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Can cities become smart without being sustainable? A systematic review of the literature

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ABSTRACT

Smart cities are widely seen as localities that actively embrace new technologies to achieve desired urban outcomes. Despite sustainability often claimed to be a desired outcome of smart city initiatives, little evidence exists how sustainability outcomes are incorporated or achieved within the smart city initiatives. This paper aims to address the question of whether cities can become smart without actually being sustainable. The study undertakes a systematic review of the smart and sustainable cities literature. The analysis highlights an expectation in the reviewed academic literature for cities to become sustainable first in order to be considered truly smart. The results point to major challenges of smart cities in delivering sustainable outcomes: (a) Smart city policies are characterised by heavy technocentricity; (b) Smart city practices involve complexities, and; (c) Smart city notions are conceptualised in an ad-hoc manner. The findings provide evidence that the current smart city practice fails to incorporate an overarching sustainability goal that is progressive and genuine. This, then, highlights the need for a post-anthropocentric approach in practice and policymaking for the development of truly smart and sustainable cities. The findings seek to stimulate prospective research and further critical debates on this topic.

1. Introduction

Urban growth is taking place on an unprecedented scale globally and its externalities on the environment and society are evident (Arbolino, Carlucci, Cirà, Ioppolo, & Yigitcanlar, 2017; Goonetilleke, Yigitcanlar, Ayoko, & Egodawatta, 2014; Kamruzzaman, Deilami, & Yigitcanlar, 2018). Unexceptionally all parts of the world, today, are confronted with various environmental and/or socioeconomic crises (Kamruzzaman, Hine, & Yigitcanlar, 2015; Moore, 2017). For instance, an increasing number and intensity of natural disasters, climate change, biodiversity loss, ecosystem destruction, regional disparities, socio-economic inequity, and knowledge and digital divides are some of them (Caprotti, 2014; Didsbury, 2004). Besides, a large number of megacities around the world are creating urban management quagmires for their administrations (Madon & Sahay, 2001; Teriman, Yigitcanlar, & Mayere, 2009). These crises are mainly caused by rapid population growth; and a net total growth of consumption of natural resources, combined with vigorous industrialisation, urbanisation, mobilisation, globalisation, agricultural intensification, and excessive consumption-driven lifestyles (Epstein & Buhovac, 2014; Yigitcanlar & Dizdaroglu, 2015; Yigitcanlar & Teriman, 2015).

The Anthropocene is known as the era of geological time during which human activity is considered to have the dominant influence on the environment, climate and ecology of the earth (Derickson, 2018; Lewis & Maslin, 2015). In the Anthropocene, urban and environmental issues induced by the above crises (e.g., environmental pollution, biodiversity loss, resources shortage, traffic congestion, socioeconomic inequities) have become highly problematic for urban administrations to handle (Dizdaroglu, Yigitcanlar, & Dawes, 2012; Mahbub, Goonetilleke, Ayoko, Egodawatta, & Yigitcanlar, 2011; Wu, Zhang, Shen, Mo, & Peng, 2018). At this dire strait, technology is seen as a potential saviour (Paroutis, Bennett, & Heracleous, 2014; Van den

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Buuse & Kolk, 2018; Yigitcanlar, 2009). The rapid advancements in information and communication technologies (ICTs) gave urban administrators a hope that the impacts of global scale environmental and socioeconomic crises can possibly be eased with the aid of technologies—such as achieving cities' climate targets by lowering energy use and greenhouse gas emissions (Lee, Yigitcanlar, Hoon, & Taik, 2008; Rice & Martin, 2018). The need for cities to reap the benefits of smart urban technologies is widely advocated, due to the recent rapid progress in the technology innovation domain generating feasible technology solutions for cities (Hollands, 2008; Söderström, Paasche, & Klauser, 2014).

The potential of these technologies in providing effective instruments for the development of model cities of the century has made smart cities a highly attractive notion for urban administrators and planners (Bibri, 2018a; Macke, Casagrande, Sarate, & Silva, 2018). Consequently, the smart city model has been promoted as an ample instrument to manage aforementioned urban and environmental challenges (Meijer & Bolívar, 2016; Wu et al., 2018). However, there are various views in the literature on what a smart city is or what makes a city smart (see Table 1). In theory, smart cities should contribute to the formation of high-quality, healthy and regenerative built environments modelled around the circular economy and with a net positive impact on the natural environment (2014, Angelidou, 2014; Birkeland, 2002; Heo et al., 2014). However, technology alone cannot be a panacea to all of the development ills. Cities can only be considered smart when they invest in the growth of human, social and environmental capitals that generate sustainable urban development (Caragliu, Del Bo, & Nijkamp, 2011; Carrillo, Yigitcanlar, Garcia, & Lonnqvist, 2014; Kourtit & Nijkamp, 2012). It is argued that only this holistic view can help in building truly smart cities (Alizadeh & Irajifar, 2018; Foth, 2018; Ibrahim, Adams, & El-Zaart, 2015; Yigitcanlar, 2015).

Today, the smart cities notion has become a global phenomenon and a movement; where its promise is to enable us to use resources in cities in more efficient ways, to make public transport more attractive, and to provide planners and decision-makers with data to allocate resources more accurately (Townsend, 2013). The shift in the smart city discourse is evident in national-level (e.g., South Korea, Australia, India, USA) as well as in city-level policies and initiatives (e.g., Amsterdam, San Francisco, Seoul, Vienna) (Cowley, Joss, & Dayot, 2018; Cugurullo, 2016; Foth, 2017). There are, presently, hundreds of smart city initiatives underway across the world, large populations are affected by them, and substantial resources are dedicated to these projects (Monfaredzadeh & Berardi, 2015; Praharaj, Han, & Hawken, 2018). While some of these projects are incorporating dimensions beyond technology, there is little evidence in practice that sustainability targets are achieved in cities claiming to be smart cities in order to move the smart city notion closer to the goal of a sustainable city (Yigitcanlar & Kamruzzaman, 2018a; Yigitcanlar & Kamruzzaman, 2018b).

On the one hand, advocates see smart cities as a promise for a new and sustainable urban future, providing technological solutions to our urban challenges and changing how we manage and live in cities. In contrast, critics view smart cities as another form of neoliberal urban entrepreneurialism, in pursuit of old-fashioned growth agendas. A mere focus on efficiency gains is not going to bring true sustainability to our cities. Keeping these two conflicting views in mind, some scholars also reconceptualise smart cities as 'smart sustainable cities' and offer transformation roadmaps to guide urban administrators, managers and planners in understanding the essential stages and components to be considered during the transformation journey (Ibrahim, El-Zaart, & Adams, 2018; Ibrahim, El-Zaart, & Adams, 2017).

Against this backdrop, this paper aims to address the research question of whether cities can become smart without actually being sustainable. The methodological approach of this investigation includes the systematic selection of relevant academic articles from the smart city literature. This is followed by analysis and critical review. The last step is, then, the discussion of the findings and draw conclusions.

2. Materials and methods

2.1. Smart cities and sustainable urban development

Cities are human-dominated living organisms that perform the most dramatic manifestations of human activities (Dizdaroglu & Yigitcanlar, 2016; Dizdaroglu & Yigitcanlar, 2014). According to Yigitcanlar and Kamruzzaman (2015), p.14677), human activities "degrade natural habitats, simplify species composition, disrupt hydrological systems, and modify energy flow and nutrient cycling." Sustainable urban development practices, thus, are critical to deal with these problems adequately (Arbolino, Simone, Carlucci, Yigitcanlar, & Ioppolo, 2018; Arbolino, Carlucci, Simone, Yigitcanlar, & Ioppolo, 2018; Perveen, Kamruzzaman, & Yigitcanlar, 2017). Sustainable urban development requires an interlinked triad comprising economy, society and nature that facilitates the establishment of a socioeconomic system that does not harm the natural world (Dur, Yigitcanlar, & Bunker, 2014; Dur & Yigitcanlar, 2015; Ioppolo, Cucurachi, Salomone, Shi, & Yigitcanlar, 2018).

As stated by Fu and Zhang (2017), p. 113), "it has become common practice to contrive a city concept for transforming our cities into a more sustainable urban form. The salience of these terms has been mutually reinforced whenever it is advocated in policy discourse or seriously elaborated in the academic field. To date, a multitude of city concepts intending to depict a more sustainable and prosperous urban future have been contrived and debated. Of these concepts, the 'smart city' and 'sustainable city' are the most outstanding and persistent [ones]."

The smart city notion, initially, was a spin off concept originating from the smart growth movement in the 1990s, which basically advocates planning strategies to address sprawl development and associated environmental 'externalities' (Perveen, Kamruzzaman, & Yigitcanlar, 2018; Downs, 2005; Perveen, Yigitcanlar, Kamruzzaman, & Hayes, 2017). Despite its original sustainable urban development roots, the smart city concept has become popular following a speech by Samuel J. Palmisano, then IBM Chairman, President and CEO, on "A Smarter Planet: The Next Leadership Agenda" on 12 November 2008 (Söderström et al., 2014). Consequently, as argued by Yigitcanlar, Kamruzzaman, Kamruzzaman et al. (2018), p. 2), it has evolved to mean "almost any form of technology-based innovation in the planning, development, operation and management of cities, for example, the deployment of smart mobility solutions to combat urban traffic challenges….With the offerings of digital technologies and online urban planning opportunities, this concept increased its popularity among the urban technocrats."

