et al. (2017)		
NomaBlue	Boukhechba et al. (2017)		
Wireless Sensor Network	Garcia-Font et al. (2017); Ueyama et al. (2017)		
Attractors	Ianuale et al. (2016)	Data vitalization layer (ChaunTao et al., 2015)	Analysis of patterns in data implied.
Data management	Khatoun and Zeadally		

	(2016)		
Data mining	Alyoubi (2017)		
Data storage and vitalization	Wenge et al. (2014)		
Human dynamics	Paul et al. (2016)		Analysis of human behavior in data implied.
Cloud computing	Nuaimi et al. (2015); Petrolo et al. (2017)	Common data and service layer (ChaunTao et al., 2015)	
Domain service	Wenge et al. (2014)		
Support service	Wenge et al. (2014)		
Adaptability	Garau et al. (2016); Longworth and Osborne (2010); Papa et al. (2015); Rasouli et al. (2017)	Learning capacity layer [Proposed; grounded in Garau et al. (2016)]	Adaptability in regards to *climate change* (Papa et al., 2015) implied.
Transformability	Longworth and Osborne (2010); Papa et al. (2015); Stratigea et al. (2015)		
Persistence	Annaswamy et al., 2016; Papa et al. (2015)		Resilience of infrastructure (Annaswamy et al., 2016) is essential.
Efficient transportation	Menouar et al. (2017)	Domain application layer (ChaunTao et al., 2015)	These are facets of *Smart mobility* (Giffinger et al., 2007). *Smart transport* (ChaunTao et al., 2015) and *Smart mobility* are synonymous terms.
Autonomic transport system	Schlingensiepen et al. (2015)		
Public vehicles (PV)	Zhu et al. (2016)		
Mobility	Poslad et al. (2015); Rasouli et al. (2017)		

City intelligence	Pan et al. (2016)		
ICT-enabled public services	Pérez González and Díaz Díaz (2015)		These are facets of *Smart governance* (Giffinger et al., 2007).
Algorhythmic governance	Coletta and Kitchin (2017)		
Smart collaboration	Viale Pereira et al. (2017)		
Legal self-regulation	Vilar Guimaraes et al. (2016)		
Smart governance	Bolívar and Meijer (2016)		
Services	Anthopoulos et al. (2016); Alyoubi (2017); Degbelo et al. (2016); Poslad et al. (2015); Talari et al. (2017); Wenge et al. (2014)		*Citizen-centric services* (Degbelo et al., 2016) implied. Notable indicators include *IoT applications* (Talari et al., 2017), *Smart applications* (Alyoubi, 2017) and *Event-driven application* (Wenge et al., 2014); SUNSET (Poslad et al., 2015).
Intelligent energy management	Kylili and Fokaides (2015)		Facet of *Smart environment* (Giffinger et al., 2007).
Efficient environment*	Hung and Peng (2017)		

Smart citizens	Markkula and Kune (2015); Martelli (2017)		Synonymous with *Smart people* (Giffinger et al., 2007).
MOOCs	Holotescu et al. (2017)		These are facets of *Smart living* (Giffinger et al., 2007). *Smart education* (ChuanTao et al., 2015) is a subset of *Smart living* because Giffinger et al (2007).
Applications facilitating social activities	Boukhechba et al. (2017)		
Smart healthcare	Zhang et al. (2017)		
Preemption	White (2016)	Anticipation layer [Proposed; grounded in White (2016)]	
Precaution	White (2016)		
Preparation	White (2016)		Adaptability implied.
Citizen perspectives	Thomas et al. (2016)		Citizen engagement implied.
Smart city vision	Grossi and Pianezzi (2017); Hoelscher (2016); Zubizarreta et al. (2016)	Vision and Strategy layer [Proposed; grounded in Zubizarreta et al. (2016)]	Smart city concepts should be grounded in urgent urban problems (Grossi & Pianezzi, 2017).
Smart growth principle	Basiri et al. (2017); Bibri and Krogstie		Notable initiatives

