Smart Cities: Advances in Research - an Information Systems Perspective

Abstract

Smart cities employ information and communication technologies to improve: the quality of life for its citizens, the local economy, transport, traffic management, environment, and interaction with government. Due to the relevance of *smart cities* (also referred using other related terms such as Digital City, Information City, Intelligent City, Knowledge-based City, Ubiquitous City, Wired City) to various stakeholders and the benefits and challenges associated with its implementation, the concept of *smart cities* has attracted significant attention from researchers within multiple fields, including information systems. This study provides a valuable synthesis of the relevant literature by analysing and discussing the key findings from existing research on issues related to *smart cities* from an Information Systems perspective. The research analysed and discussed in this study focuses on number of aspects of *smart cities*: smart mobility, smart living, smart environment, smart citizens, smart government, and smart architecture as well as related technologies and concepts. The discussion also focusses on the alignment of *smart cities* with the UN sustainable development goals. This comprehensive review offers critical insight to the key underlying research themes within *smart cities*, highlighting the limitations of current developments and potential future directions.

Keywords: Information Systems; Smart Cities; Literature Review; Sustainable Development Goals

1. Introduction

Cities play an important role in shaping environmental and socio-economic aspects at a global level (Albino et al. 2015). The city infrastructure attracts increasing numbers of people seeking the benefits of urbanisation over the traditional rural lifestyles within many cultural contexts. The United Nations (UN) predicts that 6.5 billion people will live in cities by 2050 (Streitz, 2015). As a result, cities are facing numerous challenges as their resources and infrastructure are placed under ever increasing levels of strain (Breetzke & Flowerday, 2016). An emerging trend to manage and minimise the impact of these challenges is the utilisation of Information and Communication Technology (ICT) within an accessible integrated infrastructure. This concept is known as *smart cities*. This topic is proving to be a strong research area that is gaining significant attention from academics as well as practitioners. Many cities are focussing their efforts to become "smarter" by employing ICT to improve various aspects of city operation and management, including: local economy, transport, traffic management, environment, quality of life for citizens, and electronic delivery of public services (Li et al. 2016). Locations of *smart cities* initiatives include: Busan (South Korea), Santander (Spain), Chicago (United States), and Milton Keynes (United Kingdom). India has embarked on an initiative to transform circa 100 cities as *smart cities* by revamping and modernising their infrastructure via the use of technology (GoI, 2018).

Due to the relevance of *smart cities* to various stakeholders and the benefits and challenges associated with its implementation, the concept has been attracting significant attention from researchers within multiple genre studies, including: Internet of Things (IoT), Information Systems (IS) and more mainstream computer science and engineering disciplines. This is evidenced by the increasing body of research within academic journals as well as books and conference proceedings. We posit that the existing research on *smart cities* has reached a level of maturity where a thorough analysis and review of the key topics can offer researchers a timely and succinct appraisal of the critical areas and future direction. A comprehensive review can provide a valuable information source to researchers and

practitioners alike on this emerging and important topic. A limited number of review studies covering *smart cities* have been published within the literature (Albino et al. 2015; Anthopoulos, 2015; Bibri & Krogstie, 2017; Cocchia, 2014; Chatterjee & Kar, 2015; Chauhan et al. 2016). However, although this existing research has provided a timely overview of the overall subject area, many of these studies are limited by their lack of detailed specific analysis from an IS context. The IS focus is particularly important as the implementation and use of IS has proved to be core to the design and development of *smart cities*. This is also important as IS led projects have experienced high rate of failure in the past (See for example, Dwivedi et al. 2015; Hughes et al. 2015; 2016; 2017). This study attempts to bridge this gap in the literature by conducting a comprehensive analysis and review based on a detailed synthesis of *smart cities* related research published within IS focussed journals. We present this comprehensive review as a valuable contribution to the *smart cities* research topic highlighting the key accomplishments, current issues, and articulate the challenges and opportunities for this expanding field of research. More specifically, this review aims to explore some of the key themes relating to the following topics:

- Defining the term *smart cities* from an IS literature focussed context.
- The evolution of *smart cities* related research over the past two decades.
- Analysis and discussion of many of the key *smart cities* themes from the IS based literature.
- Identifying the limitations within the extant literature and exploring the potential directions for future research.