As stated by Ibrahim et al. (2018), p.530), "there is neither a single template for framing the [smart city] concept, nor a one-size-fits-all definition for it… Depending on the lens or viewpoint taken, there exist various definitions and dimensions of the concept." This is to say there is, however, no consensus established so far on what a smart city is and what its main domains and dimensions are. A collection of popular smart city definitions can be found in Table 1. The reason for not having a common smart city definition is elaborated by Yigitcanlar, Kamruzzaman, Kamruzzaman et al. (2018), p. 3) as "the fast-growing literature on smart cities comes from the streams of academic, commercial and (inter)national organisations researching on and practicing smart cities. These groups have a different take on the concept as they see it from different lenses such as disciplinary, practice- or conceptualisation-orientation, and domain-orientation, e.g., technology, economy, society, environment, governance." Additionally, while there are a variety of smart city dimensions proposed, one of the most popular sets is the one used in the EU's smart city wheel (EU, 2014)—i.e., smart economy, smart people, smart governance, smart mobility, smart environment and smart living (Giffinger et al., 2007).

This study adopts the following smart city definition derived from Yigitcanlar et al. (2018a, 2018b): *The smart city is an urban locality*

Table 1
Selection of broad smart city definitions and domains, sorted by year of publication (derived from Yigitcanlar, Kamruzzaman, Kamruzzaman et al., 2018).

No	Reference	Definition	Domain
1	Yigitcanlar, Kamruzzaman, Kamruzzaman et al. (2018)	An ideal model to build the cities of the 21 st century, in the case, its practice involves a system of systems approach and a sustainable and balanced view on the economic, societal, environmental and institutional development domains	Community, policy, technology, productivity, innovation, liveability, wellbeing, sustainability, accessibility, governance, planning
2	Lara et al. (2016)	A community that systematically promotes the overall wellbeing for all of its members, and flexible enough to proactively and sustainably become an increasingly better place to live, work and play	Community, wellbeing, sustainability, liveability
3	Yigitcanlar (2016)	An ideal form to build the sustainable cities of the 21 st century, in the case that a balanced and sustainable view on economic, societal, environmental and institutional development is realised	Sustainability, productivity, governance, community
4	ITU (2014)	An innovative city that uses ICTs 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 and environmental aspects	Technology, productivity, innovation, community, liveability, wellbeing, sustainability
5	Piro, Cianci, Grieco, Boggia, & Camarda (2014)	A city that intends as an urban environment which, supported by pervasive ICT systems, is able to offer advanced and innovative services to citizens in order to improve the overall quality of their life	Technology, liveability, policy
6	Alkandari, Alnasheet, & Alshaikhli (2012)	A city that uses a smart system characterised by the interaction between infrastructure, capital, behaviours and cultures, achieved through their integration	Technology, productivity, community, governance
7	Lazaroiu & Roscia (2012)	A city that represents the future challenge, a city model where the technology is in service to the person and to his economic and social life quality improvement	Technology, prosperity, liveability, wellbeing
8	Schaffers et al. (2012)	A safe, secure environmentally green, and efficient urban centre of the future with advanced infrastructures such as sensors, electronics, and networks to stimulate sustainable economic growth and a high quality of life	Technology, productivity, liveability, sustainability
9	Caragliu et al. (2011)	A city that is smart when investments in human and social capital and traditional transport and modern ICT infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance	Community, technology, liveability, sustainability, governance, policy, accessibility
10	Gonzalez & Rossi (2011)	A public administration or authority that delivers or aims to a set of new generation services and infrastructure, based on information and communication technologies	Governance, policy, technology
11	Hernandez-Munoz et al. (2011)	A city that represents an extraordinary rich ecosystem to promote the generation of massive deployments of city-scale applications and services for a large number of activity sectors	Technology, governance
12	Nam & Pardo (2011)	A humane city that has multiple opportunities to exploit its human potential and lead a creative life	Community, wellbeing, productivity
13	Zhao (2011)	A city that improves the quality of life, including ecological, cultural, political, institutional, social, and economic components without leaving a burden on future generations	Liveability, governance, sustainability, community, productivity
14	Belissent (2010)	A city that uses ICTs to make the critical infrastructure components and services of a city—administration, education, healthcare, public safety, real estate, transportation, and utilities—more aware, interactive, and efficient	Technology, accessibility, liveability, governance
15	Eger (2009)	A particular idea of local community, one where city governments, enterprises and residents use ICTs to reinvent and reinforce the community's role in the new service economy, create jobs locally and improve the quality of community life	Community, governance, technology, liveability, productivity
16	Paskaleva (2009)	A city that takes advantages of the opportunities offered by ICT in increasing local prosperity and competitiveness—an approach that implies integrated urban development involving multi-actor, multi-sector and multi-level perspectives	Productivity, technology, policy
17	Rios (2008)	A city that gives inspiration, shares culture, knowledge, and life, a city that motivates its inhabitants to create and flourish in their own lives—it is an admired city, a vessel to intelligence, but ultimately an incubator of empowered spaces	Community, liveability, productivity
18	Giffinger et al. (2007)	A city well 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	Community, governance, accessibility, technology, productivity, policy
19	Partridge (2004)	A city that actively embraces new technologies seeking to be a more open society where technology makes easier for people to have their say, gain access to services and to stay in touch with what is happening around them, simply and cheaply	Technology, community, accessibility, liveability
20	Odendaal (2003)	A city that capitalises on the opportunities presented by ICTs in promoting its prosperity and influence	Technology, productivity
21	Bowerman et al. (2000)	A city that monitors and integrates conditions of all of its critical infrastructures including roads, bridges, tunnels, rails, subways, airports, sea-ports, communications, water, power, even major buildings, can better optimise its resources, plan its preventive maintenance activities, and monitor security aspects while maximising services to its citizens	Policy, governance, accessibility, liveability
22	Hall et al. (2000)	An urban centre of the future, made safe, secure environmentally green, and efficient because all structures—whether for power, water, transportation, etc. are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms	Sustainability, technology, governance

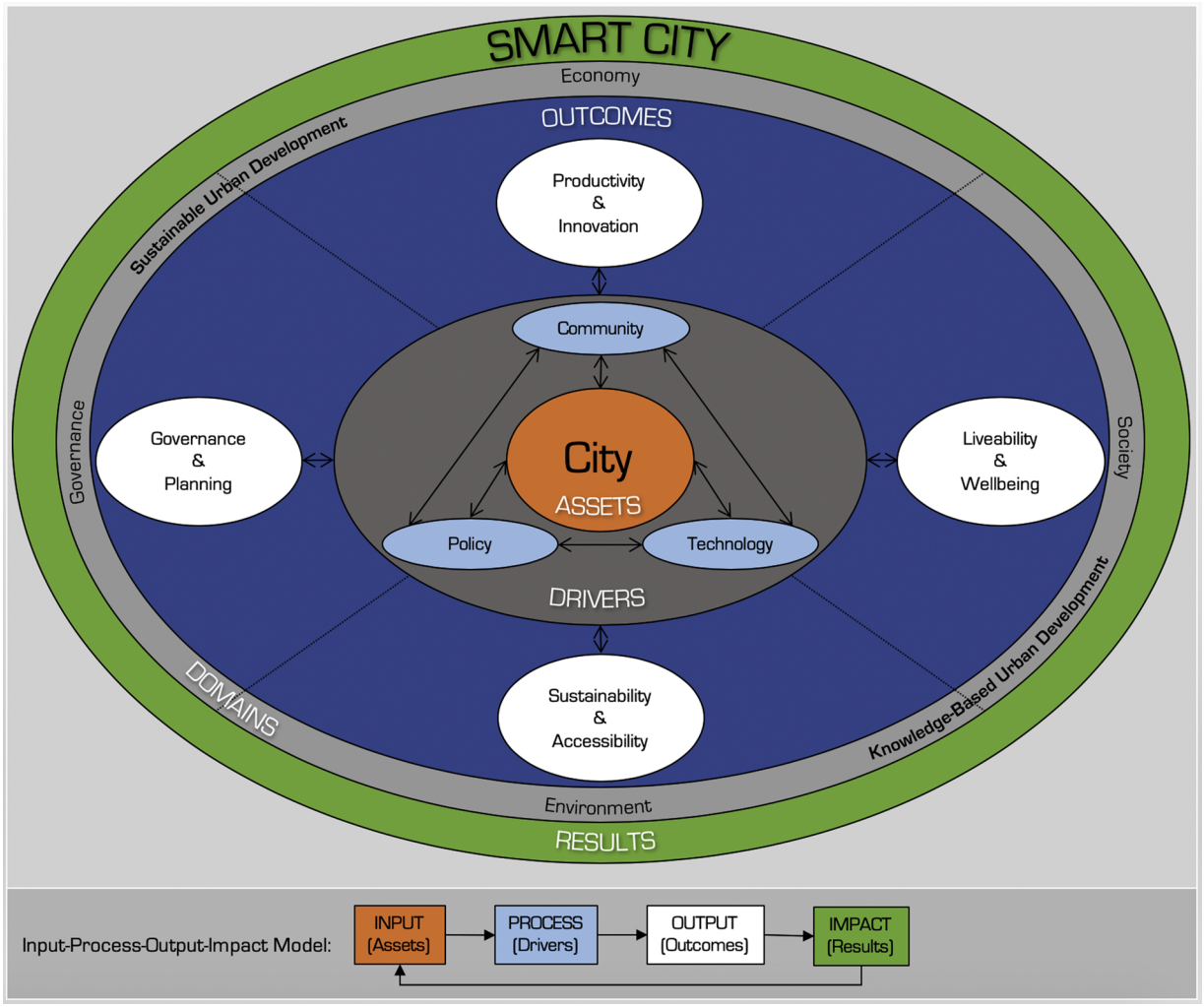

Fig. 1. A multidimensional smart city framework (derived from Yigitcanlar, Kamruzzaman, Kamruzzaman et al., 2018, 2018c).