	(2017); Caragliu et al. (2011); de Jong et al. (2015); Das (2017); Georgescu et al. (2015); Kummitha and Crutzen (2017); Stratigea et al. (2015); Semanjski et al. (2016)		include *Policy 2.0 platform* (Semanjski et al., 2016) and *Participatory planning framework* (Stratigea et al., 2015).
Security measures	Castelli et al. (2017); Garcia-Font et al. (2017); Khatoun and Zeadally (2016); Khatoun and Zeadally (2017); Khan et al. (2017); Nuaimi et al. (2015); Zhang et al. (2017)	Security and authentication plane (ChaunTao et al., 2015)	Urban smart security (Castelli et al., 2017); VANET security (Khatoun & Zeadally, 2016)
Privacy	Khatoun and Zeadally (2017); Khan et al. (2017); Martínez-Ballesté et al. (2013); Nuaimi et al. (2015); Ogie (2016); Petrolo et al. (2017); Zhang et al. (2017)		Privacy-Aware (Ballesté et al., 2013)
Evaluation	Georgescu et al. (2015); Fu and Zhang (2017)	Standard and evaluation plane (ChaunTao et al., 2015)	
Integration (of the smart city components)	Mattoni et al. (2015)		Core aspect of the proposition of ChaunTao et al. (2015); see figure 2.

Eco-friendly emphasized

The 'overarching themes' represent an appropriate fit for the 'elements' – in relation to the *smart city* concept – in the context of a multidisciplinary perspectives model for defining *smart cities*, which would be impractical to collate and accommodate otherwise. Figure 5 represent the structure of these overarching themes.

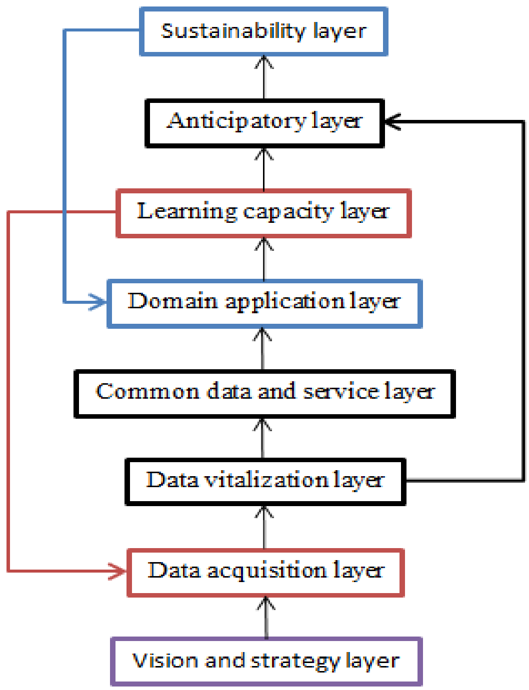

Figure 5
Overarching themes of the multidisciplinary character of the *smart* form discourse

Discussion

Under the ***smart*** form discourse, two point-of-views are significant as in they seem to dominate and/or direct discussions in relation to the *smart city* concept within the literature body; conceptually distinguished as *data-centric* (n = 37; repetitions adjusted) and *sustainability-centric* (n = 29; repetitions adjusted) in this study – see Table 3. The *data-centric* point-of-view is centered on the proposition of ChaunTao et al. (2015) and the *sustainability-centric* point-of-view is centered on the proposition of Ahvenniemi et al. (2017) respectively.

Ahvenniemi et al. (2017) conducted a bibliometric analysis of urban sustainability frameworks (environmental sustainability emphasized) and smart city frameworks (economic and social aspects emphasized), and advocated reconciliation of the two discourses in their proposition which encompass environmental, economic and social sustainability indicators. Ahvenniemi et al. (2017) also highlighted Bifulco, Tregua, Amitrano and D'Auria (2016) as the original proponents of this reconciliation effort. In support of this reconciliation effort, this study promotes *sustainability layer* as a facet of the multidisciplinary character of the *smart* form discourse (Figure 5). Furthermore, the *sustainability-centric* point-of-view also accommodates eco-friendly perspectives within the 'environmental sustainability' segment of its proposed composition (Kylili & Fokaides, 2015; Hirš et al., 2016; Staino et al., 2016; Hung & Peng, 2017).

White (2016) in particular, emphasized *risk-aware* characteristic (i.e. anticipatory logics) for *smart cities*. White (2016) asserted that emerging realities can serve as the basis of rationalization for technological intervention in the present. Literature suggest that future is increasingly unpredictable and hazardous under the shadow of climate change (Amin, 2013), and a smart city will account for disruptions (unforeseen and otherwise) in the interest of protecting its citizens (White, 2016). In support of this point-of-view, this study promotes *anticipatory layer* as a facet of the multidisciplinary character of the *smart* from discourse (Figure 5) and its 'preparation' segment tie-in with the 'adaptability' segment of the *learning capacity layer* since both are homogeneous notions.