The remaining sections of this study are organised as follows. Section 2 provides a brief overview of the methods used to identify the relevant research included within this review. Section 3 provides the various definitions of *smart cities* that have been formulated by previous studies. This section outlines the evolution of research over the past 20 years concentrating on the key themes emerging from existing research. Section 4 discusses the key aspects of the research, highlights any limitations within existing studies and explores the potential directions for future research. This section also reviews the UN sustainability goals in the context of *smart cities*. The study is concluded within Section 5.

2. Literature Search Method

This study employed a keyword search based approach for identifying relevant articles (Williams et al. 2015; Williams et al. 2009). Several alternative or closely related keywords namely, "Smart City" OR "Smart Cities" OR "Digital City" OR "Information City" OR "Intelligent City" OR "Knowledge-based City" OR "Ubiquitous City" OR "Wired City" were searched via the Scopus database. In order to identify all possible articles relevant to *smart cities*, the search allowed for instances of the aforementioned keywords in the article title, abstract and keywords list. Since the purpose of this study is to obtain a greater understanding of the current state of research on *smart cities* from an IS perspective, the search was restricted to journals listed in the 'Information Management' category of the Academic Journal Guide 2018 (AJG 2018[1]). The AJS 2018 is an Association of Business Schools (ABS) publication and is a ranked list of peer reviewed business related journals. Although this approach restricted the search to only 94 journals from the AJG 2018 ranking, it also ensured that all articles identified directly relate to IS. There were some exceptions. Some search outputs such as: *International Arab Journal of Information Technology, Journal of Information Technology Research and International Journal of Information Processing and Management* did not appear in the AJG2018 list but were included due to relevance. Outputs from these journals were manually checked to ensure that they were within the scope of this literature review. All studies were processed by the authors and reviewed to ensure relevance and that the research offered a contribution to the *smart cities*

[1] https://charteredabs.org/academic-journal-guide-2018/

discussion. The search and subsequent review resulted in 104 outputs that formed the literature review for this study. The selected studies have appeared in 43 separate journals, including 19 journals that have published two or more articles relating to *smart cities*. The remaining 24 journals have contributed just one article each. This distribution of IS related *smart cities* research highlights that this topic has yet to feature in over 85% of the selected journals. This perhaps suggests that *smart cities* based research is still within the nascent stage, highlighting the potential scope for further contribution to this important genre of research.

3 Analysis of Smart City Research from IS Perspective

This section develops the discussion on how *smart cites* has been defined within the IS focussed literature and to outline many of the key themes from the existing research.

3.1 Exploring the definitions of Smart Cities within the IS Literature

Numerous closely related definitions of *smart cities* have been proposed over the past decade, with a plethora of differing terms and explanations suggesting a lack of a unified and accepted definition (Chong et al. 2018; Schaffers et al. 2012; Zhuhadar et al. 2017). Studies tend to reference a number of alternative terms within the literature, such as: digital cities (Sun and Poole, 2010; Keegan et al. 2012), intelligent cities (Tan, 1999), wired cities (Targowski, 1990), information city (Stolfi & Sussman, 2001; Sproull & Patterson, 2004; Fietkiewicz et al. 2017), ubiquitous cities (Shin, 2009) and sensing city (Mone, 2015). The existing definitions tend to focus on different aspects, for example, the majority of definitions of *smart cities* tend to focus on the role of technology. Peng et al. (2017) defines *smart cities* as cities developed to utilise a set of advanced technologies including: smart hardware devices, e.g. wireless sensors, smart meters, smart vehicles, smart phones, mobile networks, data storage technologies and software. The study by Gue et al. (2016) states that *smart cities* are an urban development vision to integrate multiple ICT solutions to manage a city's assets. These definitions emphasise the criticality of an integrated IS playing a vital role within *smart cities*, offering advanced services within an intelligent transport system, building management, energy and environment monitoring, security, public safety, and e-commerce (Hernndez-Muoz et al. 2011; Schafferes et al. 2011). IS effectively acts as an enabler for the interconnection of all the actors of *smart cities* (Anthopoulos and Fitsilis, 2010; Piro et al. 2014).