functioning as a healthy system of systems with sustainable and knowledge-based development activities to generate desired outcomes for all humans and non-humans. The rationale for the adoption is that while offering comprehensive conceptualisation, it also provides a practical process with analytical elements. This definition envisages the smart city as a system of systems targeting a sustainable and knowledge-based development view (see Yigitcanlar et al., 2012; Yigitcanlar & Bulu, 2015). This view suggests interconnecting assets, drivers, outcomes and results strategically to realise the potential in our cities to become smart and sustainable. In this perspective, assets are the inputs or resources of a city that its development is situated on; driving forces are denoted as processes or opportunities for the smart city formation; desired outcomes are the outputs or achievements to realise sustainable urban development to benefit both society and the environment; results are the impacts that transform a city into a smart city (Yigitcanlar, Foth, & Kamruzzaman, 2018; Yigitcanlar & Kamruzzaman, 2014; Yigitcanlar, Kamruzzaman, Kamruzzaman et al., 2018). This multidimensional conceptual view is illustrated in Fig. 1.

From the urban environmental sustainability point of view, some scholars, such as Wachsmuth and Angelo (2018), p. 2), see smart cities as "a distinctive pairing of high-tech environmental strategies with traditionally green interventions such as parks and gardens" also including vertical and roof-top ones. Others see smart cities as zero- or low-carbon localities emitting none to low greenhouse gases as a result of the application of smart green technologies (Kim, 2018) or even achieving a net positive impact (2014, Birkeland, 2002). Some scholars, such as Bibri and Krogstie (2017b) and Bonato and Orsini (2018), argue that smart and sustainable cities should adopt a circular economy model.

According to Bibri (2018b), p. 47), the smart city model should "strive to maximise efficiency of energy and material resources, create a zero-waste system, support renewable energy production and consumption, promote carbon-neutrality and reduce pollution, decrease transport needs and encourage walking and cycling, provide efficient and sustainable transport, preserve ecosystems, emphasize design scalability and spatial proximity, and promote liveability and sustainable community." This is to say, the focus of truly smart cities should be well beyond technological innovations and technical quick fixes (see Taamallah, Khemaja, & Faiz, 2017).

Concerned with the abovementioned issues, in recent years some scholars developed comprehensive smart city conceptualisations. Caragliu et al. (2011); Lee, Hancock, and Hu, (2014); Angelidou (2015); Foth et al. (2015); Ibrahim et al. (2017); Fernandez-Anez, Fernández-Güell, and Giffinger, (2018), and Yigitcanlar, Kamruzzaman, Kamruzzaman et al. (2018) are among those. Besides, some scholars concentrated on the conceptualisation issue from the angle of determining the key factors and policies for smart city transformation (D'Auria, Tregua, & Vallejo-Martos, 2018; Kumar, Singh, Gupta, & Madaan, 2018; Myeong, Jung, & Lee, 2018). The main purpose of these conceptualisation works is to disseminate a sound understanding

(among the academic community, urban policymaking circles and beyond) that cities should be smart in every aspect, not just applying some hip or cool technologies to address specific urban challenges.

The need for a holistic approach to the smart city, similar to the conceptualisation presented in Fig. 1, is also advocated by a number of scholars (i.e., Hollands, 2008; Kunzmann, 2014; Castelnovo, Misuraca, & Savoldelli, 2016; Angelidou, 2017; Mora, Bolici, & Deakin, 2017; Fernandez-Anez et al., 2018). These scholars argue that establishing a simultaneously socially inclusive, environmentally friendly and economically sustainable city is the only way to combat encountered and prospective socioeconomic, enviro-spatial and governance problems. Adoption of such an approach is deemed critical for smart cities to become the model urban form and development paradigm (Yigitcanlar & Lee, 2014).

2.2. Methodology of the review

This study undertakes a systematic literature review to address the research question of: *Can cities become smart without actually being sustainable?* This distinguishes our study from other recent systematic reviews of the smart city literature such as Ingwersen and Serrano-López (2018) who omitted key smart city scholars and did not incorporate a post-anthropocentric notion of sustainability concerns in their assessment. Our study adopts a three-stage procedure as the methodologic approach. Highlighted by Bask and Rajahonka (2017), p. 562), "[Stage 1] Planning stage contains objectives and review protocol for a systematic review, defining sources and procedures for literature searches. [Stage 2] Conducting the review stage contains descriptive and structural analysis. [Stage 3] Reporting and dissemination stage contains analysis and synthesis of the results according to the established objectives."

In Stage 1 (planning stage), a research plan involving the research aim and question, keywords and a set of inclusion and exclusion criteria was developed. The research aim was framed to identify the links between the smart city and urban sustainability literatures in order to address the research question of whether cities can become smart without actually being sustainable. Therefore, 'smart cities', sustainable cities', 'urban smartness' and 'urban sustainability' were selected as the search keywords. The inclusion criteria were determined as academic journal articles, available online in full-text and published in English, that are relevant to the research aim; meaning selection of the articles that relate to and help addressing the research aim and question. The exclusion criteria were determined as publications other than those mentioned in the inclusion criteria. The search was conducted using the following databases: Scopus, ScienceDirect, Web of Science, Directory of Open Access Journals, Wiley Online Library.

In Stage 2 (conducting the review stage), the search task of the relevant articles was undertaken in June 2018. No starting publication date was introduced in the search, where the end date was when the search was conducted, in June 2018. The following keywords were used in the search to identify articles that contain smart and sustainable aspects of cities: 'smart', 'smartness', 'sustainable', 'sustainability', 'city', 'cities' and 'urban'. The query string used for database searches was: (("smart" OR "smartness") AND ("sustainable" OR "sustainability") AND ("city" OR "cities" OR "urban")). The keywords were directed to the titles and abstracts of the searched articles. The abstracts of the selected articles were read. In the case that abstracts were found relevant, the full-texts were read to decide whether to include the article in the review pool. Initially, the search returned in total 423 articles. All of them were 'eye-balled' for consistency and accuracy of the keyword search (see Yin, 1994). After evaluating the abstracts against the research aim and also removing duplicates, this figure was brought down to 92 articles. The full-texts of these initially screened articles were then read against the research aim. This resulted in the selection of the final 35 articles. Lastly, these 35 articles were re-read, reviewed, categorised and analysed. This literature selection procedure is illustrated in Fig. 2.

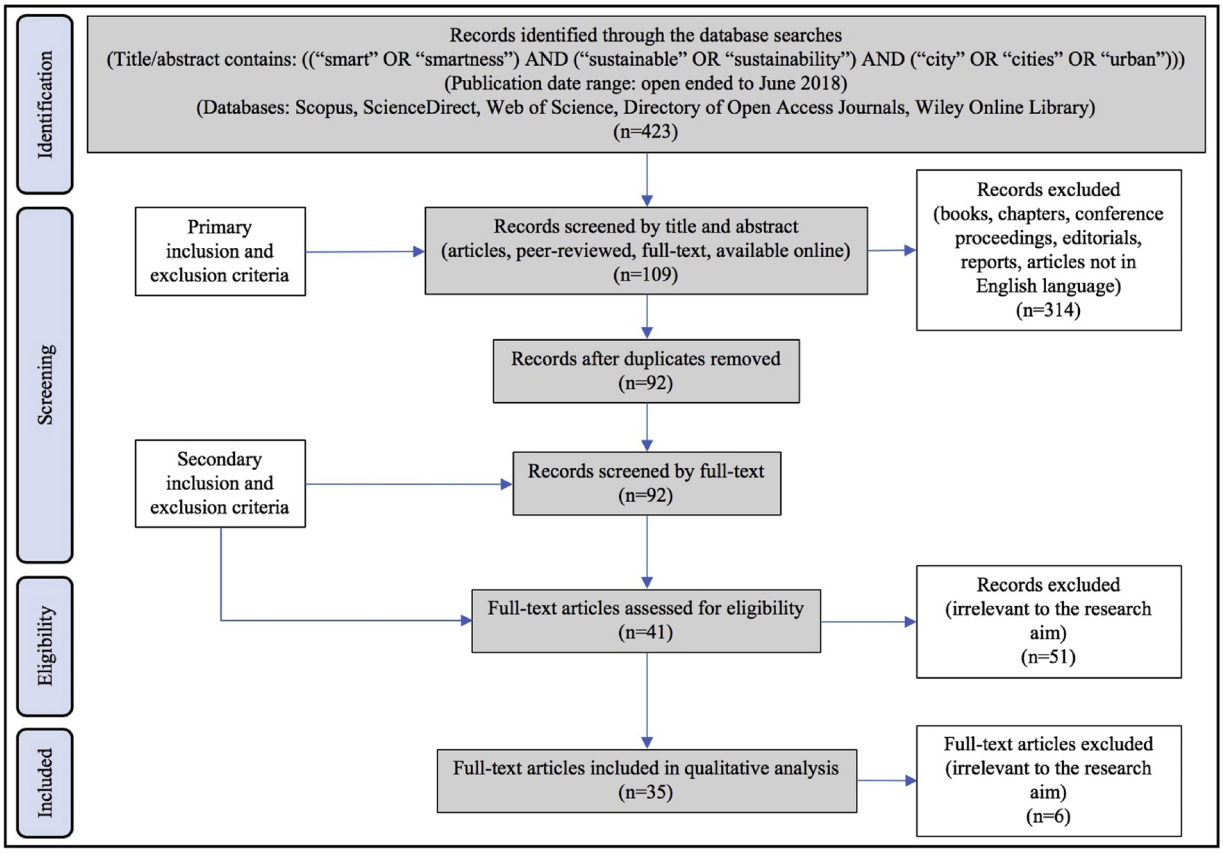

Fig. 2. Literature selection procedure.