Literature suggests that a smart city is a *learning* entity at its core (Cutter, Barnes, Berry, Burton, Evans, Tate and Webb, 2008; Sinkiene, Grumadaite and Liugailaite-Radzvickiene, 2014), and the *learning capacity* of an urban entity is characterized by the dynamic interplay of persistence (in the short term), adaptability (in the medium term) and transformability (in the long-term) over time and across space in the face of climate change and/or uncertain future (Papa et al., 2015); this characteristic is essential to urban sustainability. Additionally, Papa et al. (2015) asserted that attributes such as networking capacity, monitoring capacity, knowledge, memory, collaboration and participation contribute to the *learning capacity* of an urban entity. Furthermore, Papa et al. (2015) asserted that *learning capacity* of an urban entity also facilitates its capacity to *anticipate* events in advance; suggesting a tie-in between learning capacity and anticipatory logics. In support of this point-of-view, this study promotes *learning capacity layer* as a facet of the multidisciplinary character of the smart from discourse (Figure 5). In the context of *smart cities*, the IoT infrastructure is expected to contribute to its *learning capacity* because it enables people and devices to connect for exchanging data and/or information, monitoring of urban environment, storage and processing of accumulated data and/or information for desired ends and facilitate collaboration between stakeholders – see figure 2.

Privacy represents a growing concern in connection with the *data-centric* point-of-view (Martínez-Ballesté, Pérez-Martínez and Solanas (2013); Nuaimi et al. (2015); Ogie (2016); Khatoun and Zeadally (2017); Khan, Pervez and Abbasi (2017); Petrolo, Loscri and Mitton (2017); Zhang, Li, Zheng, Chen and Li, 2017), and deserve a spotlight in the perspectives model accordingly.

In order to transform an existing city into a smart city, an appropriate vision and strategy is advised. Zubizarreta et al. (2016) conducted a multidisciplinary analysis in relation to the *smart city* concept and came to understand that technology is a driver of urban development but in the absence of an appropriate strategy and purpose towards this end, disorder may ensue, and smart city applications might fail to live up to expectations. In support of this point-of-view, this study promotes *vision and strategy layer* as a facet of the multidisciplinary character of the smart from discourse (Figure 5).

The aforementioned observations suggest convergence of perspectives in relation to the three conspicuous city forms (refer to section 1), and in turn, made it feasible to advance a coherent whole in steering urbanization (Figure 6).