Table 2
Selection criteria for the formulation of categories.

No	Selection criteria
1	Determine the key critiques and challenges of smart cities by using the eye-balling technique in the selected literature
2	Detect the issues relating to the sustainable development of smart cities and the smart-sustainable dichotomy among them
3	Identify the issues with negative impact, cautions or warnings on the sustainable development of smart cities among them
4	Group the identified key issues with similarities to form broader potential categories containing adequate number of literature pieces
5	Shortlist the categories and crosscheck the reliability of these categories with the other published smart city literature and review studies
6	Reconsider the shortlisted categories by going through the selected and reviewed literature one more time
7	Confirm the selection and classification of the categories and finalise the formulation of categories
8	Place the reviewed literature pieces under the determined categories—in the case of overlaps, determine the most relevant fit for the literature in one of the categories

The study relies on a descriptive rather than statistical analysis of results. Qualitative techniques of pattern matching and explanation building have been adopted to descriptively categorise the journal articles under specific categories (Yin, 2015). In this regard, pattern matching refers to scanning for commonalities and disparities in which an eye-balling technique is sufficiently convincing to draw a conclusion or categorisation (Yin, 1994). The categorisation of the reviewed literature under specific themes is done in four steps. The selection criteria for the formulation of categories are listed in Table 2. Firstly, the key critiques and challenges raised in the reviewed materials were tabulated; highlighting the major challenges and critiques raised on the sustainability of smart cities. Secondly, the most important themes to best categorise the reviewed literature, in relation to the research aim, were determined. Then, these themes were cross-checked with the other review studies, identified critiques and challenges on the investigated topic (e.g., Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017; Mora et al., 2017; Mora, Deakin, & Reid, 2018; D'Auria et al., 2018; Komninos & Mora, 2018) to verify or reconsider the common themes. Following this, the categorisation was amended and finalised under the three themes, which are *technocentricity*, *practice complexity* and *ad-hoc conceptualisation* of smart cities, and presented in Tables 3–5. However, a possible bias in allocation of articles under specific categories should be noted; as some of the papers' coverage extend beyond the allocated category.

In Stage 3 (reporting and dissemination stage), the work focused on writing up and presenting our findings in the format of a literature review paper. At the write-up stage, other publications on the topic were also incorporated as additional supporting literature evidence to better analyse the topic and elaborate the overall findings. With the inclusion of additional literature identified—including the seminal literary works that have not been a part of the selected databases—by the authors and peer reviewers, the total number of reviewed, cited and quoted references was increased to 170 literature pieces.

3. Results

3.1. General observations

The descriptive analysis of the selected 35 literature pieces was commenced by classifying them according to their publication year. This classification disclosed that during the last couple of years the attention given to the topic has increased dramatically. Close to half of the articles (n = 16; 45.7%) were published in 2018, a bit over quarter of them (n = 10; 28.6%) were in 2017 and slightly more than quarter of them (n = 9; 25.7%) were in 2016 or earlier (the earliest being 2013). These figures show parallels to other review works stating the increase in the smart city literature during the last few years (Mora et al., 2017; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014; Ingwersen & Serrano-López, 2018; Komninos & Mora, 2018).

In terms of the affiliations of the authors, most of the leading countries in the smart and sustainable cities discourse are from the North American, European and Oceanian contexts. However, some South East Asian cities, particularly from Singapore and South Korea, are commonly referred to among the best practice examples in the field. This finding is in line with Yigitcanlar (2016), who underlines the growing interest from the Western countries in establishing environmentally sustainable smart cities. In terms of the journals these articles are published in, with six articles, *Sustainable Cities and Society* comes first. This is followed by four articles in the *Journal of Cleaner Production*, and then three articles each in *Cities* and *Technological Forecasting and Social Change*. More than one-third of them (13 articles) were published in urban studies focused journals, another slightly over one-third (12 articles) in environmental studies focused journals, over one-fifth (eight articles) in science and technology studies focused journals and two of them in transport studies focused journals. We acknowledge a risk of bias in our selection strategy, which focusses only on journals, whereas the technology, engineering and design fields often publish cutting edge works in prestigious conference proceedings.

After carefully reviewing the selected 35 papers, they were categorised under three groups based on the main critiques provided on the challenges of achieving sustainability outcome and limitations of smart cities. The reviewed literature was categorised into the followings: (a) Technocentricity of smart cities (11 papers)—highlighting issues around the heavily technology-centred conceptualisation and practice of smart cities; (b) Practice complexity of smart cities (12 papers)—highlighting issues around the highly difficult or even unmanageable complexities impacting the smart city practice; (c) Ad-hoc conceptualisation of smart cities (12 papers)—highlighting issues around the absence of or limited comprehensive and systems thinking in addressing challenges pertaining to sustainability of smart cities. It is important to note that although these papers are assigned a single category, many of them also relate to other categories. The results of our analysis are presented under the three categories in the following sections. The specific limitations of smart cities to achieve sustainability outcome raised in the reviewed literature are also listed in Tables 3–5.

3.2. Heavy technocentricity of smart cities

Almost one-third (32%) of the reviewed papers include some degree of criticism on the heavy technocentricity of the smart city notion and/or practice (Table 3). Heavy technocentricity refers to the technology obsession or dominance that prioritises technology-based solutions and neglects solutions that have nothing to do with technology.

Sustainable urban development is a multifaceted phenomenon and environmental sustainability is the most intricate aspect of it (Arbolino, De Simone, Yigitcanlar, & Ioppolo, 2018; Goodland, 1995; Moldan, Janoušková, & Hák, 2012). As for Balducci and Ferrara (2018), p. 395), "environmental sustainability is fundamental in a world where resources are increasingly scarce: in smart cities any kind of exploitation (from energy to commodity) must ensure safe and renewable energy use. In smart cities, vehicle traffic is obviously managed dynamically and in real-time with constant exchange of information between flow management (traffic lights, car parks, public transport) and drivers who have traffic information, car seats available, saving time and fuel and

Table 3
Heavy technocentricity problem of smart cities, sorted by year of publication.

No	Literature	Journal	Title	Aim	Challenge	Critique
1	Deakin and Reid (2018)	*Journal of Cleaner Production*	Smart cities: under-gridding the sustainability of city-districts as energy efficient-low carbon zones	Demonstrating how the urban morphology of smart city solutions matter in the sense they tell us that being aware of the considerable energy savings and carbon emissions reductions, which technology offers cities to be smart, is not enough	Seeing sustainability solutions in smart cities predominantly through the technology lens	Under-gridding the sustainability of smart city districts with smart technologies as energy efficient-low carbon zones, where inclusive growth strategy is not resilient enough, does not generate an opportunity for the ecological footprint to stabilise the transition towards the post-carbon economy of a climate neutral adaptation
2	Macke et al. (2018)	*Journal of Cleaner Production*	Smart city and quality of life: Citizens' perception in a Brazilian case study	Evaluating the perception of quality of life in a smart city and to analyse the main elements of citizens' satisfaction with their home city	Issues around the technologies for sustainability used in smart cities hampering achieving desired outcomes	Sustainability dimension of a smart city project involves the adoption of smart technologies in order to mitigate environment impacts and implement policies of natural ecosystem regeneration. However, these technologies are not simple, integrated, cost-effective and resource efficient
3	Marsal-Llacuna (2018)	*Environment, Development and Sustainability*	How to succeed in implementing (smart) sustainable urban agendas: "keep cities smart, make communities intelligent"	Investigating ways to succeed in developing and implementing smart and sustainable urban agendas	Poor sustainability execution in smart cities due to heavy focus on technologic solutions	Smart city practice lacks of successful execution of urban planning through technology-based interventions to achieve sustainable outcomes due to a mismatch between policy and practice
4	Noy and Givoni (2018)	*Sustainability*	Is 'smart mobility' sustainable? Examining the views and beliefs of transport's technological entrepreneurs	Examining the extent to which 'smart' and 'sustainable' are aligned with each other by conducting a survey amongst the main actors within smart mobility	Sector-driven different views on what smart and sustainable are and should be, practice has a dominant techno-centric view	There is a mismatch in the practice between interpretation and understanding of what is 'smart' and what is 'sustainable'. It is clear that the concern of technology firms is primarily with commercial considerations and that their appreciation of what it takes to advance towards a more sustainable transport system is lacking
5	Dall'O et al. (2017)	*Sustainable Cities and Society*	Evaluation of cities' smartness by means of indicators for small and medium cities and communities: a methodology for Northern Italy	Expanding the role of environmental and critical thinking in governance strategies adopted by small and medium-size cities in Europe	Lack of a beyond technology approach that is need for smart cities to deliver sustainable outcomes	Technological innovation is to be considered a positive addition and it must not remain the only goal of the evolution of smart cities. The goal should rather be sustainability in its environmental, social and economic components
6	Stratigea et al. (2017)	*International Journal of E-Planning Research*	In search of indicators for assessing smart and sustainable cities and communities' performance	Evaluating the global state-of-the-art approaches for assessing smart cities' performance as to sustainability objectives	Too much technology focus and not enough holistic approaches to deliver sustainability	Smart city concept has limitations in achieving sustainability; resulting in a shift from a technology-driven to a more holistic approach by means of integrating city attributes in pursuing smart and sustainable development
7	Trindade et al. (2017)	*Journal of Open Innovation*	Sustainable development of smart cities: a systematic review of the literature	Analysing literature focusing on both environmental sustainability and smart city concepts to understand the relationship between them	Lack of convincing policy and practice commitment to sustainable urban development in smart cities due to techno-centric view	Although smart city is conceptualised as a city that uses technology to generate environmental gains and sustainable outcomes, smart cities do not showcase a strong commitment to sustainable urban development goals

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Table 3 (*continued*)

No	Literature	Journal	Title	Aim	Challenge	Critique
8	Niaros (2016)	*TripleC: Communication, Capitalism & Critique*	Introducing a taxonomy of the "smart city": towards a commons-oriented approach?	Contributing to the ongoing dialogue by providing a taxonomy of the smart city, based on certain technology governance models	Environmental sustainability, both in theory and practice, is only loosely associated with the smart cities notion and projects	A 'commons-based approach' is needed to link socio-environmental aspects much strongly with the smart cities theory and practice; the demand-driven production system established in the commons-oriented smart city reduces consumption of ICTs and utilises the existing conditions in the city allow for more sustainable outcomes
9	Ramaswami et al. (2016)	*Science*	Meta-principles for developing smart, sustainable, and healthy cities	Identifying key dimensions and developmental principles of cities to focus attention on the systems-level decisions that society faces to transition toward a smart, sustainable, and healthy urban future	Smart city practice with too much technology focus not being able to incorporate multisectoral, multi-scalar and social-ecological-infrastructural systems adequately	To achieve the full potential of smart cities, discussions must move beyond technology and data to envision cities as multisectoral, multi-scalar, social-ecological-infrastructural systems with diverse actors, priorities, and solutions
10	De Jong, Joss, Schraven, Zhan, and Weijnen, (2015)	*Journal of Cleaner Production*	Sustainable–smart–resilient–low carbon–eco–knowledge cities: making sense of a multitude of concepts promoting sustainable urbanization	Investigating how different city categories, each embody distinct conceptual perspectives, are understood theoretically and applied in policy	Smart city practice that is techno-centric not delivering concrete environmental sustainability outcomes	The smart city category is relatively weakly related to the sustainable city category–it is also not immediately obvious what concrete environmental progress can be expected from large-scale technology-centric smart city development activities
11	Herrschel (2013)	*Urban Studies*	Competitiveness and sustainability: can 'smart city regionalism' square the circle?	Examining the effects of the resulting specific local conditions on adopting 'smartness' in the scalar positioning of policymaking	The techno-centric view limiting smart cities to moderate conflicting and competing goals of competitiveness and sustainability	In the case smart city concept is seen beyond a techno-centric point-of-view, smart city regionalism can serve as a vehicle for negotiation between the conflicting and competing goals of competitiveness and sustainability

Table 4
Practice complexity problem of smart cities, sorted by year of publication.

No	Literature	Journal	Title	Aim	Challenge	Critique
1	Ibrahim et al. (2018)	*Sustainable Cities and Society*	Smart sustainable cities roadmap: readiness for transformation towards urban sustainability	Addressing how to realise a smart sustainable city transformation roadmap through a sound theoretical foundation by linking the theory of change to the smart sustainable cities concept	Complexity of sustainability being mostly ignored in smart city planning	Smart sustainable city transformation is a continuous, long-term, complex and complicated process that requires radical changes to be introduced—to be planned effectively and efficiently, a thorough high-level overview roadmap of needed aspects to be considered during a transformation process is required
2	Lyons (2018)	*Transportation Research Part A*	Getting smart about urban mobility: aligning the paradigms of smart and sustainable	Examining what is really meant by smart in the context of cities and urban mobility	Not delivering social and environmental sustainability due to misalignment of smart city development goals	Smart city notion comes with a caution, as large corporations are exerting significant influence in pursuit of goals that may not strongly align with those of urban planners concerned with social and environmental sustainability
3	Silva et al. (2018a)	*Sustainable Cities and Society*	Towards sustainable smart cities: a review of trends, architectures, components, and open challenges in smart cities	Delivering the essence of sustainable smart cities	Smart city implementation challenges to deliver sustainability	Implementation of sustainable smart cities is challenged throughout design, implementation, and operation stages—cost, heterogeneity among devices, enormous data collection and analysis, information security, and sustainability are the key challenges
4	Yigitcanlar and Kamruzzaman (2018b)	*Land Use Policy*	Does smart city policy lead to sustainability of cities?	Studying the impact and effectiveness of urban smartness on sustainability outcomes in the case of UK cities	Gaps between policy and practice limiting sustainability achievements in smart cities	Smart city policy does not generate clear sustainable urban development outcomes despite their claims
5	Zawieska and Pieriegud (2018)	*Transport Policy*	Smart city as a tool for sustainable mobility and transport decarbonization	Investigating the potential contribution of smart city solutions and their impact on future transport-related greenhouse gas emission levels	Delivering sustainability being challenging as it requires major investment and behavioural change in smart cities	Meeting the greenhouse gas emission reduction targets set by the European Union is highly challenging for smart cities, as these cities require to establish an in-depth transformation of their transport and energy sectors
6	Anthopoulos (2017)	*Cities*	Smart utopia vs smart reality: learning by experience from 10 smart city cases	Performing an analysis of city cases that claim to be smart to determine the minimum set of features that a city must hold in order to self-claim to be smart	Sustainability not being seen as a compulsory component of smart cities in the techno-centric approach	In the current techno-centric practice, for cities to be self-claimed as smart the fundamental requirements include them having: a smart agenda; open data; services or apps; smart infrastructure—where the critical sustainability issue is not seen as a requirement
7	Haarstad (2017)	*Journal of Environmental Policy & Planning*	Constructing the sustainable city: examining the role of sustainability in the 'smart city' discourse	Examining the role that sustainability plays in the smart city discourse	Lack of enough attention to sustainability in the smartness agendas of cities	The smart city agenda is driven more by concerns for economic growth and innovation rather than by environmental sustainability per se as the smartness agenda is bound up with the aim of fostering innovation and competitiveness in the knowledge economy
8	Hara et al. (2016)	*Sustainability*	New key performance indicators for a smart sustainable city	Developing key performance indicators based on the triple-bottom-line approach to evaluate a smart sustainable city in Japan	Lack of key performance evaluation in place in smart city initiatives to measure sustainability progress	Smart city practice fails to produce triple-bottom-line sustainability; additionally, development and application of comprehensive key performance indicators are also absent in the practice
9	Marsal-Llacuna et al. (2015)	*Technological Forecasting and Social Change*	Lessons in urban monitoring taken from sustainable and livable cities to better address the smart cities initiative	Developing a set of indicators and indices for efficient real-time monitoring of liveability and sustainability in smart cities	Lack of holistic smart city sustainability progress and performance monitoring and assessment measures in place	Progress and performance of smart city practice are not monitored adequately, which might be a contributing factor for their under-performance in the sustainability domain

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Table 4 (*continued*)

No	Literature	Journal	Title	Aim	Challenge	Critique
10	Monfaredzadeh and Berardi (2015)	*International Journal of Sustainable Building Technology and Urban Development*	Beneath the smart city: dichotomy between sustainability and competitiveness	Comparing the indicators used in rating systems for smart cities, sustainable cities, and competitive cities to figure out what these concepts seek to achieve and where they complement and contrast	Smart cities mostly being only concerned of pockets of the natural environment surrounded in the built environment open for human use and interaction	Sustainable city systems emphasise more environmental issues in comparison to smart city systems that focus more on people and living; smart city systems mainly focus on the virtual and human/built environment rather than the natural one
11	Yigitcanlar (2015)	*Australian Planner*	Smart cities: an effective urban development and management model?	Examining the smart city model and smart urban technology applications and infrastructures in the contemporary city context	Smart city practice failing to produce either concrete or promising sustainable urban development outcomes	Smart city practice encounters major challenges in the shaping up of the built environment that produces prosperous and sustainable urban futures for all citizens
12	Yigitcanlar and Lee (2014)	*Technological Forecasting and Social Change*	Korean ubiquitous-eco-city: a smart-sustainable urban form or a branding hoax?	Placing the smart city notion and its Korean practice under the microscope to determine whether it can produce a smart and sustainable urban form	Failure of the smart city practice is not only limited to sustainable outcomes in environment but also economic, societal and governance areas	Smart city practice has failed to produce its promised sustainable development outcomes, not only in built and natural environmental areas but also economic, societal and governance domains

contributing to the reduction of road congestion and emissions."

In the context of smart cities, intelligent transport system (ITS) enables efficiency in the management of the transport system and generates smart mobility (Garau, Masala, & Pinna, 2016). In order to achieve smart mobility, electric and autonomous vehicles are seen as an integral part of future smart cities (Firnkorn & Müller, 2015; Lim & Taeihagh, 2018). However, technology cannot create urban smartness alone; the real urban smartness comes from citizens and urban administrators and policymakers directly (Morse, 2014).