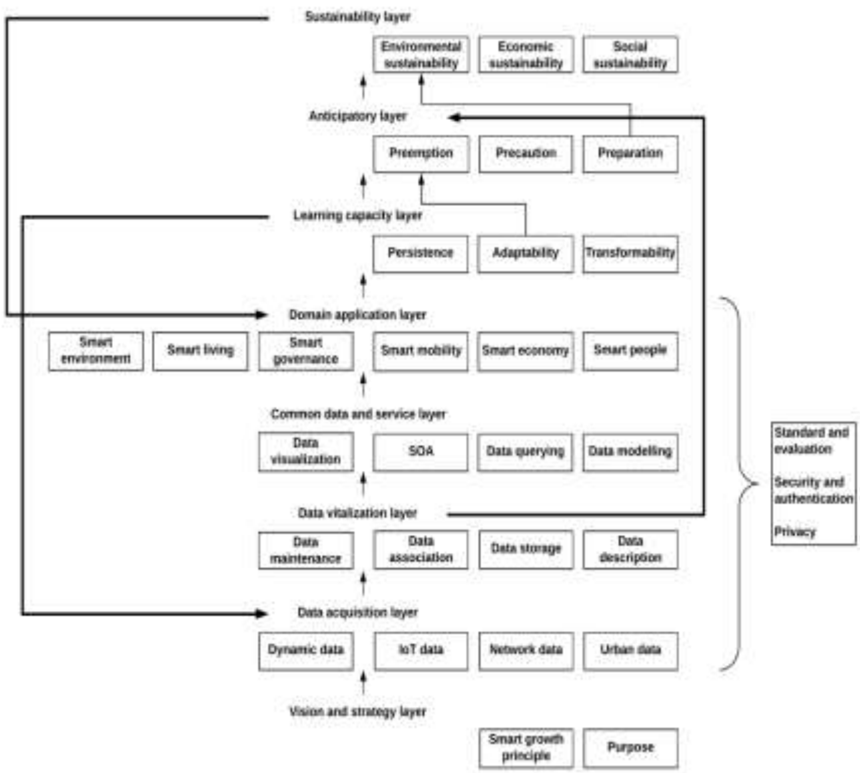

Figure 6
The multidisciplinary perspectives model for *smart cities*

Figure 6 was created in Lucidchart application and represents the multidisciplinary perspectives model of the *smart* form discourse in the domain of urbanization; figure 6 expands on figure 5 and, by extension, figure 2 by highlighting the key components of each overarching theme (layer) of the smart form discourse in the same manner as in figure 2. The *layer-component* associations are grounded in the content of figure 2, table 3 and arguments of section 5 respectively.

Conclusion

Smart cities represent a popular theme for research with extensive body of literature which is expanding over time. Conversely, this theme incorporates a wide range of (varying) perspectives which in turn give the impression of a poorly defined phenomenon. At this juncture, efforts towards consensus-building in regards to defining *smart cities* need attention. To this end, this study provides an overview of such efforts in the past (Section 2) and features a systematic literature review to propose a comprehensive multidisciplinary perspectives model for defining *smart cities* (Figure 6).

A prominent concern of urbanization is to address affiliated challenges and/or strive for sustainability in the long-term. Towards this end, three conspicuous city forms are being advanced in the literature body such as ***sustainable***, ***smart*** and ***eco-friendly***, but these disparate advances might confuse the concerned actors who are looking forward to steer urbanization through present-day realities and emerging threats. Findings of this study suggest convergence of the aforementioned perspectives under the ***smart*** form discourse, which in turn lead to a coherent whole in regards to propositions for urbanization. Accordingly, this study advances the notion that a city is truly smart when it is able to capitalize on its resources for desired ends, is risk-aware and strives for sustainability in the long-term.

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Footnotes

[1] Google Scholar unveiled 1376 citations of this report as of August 19, 2018.
[2] Proposed by Harrison, Eckman, Hamilton, Hartswick, Kalagnanam, Paraszczak and Williams (2010), Liu and Peng (2014), Al-Hader, Rodzi, Sharif and Ahmad (2009), Cimmino, Pecorella, Fantacci, Granelli, Rahman, Sacchi, Camillo and Harsh (2014), Balakrishna (2012), Anthopoulos and Fitsilis (2010), Theodoridis, Mylonas and Chatzigiannakis (2013), Zygiaris (2013), and Wenge, Zhang, Dave, Chao and Hao (2014).
[3] Entry of this data in *Microsoft Office Excel 2013* with the consent of co-authors.
[4] Table 5 highlight citations of articles that were shortlisted for review but were found to be inaccessible at the time of literature search.

Table 5
Overview of inaccessible content at the time of literature search

Search terms	**Web of Science based results**	**After screening**	**Inaccessible**	**Authors**
"Smart city concept"	33	18	-	de Alencar Xavier, Y. M., & Vilar Guimaraes, P. B. (2016); Legeny, J., Morgenstein, P., & Spacek, R. (2016); Bhide, V. (2017); Papadopoulou, C. A., &
"Smart cities"	175 (refined)	81	15	
Total	**208**	**99**	**15**	

				Giaoutzi, M. (2017); Hudec, O. (2017); Caragliu, A., & Del Bo, C. F. (2016); Salvia, M., Cornacchia, C., Di Renzo, G. C., Braccio, G., Annunziato, M., Colangelo, A., ... & Lapenna, V. (2016); Zaharia, M. H. (2016); Van Wegen, W., & Powell, M. (2016); Cong, X., Liu, Z., & Wang, Y. (2016); Hayat, P. (2016); Amakpah, S. W., Larbi, M., Liu, G., & Zhang, L. (2016); Petersen, S. A., Concilio, Grazia, & Oliveira, M. (2015); Kim, J. S. (2015); Cantone, F., Marrelli, M., & Motta, E. (2015)

[5] The **Web of Science** bibliographic database provides numerous options to filter results including through keywords, years, publication characteristics and "**Web of Science** discipline categories." The *smart city* concept is grounded in multidisciplinary characteristics in which a variety of ICTs provide the common technical platform to various disciplines for relevant contributions (ChaunTao et al., 2015). Therefore, a multidisciplinary approach towards consensus-building is necessary which strives for integration of propositions of various disciplines for the benefit of concerned actors. Accordingly, I did not consider it appropriate to filter results through "**Web of Science** discipline categories" option.

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