The abovementioned view finds increasing support in the academic smart city literature. For instance, according to Han and Hawken (2018), p. 1), "current discourse on smart cities is obsessed with technological capability and development. Global rankings reduce cities to a one-dimensional business model and series of metrics. If the term smart city is to have any enduring value, technology must be used to develop a city's unique cultural identity and quality of life for the future." Likewise, Costa and Oliveira (2017) and Almeida, Doneda, and Costa, (2018) highlight the importance of consolidated smart city policies (moving beyond the technology obsession) to generate clear results for the sustainability of both society and the environment.

Some scholars accuse the business nature of the smart city practice for the smart city agenda at the global scale (Yigitcanlar, Kamruzzaman, Buys, & Perveen, 2018). Major engineering, construction, technology and consultancy firms (e.g., AT&T, CISCO, Ericsson, Google, Hitachi, Huawei, IBM, Intel, KPMG, McKinsey, Microsoft, Oracle, Schneider Electric, Siemens, Toshiba) play a leading role in the formation of smart city agendas and policies, which poses a risk and conflict of interest (Alizadeh, 2017; Wiig, 2015). On that very point, Noy and Givoni (2018), p. 13) state that private smart city "business actors are expected, even required, to be concerned primarily with the commercial goals of their companies and with profitability. However, it becomes a problem if these same actors and companies are the ones who set the agenda, drive and largely determine transport policy and planning and are the ones who lead public transport policy and research institutions."

Further dwelling on the mainly technocentric perspective of smart cities, scholars highlight the need for the urban smartness issue to be considered beyond technological innovation (i.e., Herrschel, 2013; Haarstad, 2017; Dall'O, Bruni, Panza, Sarto, & Khayatian, 2017; Balducci & Ferrara, 2018; Yigitcanlar & Kamruzzaman, 2018b). For example, according to Haarstad (2017), the current smart city agendas are driven mostly by the concerns for economic growth and innovation rather than by environmental sustainability. The smartness agenda of cities pursuing smart city formation is, thus, bound up with the aim of fostering innovation and competitiveness in the knowledge economy. This misconception on the urban smartness issue is also causing ill-informed investment of the limited public funds in many cities.

Another important issue highlighted in the reviewed literature concentrates on the complexity, integration, cost-effectiveness and resource efficiency of smart city technologies (Macke et al., 2018). Fortunately, many local policymakers are aware of these issues (at least the cost issue) yet still remain reluctant to implement large-scale smart city projects. Beyond the initial investment cost, many urban administrators are concerned with the future update and upgrade requirements that might make them dependent to the technology solution company for a very long time (Yigitcanlar, 2016). This is referred to as a 'vendor lock-in' (Kitchin, 2014). Most people regularly update their computers, smart mobile devices and smart TVs for security and new functionality purposes.

Furthermore, 'planned obsolescence' causes these devices not to function properly after a certain period of time requiring consumers to replace or upgrade them (Satyro, Sacomano, Contador, & Telles, 2018). The prospect of installing millions of Internet of Things (IoT) sensors and devices across a city that eventually all require replacement due to planned obsolescence worries many sensible urban administrators who shy away from such investments (Rathore, Ahmad, Paul, & Rho, 2016;

Table 5
Ad-hoc conceptualisation problem of smart cities, sorted by year of publication.

No	Literature	Journal	Title	Aim	Challenge	Critique
1	Balducci and Ferrara (2018)	*Ecological Indicators*	Using urban environmental policy data to understand the domains of smartness: an analysis of spatial autocorrelation for all the Italian chief towns	Synthesising the information coming from the urban data and to identify the components that had the most relevant impact among the smart policies	Sustainability being seen only as an ancillary issue to smart cities	Environmental dimension, in the smart city practice, is often not explicitly treated but interrelated to the others as a strategic component to promote quality of life and urban sustainability
2	Bibri (2018a)	*Sustainable Cities and Society*	A foundational framework for smart sustainable city development: theoretical, disciplinary, and discursive dimensions and their synergies	Exploring how and to what extent sustainability and technology have become influential in city development	No systems thinking placed in smart city to address environmental sustainability challenges	Smart city does not adopt systems thinking perspective to provide novel solutions for addressing environmental and socioeconomic challenges pertaining to sustainability
3	Chang et al. (2018)	*Journal of Open Innovation*	Knowledge-based, smart and sustainable cities: a provocation for a conceptual framework	Scrutinising currently available methods and tools for the performance assessment of smart and sustainable cities	Incapability of delivering sustainability as smart city being highly ad-hoc in nature	Smart city practice is ad-hoc in nature and lacks of a knowledge-based urban development perspective to generate desired sustainable outcomes
4	Colding et al. (2018)	*Environment and Planning B*	The smart city model: a new panacea for urban sustainability or unmanageable complexity?	Exploring whether smart city developments have a bearing on the issue of whether a society can be destroyed by its own costs of sustaining itself	Misconception of the sustainability concept in the smart city context	Smart cities are often uncritically launched as a sustainable way of developing cities—instead of a new panacea for urban sustainability, the smart city model could open up for a future of unmanageable complexity
5	Cugurullo (2018)	*Environment and Planning A*	Exposing smart cities and eco-cities: Frankenstein urbanism and the sustainability challenges of the experimental city	Investigating the sustainability of smart cities in the cases of Hong Kong and Masdar city	Fragmented nature and conceptualisation of smart cities hampering sustainability achievements in these cities	Smart city is a fragmented city made of disconnected and often incongruous pieces of urban fabric with serious limitations in addressing issues of sustainability
6	Martin et al. (2018)	*Technological Forecasting and Social Change*	Smart and sustainable? Five tensions in the visions and practices of the smart-sustainable city in Europe and North America	Conducting empirically informed analysis of smart city policy and visions alongside the actual experiences of smart city initiatives	Variance between what smart city should be and what its current sustainable development practice generates inconsistencies	There are tensions between smart city and goals of sustainable urban development—reinforcing neoliberal economic growth; focusing on affluent populations; disempowering citizens; neglecting environmental protection; failing to challenge consumerist cultures
7	Yigitcanlar, Kamruzzaman, Kamruzzaman et al. (2018)	*Cities*	Understanding smart cities: intertwining development drivers with desired outcomes in a multidimensional framework	Providing a sound big picture view of smart city conceptualisation with an emphasis on the sustainability	Sustainability being perceived only ancillary to smart city due to lack of a widely accepted holistic conceptualisation	Sustainable urban development principles are not necessarily placed at the heart of current smart city practice
8	Ahvenniemi et al. (2017)	*Cities*	What are the differences between sustainable and smart cities?	Developing an understanding of the similarities and differences between the sustainable and smart cities concepts and respective assessment frameworks	Lack of a widely accepted conceptualisation of smart and sustainable cities	The current large gap between smart city and sustainable city frameworks suggest that there is a need for developing smart city frameworks further or re-defining or re-conceptualising the smart city concept
9	Bibri and Krogstie (2017b)	*Sustainable Cities and Society*	Smart sustainable cities of the future: an extensive interdisciplinary literature review	Determining discrepancies between smart and sustainable cities	Smart cities being failed to deliver sustainability due to various reasons mainly driven from misconceptualisation	Smart city has shortcomings, difficulties, uncertainties, paradoxes, and fallacies in relation to sustainable urban form
10	Bibri and Krogstie (2017a)	*Sustainable Cities and Society*	On the social shaping dimensions of smart sustainable cities: a study in science, technology, and society	Analysing the nature, practice, and impact of the new wave of technology for urban sustainability as a form of science and technology within the defining context of smart sustainable cities	Smart cities lack holistic approaches subsequently they fail to address the sustainability challenge	Smart city practice needs to be reoriented in a more environmentally sustainable direction, as it cannot, as currently practiced, solve the complex environmental problems placed in the agenda of smart sustainable cities as a holistic approach to urban development
11	Colding and Barthel (2017)	*Journal of Cleaner Production*	An urban ecology critique on the "smart city" model	Raising some critical concerns and gaps in the booming literature on smart cities; concerns that deserve greater attention from scientists, policy makers and urban planners	Misconceptualised smart city practice may contribute to the deterioration of human and nature relations	The practice of smart city solutions may affect the autonomy of urban governance, personal integrity and how it may affect the resilience of infrastructures that provide inhabitants with basic needs, such as food, energy and water security; moreover, smart city developments may change human-nature relations
12	Mundoli et al. (2017)	*Decision*	The "sustainable" in smart cities: ignoring the importance of urban ecosystems	Arguing that the smart city model proposed for an urbanising India ignores key elements of environmental sustainability	Poor conceptualisation and delivery of urban ecosystem approach in smart cities	Smart is a catchy prefix for cities, but sustainability and equity are enduring qualities—developing both ecologically and socio-culturally smart cities requires reconceptualisation of the notion to move towards a multi-faceted use-value of urban ecosystems

Silva, Khan, & Han, 2018). Nevertheless, the point is not omitting sensing technologies to collect useful data to inform better decision-making. It is rather stating that not so carefully planned technology investments could risk the best use of taxpayers' money. The planned obsolescence issue also contributes to growing problems of rare earth metal depletion, an inability to trace and avoid conflict resources in smart city and IoT supply chains and an ever-increasing amount of e-waste being exported and dumped in places such as Accra in Ghana and the Guangdong Province of China.

While smart city sceptics rightfully argue that many solutions to urban problems have nothing to do with technology, such as plans, policies and regulations. They also advocate the importance of smart mentality over smart technology; thus, cities must reap the benefits of the appropriate technology opportunities without becoming obsessed with them (Kunzmann, 2014; Vanolo, 2014). Keeping this in mind, our review of the literature in this category raises an important question: *What are the appropriate technologies and the right amount of techno-centrism to bring sustainability to our cities?*

3.3. Practice complexity of smart cities

Slightly over one-third (34%) of the reviewed papers mainly raised issues around the challenges coming from the practice complexity of smart cities (Table 4).

Cities are highly complex (meaning sophisticated, intricate and complicated) system of systems; involving various economic, societal, environmental, governance and technical systems and their sub-systems (Albeverio et al., 2007). Managing complexity (meaning analysing and optimising all involved systems and subsystems) in cities has always been a major challenge for urban policymakers, managers and planners, and it requires a holistic approach that can comfortably deal with these entanglements (Batty, 2009). Throughout history, cities have always endured long periods of socioeconomic and environmental changes and challenges. Speculation prevails that the forthcoming changes in the age of the Anthropocene will be even greater than ever before (Derickson, 2018; Stewart, Kennedy, Facchini, & Mele, 2018). Moreover, as historical trends reveal, the complexity of urban systems will increase over time due to rapid urbanisation and population hike (Colding, Colding, & Barthel, 2018). A sustainable urban development pathway, hence, to establish smart and sustainable cities is the only way to support socioeconomic development and withstand environmental changes and challenges, while securing a healthy and prosperous environment for humans and non-humans (Foth, 2017; Yigitcanlar, Dur, & Dizdaroglu, 2015).

An investigation of the literature, by Jepson and Edwards (2010), finds the three most common development approaches that are directly associated with sustainable urban development. These are new urbanism, ecological city (eco-city), and smart growth. Up until the recent smart city movement, smart growth and new urbanism were relatively mainstreamed, particularly in North America. This was mainly due to the integration of these two approaches into the planning strategies of some of the North American cities. The eco-city model has also been less influential in many parts of the world, particularly in Europe, Oceania and South East Asia (Jepson & Edwards, 2010).

With the rise of the smart city notion, cities that adopt the above-mentioned three development approaches started to embrace technology as part of the solution or as the pivotal driver of development (Silva, Khan, & Han, 2017, b). However, the confusion of what a smart city is generates an issue, particularly for urban policymakers. Likewise, such confusion is evident in the academic literature as well. A possible reason for that might be the word 'smart' (as there are many different ways of perceiving the smartness of a city) (Lara, Costa, Furlani, & Yigitcanlar, 2016). Some scholars perceive 'smart' in the smart city the same as in 'smart growth,' that is, a development that provides an opportunity to implement some of the historic concerns of urban sustainability advocates (Alexander & Tomalty, 2002). Others interpret 'smart' to mean digital or intelligent cities (Kitchin, 2014; Komninos, 2013) that connect innovation strategies and digital growth strategies for establishing smart environments and sustainable economic growth (Komninos, 2016). While the former is more environmentally sound, the latter is fiscally more prudent, at least in the short-term.

A recent empirical study by Yigitcanlar and Kamruzzaman (2018b) reveals that there is little evidence that sustainability targets are achieved in cities that are recognised or claim to be smart cities. In spite of the clear empirical evidence, research by Noy and Givoni (2018) finds that the prevalent belief amongst technology firms is still that smart technology developments alone, for example, connected and autonomous driving technologies, can lead to sustainability, especially in the transport area. Noy and Givoni (2018) raise this issue as a real concern for the planning and development of smart cities. Unfortunately, complexities involved in developing truly smart cities are pushing policymakers to opt for short-term wins implementing blackbox technology solutions promoted by technology companies.

The practice complexity of smart cities is evident (Colding et al., 2018). Although applying 'complexity science' to achieve urban sustainability is, theoretically, plausible (UNU-IAS, 2017); most urban administrators ignore (or are not even aware of) the smart city complexities and challenges in the policy and plan making processes and during the implementation stages of those (Ibrahim et al., 2018). Some urban administrators are mindful and somehow incorporate strong policies and actions to combat unsustainable development (Fernandez-Anez et al., 2018). However, in many cases, either strong policies and plans are not implemented in practice (Silva, Khan, & Han, 2018), or there are no adequate performance assessment measures to evaluate the outcomes, so they cannot be improved easily (Hara, Nagao, Hannoe, & Nakamura, 2016; Marsal-Llacuna, Colomer-Llinàs, & Meléndez-Frigola, 2015).

Furthermore, as stated by Colding et al. (2018), p. 7), "whether the [smart city] model is a new panacea for urban sustainability or instead opens up for a future of unmanageable complexity is an open question that deserves more debate." Keeping this particular view in mind, our review of the literature in this category raises another important question: *Will the future city models be able to manage the currently unmanageable complexity of our cities?*

3.4. Ad-Hoc conceptualisation of smart cities

Slightly over one-third (34%) of the reviewed papers raised the issue of a lack of sound smart city conceptualisations (Table 5).

The lack of progress towards smart and sustainable cities is not only limited to the issues around heavy technocentricity and practice complexity of smart cities. Martin, Evans, and Karvonen, (2018) highlight a much more prominent issue: The clear tension between aspirations of smart cities and goals of sustainable urban development. These goals include the 17 Sustainable Development Goals (SDG)—identified by the United Nations (UN) in 2015 as part of the 2030 Agenda—to shape international efforts to promote a sustainable, peaceful and equitable world. Fig. 3 lists the SDGs, where each goal is also accompanied by a set of more specific targets with indicators to measure progress (see www.un.org/sustainabledevelopment). Besides these goals being critical for smart cities, the Intergovernmental Panel on Climate Change's recent report also underlines the prominent role of sustainable development for the planet and people (IPCC, 2018, p.45): "The global transformation that would be needed to limit warming to 1.5 °C requires enabling conditions that reflect the links, synergies and trade-offs between mitigation, adaptation and sustainable development."

Consistent with this view, the smart city practice reinforces neoliberal economic growth, focuses on affluent populations, disempowers citizens, neglects environmental protection, and fails to challenge or provide real alternatives to the prevailing consumerist culture. One of the reasons for this limitation is that as smart cities evolved from various concepts originating from academia, governments, global

corporations, and international organisations, there is no agreement whatsoever on what smart cities precisely are (Letaifa, 2015).

The vision of smart cities, today, has been forcefully introduced into urban policies in many countries (Vanolo, 2014). While in theory smart is seen as inclusive of the sustainability goals, in practice, the smart and sustainable notions have often been used merely as window-dressing or reduced to ancillary aspects (Balducci & Ferrara, 2018; Serbanica & Constantin, 2017). Heavy technocentrism has distorted in many country contexts what a smart city should look like. In smart city projects, rather than producing new visions for the 'good city,' the focus has shifted to mainly generating technocentric solutions for cities. This shift, so far, proved at best to be not effective (Herrschel, 2013; Stratigea, Leka, & Panagiotopoulou, 2017) and at worst to be producing dystopian city futures (Mattern, 2017; Vanolo, 2016).

This is due to the challenges caused by the artificial smart vs. sustainable dichotomy. These challenges were highlighted in the reviewed literature. They include short-termism vs. long-term gains, elitist vs. inclusive, profit-driven vs. equilibrium-driven, business-friendly vs. environmentally-friendly, carbon-economy vs. climate-neutral-economy, materialism vs. dematerialism and so on. Addressing these challenges through sound smart city conceptualisation (e.g., Yigitcanlar, Kamruzzaman, Kamruzzaman et al., 2018) and urban policy and discourse will help formulating the right direction to establish smart and sustainable cities. This can also lead to the formation of the long-awaited model cities that are truly smart, sustainable and inclusive.

The ad-hoc smart city conceptualisation issue is heavily criticised in the reviewed literature. For instance, Bibri (2018a) pointed out the reason for smart cities not being able to address environmental and socioeconomic challenges pertaining to sustainability is due to an absence of systems-thinking. Smart city frameworks not adopting a knowledge-based urban development perspective to generate desired sustainable outcomes is also raised as a conceptualisation weakness (Chang, Sabatini-Marques, da Costa, Selig, & Yigitcanlar, 2018). Likewise, Ahvenniemi et al. (2017) emphasised the need for developing smart city frameworks further by re-defining and re-conceptualising the concept. Furthermore, Mundoli, Unnikrishnan, and Nagendra, (2017) argued that smart should be more than a catchy prefix for cities similar to the 'smart phone,' hence, reconceptualisation of the smart city notion to move towards a multi-faceted use-value of urban ecosystems is an urgent necessity.

In addition to the emerging comprehensive views on smart city conceptualisation as discussed earlier in Section 2.1, it is also useful to highlight the meta-principles as stated by Ramaswami, Russell, Culligan, Sharma, and Kumar, 2016, p. 940) that "focus attention on the [higher-order] systems-level decisions that society faces to transition towards a smart, sustainable, and healthy urban future." Advocated by Ramaswami et al. (2016), p. 941), these meta-principles for developing smart, sustainable and healthy cities include to: "(a) Focus on providing and innovating basic infrastructure for all; (b) Pursue dynamic multisector and multi-scalar urban health improvements, with attention to inequities; (c) Concentrate on urban form and multisector synergies for resource efficiency; (d) Recognise diverse strategies for resource efficiency in different city types; (e) Integrate high and vernacular technologies; (f) Apply transboundary systems analysis to inform decisions about localised versus larger-scale infrastructure; (g) Recognise coevolution of infrastructures and institutions; (h) Create capacity and transparent infrastructure governance across sectors and scales."

Lastly, the review of the literature in this category, particularly in the light of the abovementioned smart and sustainable city meta-principles, also brings the following important question to mind: *Are self-claimed comprehensive smart city conceptualisations comprehensive enough to be able to tackle the unsustainable development problems of our cities?*

4. Discussion

This paper studied whether cities can become smart without actually being sustainable and the answer based on our review is clear: No, they cannot. The reviewed 35 literature pieces highlighted limitations of the prevailing understanding on what a smart city is and what enables its successful and sustainable development. This creates a major urban policy dilemma for urban policymakers; adopting an ad-hoc technology solution approach to generate palliative remedies vs. a holistic sustainable development approach to generate long-lasting solutions. Moreover, it is still not clear what smart cities can offer as solutions to the global environmental challenges. Norman (2018), p. 2) advocates that "a key driver for smarter cities is planning for the impacts of climate change and the expected increase in urban heat island effects and extreme events (droughts, floods and coastal storms). In this context, the policy of smart cities has the potential to make a major contribution." The smart city practice, however, should not be predominantly relying on technology as a saviour to achieve sustainable outcomes. Technology solutions are needed to support the systems and processes that allow the city to achieve sustainable urban development. Nonetheless, urban smartness is beyond technological smartness. The smartness of urban leaders, policymakers, technocrats and residents along with the smartness of policies developed and actions put into practice matter more.

The findings of our systematic literature review provide strong evidence to justify this study's hypothesis: Cities *cannot* be truly smart without being sustainable. In line with Yigitcanlar, Kamruzzaman, Kamruzzaman et al. (2018), our study finds that the development of smart and sustainable cities can only be accomplished through inclusive and sustainable growth using a healthy mixture of smart people, policies and technologies. In terms of urban policy, the findings are in line with Jepson & Edwards' (2010, p. 420) suggestion: "policies that encourage the replacement of non-renewable energy and other resources, the protection of open space (particularly in relation to biological and natural processes, assets and services), the use of 'appropriate' technologies, the reduction and natural assimilation of waste, and local economic and functional self-reliance" are required to be in place for a healthy smart and sustainable city transformation (see Joss, 2015). Beyond these, a good urban policy should also include deliberate considerations and actions on the issues of accessibility, mobility, education, health, quality of life, and overall urban services and operations. Furthermore, the paper argues, in line with Norman (2018), p. 2), that "the concurrent global trends of urbanisation and climate change will require very smart and innovative solutions. However, it will take a lot more than a smart cities agenda to provide a more sustainable urban future" for our cities and societies.

An urban paradigm worth highlighting, which only recently started to emerge in the smart city discourse and appears to be promising to bring about genuinely smart and sustainable cities, is the *post-anthropocentric city* or *more-than-human city* (Abrams, 1996; Foth & Caldwell, 2018; Foth, 2017; Franklin, 2017; Haraway, 2016; Heitlinger et al., 2018; Yigitcanlar, Foth et al., 2018). While this systematic review found a notable emphasis in the smart city discourse calling for participation and engagement, which aim to increase the involvement of diverse and often marginalised citizens, a human-centred approach to smart cities comes with its own set of problems. Drawing attention to the fallacy of human exceptionalism and anthropocentrism, some scholars have started to move away from the predominant view that urban space is separate from nature and designed primarily for humans and just humans (DiSalvo & Lukens, 2011; Forlano, 2016, 2017; Luusua, Ylipulli, & Rönkkö, 2017). Anderson (2003) calls for cities to be problematised, where people, in entering into distinctively non-natural relations (political, legal and so on) realise their full humanity among a set of relations that are absent in the wholly natural lives of other living things.

Fig. 3. Sustainable development goals (www.un.org/sustainabledevelopment).

Informed by science and technology studies, critical geography, urban planning, and interaction design, these authors call for a 'more-than-human' approach to smart cities (involving biophilia, mutualism and cohabitation) (Foth, 2017; Heitlinger et al., 2018; Houston, Hillier, MacCallum, Steele, & Byrne, 2017; Smith, Bardzell, & Bardzell, 2017). By considering new ways to appreciate and cater for our broader ecological entanglements with plants, animals, and the environment at large, a more-than-human perspective to the design and development of smart cities appears highly imperative to pursue in conjunction with a circular economic model.

The study also generated a number of insights along with new research questions about potential opportunities with respect to identified challenges:

Firstly, to address the heavy technocentricity of smart cities, it is important for smart cities to involve a more specific approach based on the use of technology that complements other planning models, such as smart growth, new urbanism and strategic urban planning. Besides, as De Wijs, Witte, and Geertman, 2016, p.424) claim "technologies are not yet completely developed, and concerns about the 'loss' of personal privacy are holding back the widespread and advanced use of data supplied technologies". Moreover, technology does not necessarily need to be new to be effective, and particularly in the global south context, the most effective solutions often involve retrofitting as well as innovative uses of existing and relatively inexpensive technology. In this instance the question of 'what the appropriate technologies and the right amount of technology to bring sustainability to our cities are' is critical to address:

Secondly, to address the practice complexity of smart cities, it is important to engage complexity science offerings to the urban policy-making process. However, at the same time the trends of 'rapid population growth, growth of consumption of natural resources, vigorous industrialisation, urbanisation, mobilisation, globalisation, agricultural intensification and excessive consumption-driven lifestyles' are the main contributors of the increasing complexity that need to be urgently resolved. In this instance the question of 'whether the future city models will be able to manage the currently unmanageable complexity of our cities' is vital to answer.

Thirdly, to address the ad-hoc conceptualisation of smart cities, it is important to establish a commonly agreed definition and comprehensive conceptualisation of smart cities. However, the focus perhaps needs to be beyond the smart city concept. We need to start thinking of and conceptualising the 'post-anthropocentric city' that will bring genuine sustainability and planetary health expectations and aspirations for all (humans and non-humans). In this instance the question of 'whether self-claimed comprehensive smart city conceptualisations are comprehensive enough to be able to tackle the unsustainable development problems of our cities' is important to address.

Lastly, in addition to the above raised ones, the following questions are also worthy to concentrate on (Yigitcanlar, Foth et al., 2018): *Will urban scholars, planners, designers and activists be able to convince urban policymakers and the general public of the need for a post-anthropocentric urban turnaround? If yes, how will the actors (public, private and academic sectors jointly along with communities) pave the way for post-anthropocentric cities and more-than-human futures?*

The special report from the Intergovernmental Panel on Climate Change has put clear scientific evidence on that we have to start creating our low-carbon future today without any further delay—we have only 12 years left to act on climate change (IPCC, 2018). In theory, the smart and sustainable city poses an opportunity to create such future. In practice this can be achieved only by successfully linking the two school of thoughts—i.e., technocentric and envirocentric views—and creating a uniformed post-anthropocentric urbanism view. Nevertheless, in the transformation journey of our cities towards smart and sustainable ones, the Theory of Change (Ibrahim et al., 2017) and Ecological Human Settlement Theory (Liaros, 2018) could pave the way.

The systematic review and critique of work on smart and sustainable cities reported in this paper provide a useful reference for scholars and practitioners in related research communities and the necessary material to inform urban administrators, policymakers and planners on

the major challenges in developing smart and sustainable cities. These challenges include, but are not limited to, the inability of the policies to: (a) Abstain from the heavy technocentrism obsession, due to the aggressive promotion of technology solutions by the industry; (b) Tackle the core and long-term problems, including the sustainability issue, adequately, due to the complexities involved in the urban planning, development and management practices; (c) Achieve desired planning and practice outcomes, due to the lack of comprehensive conceptualisations (and frameworks) that uncovers the big picture view and brings together the essential elements (e.g., theories, concepts, domains, approaches) that matter most.

5. Conclusion and future work

The study at hand addressed the research question of 'whether cities can become smart without actually being sustainable' by investigating the links between the smart city and urban sustainability literatures. The results pointed out an expectation in the reviewed academic literature for cities to become sustainable first in order to be considered truly smart. The study identified three major weaknesses or challenges of smart cities in delivering sustainable outcomes. These are heavy technocentricity, practice complexity and ad-hoc conceptualisation of smart cities.

This paper contributes to the efforts in not only raising awareness in the academic and policy circles for better configuration and application of the smart and sustainable city notion, but also advocates urban administrators, managers and planners to adopt a post-anthropocentric approach in urban policy making for the development of truly smart and sustainable cities. The study, hence, can serve as a base to stimulate prospective research and further critical debates on this topic to promote the development of truly smart and sustainable cities and the post-anthropocentric urbanism practice.

In addition to the efforts of addressing the questions raised in this paper, our prospective research will continue to focus on two fronts. The first one will conduct thorough conceptual explorations and empirical case investigations into smart and sustainable cities of today's Anthropocene. We have already started this work in the area of media architecture (Foth & Caldwell, 2018). The second one will be re-imagining the ideal 21 st century city to produce a consolidated understanding of the nature and key characteristics of the Post-Anthropocene urbanism that will create truly smart and sustainable cities—or more-than-human cities—of tomorrow. We have also started this work in conceptualising post-anthropocentric urbanism (Yigitcanlar, Foth et al., 2018).

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