The literature emphasises the role of technology in the definition of a *smart cities*. However, a city cannot become smart just via the use of technology (Nam & Pardo, 2014). Technology helps to enable social, environmental, economic, and cultural progress. As a result, it is important for *smart cities* to be capable of sustaining these aspects with the help of technology. Thus, definitions of some studies have given consideration to citizens of *smart cities*. Ortiz-Fournier et al. (2017) defines *smart cities* in the context of their smart inhabitants, educational degree, quality of social interaction, integration with public life and openness to the wider world. Another group of studies focus on management and operational aspects. Huang et al. (2016) defines a city as being smart if it is run intelligently, efficiently and is sustainable. A limited number of studies focus on well-being and sustainability. Zhuhabar et al. (2017) highlights that *smart cities* balance the needs of citizens economic wellbeing and quality of life. The topic of sustainability is also referenced in Sakurai and Kokuryo (2018) where the concept of *smart cities* is discussed in the context of future sustainability. Some studies seem to approach this topic from a bottom-up approach to their definition, where the dynamics of cities are categorised via the participation of citizens, companies and organisations (Schaffers et al. 2012). *Smart cities* should focus on how technology can act as an enabler to improve the life of citizens rather than expecting technology by itself to engender change. Solutions that empower people via the use of IS based technologies are likely to provide the greatest benefits (Schaffers et al. 2012). Table 1 provides a list of the common definitions for *smart cities* used throughout the IS literature.

Table 1: Definitions of *smart cities* within IS research

Definition	Author
Smart cities are those cities that have the greatest quality of life and economic wellbeing for their citizens.	Zhuhadar et al., 2017, p. 274
A city is designated as smart if it balances economic, social, and environmental development, and if it links up to democratic processes through a participatory government. SC involves the implementation and deployment of information and communication technology (ICT) infrastructures to support social and urban growth through improving the economy, citizens' involvement and government efficiency.	Yeh 2017, p. 556
A smart city encompass an efficient, technologically advanced, sustainable, and socially inclusive city.	Pereira et al., 2017, p. 528
In a *smart city*, ICT-infused infrastructures enable the extensive monitoring and steering of city maintenance, mobility, air and water quality, energy usage, visitor movements, neighbourhood sentiment, and so on.	van Zoonen, 2016, p.472
A smart city as a place characterized by the "use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms."	Teli et al., 2015, p. 17
In *smart cities* collaborative digital environments facilitate the development of innovative applications, starting from the human capital of the city, rather than believing that the digitalization *in se* can transform and improve cities.	Schuurman et al., 2012, p. 51
The smart city is an urban innovation ecosystem, a living laboratory acting as *agent of change*.	Schaffers et al., 2012, p.2
The town concept is based on principles of sustainability intended to last well into the future. This entails a new way of doing business along with the integration of new town services and IT. The town delivers safe, sophisticated and environmentally friendly services to its residents.	Sakurai and Kokuryo, 2018, p. 19
Smart cities can be defined as a technologically advanced and modernised territory with a certain intellectual ability that deals with various social, technical, economic aspects of growth based on smart computing techniques to develop superior infrastructure constituents and services.	Rana et al., 2018, p.1
A smart city is intended 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.	Piro et al., 2014, p. 169
Smart cities are essentially built by utilising a set of advanced information and communication technologies (ICT), including smart hardware devices (e.g. wireless sensors, smart meters, smart vehicles, and smart phones), mobile networks (e.g. Wi-Fi, 3G/4G/5G network), data storage technologies (e.g. data warehouse, cloud platform), and software applications (e.g. back-office control systems, mobile apps, big data analytical tools).	Peng et al., 2017, p. 846
A smart city has smart inhabitants in terms of their educational degree, and the	Ortiz-Fournier et al.,

quality of their social interactions regarding integration and public life and the openness towards the wider world.	2017, p. 204
Is one where 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	Caragliu et al., 2011, p. 65
A smart city is defined with the meaning of smartness penetrating the urban context, the role of technologies in making a city smarter, and focal domains (infrastructures and services) that need to be smarter.	Nam and Pardo, 2014, p.2
Smart cities aim to provide more efficient, sustainable, competitive, productive, open and transparent place to live.	Li et al., 2016, p. 1249
City which develops and manages a variety of innovative services that provide information to all citizens about all aspects of city life via interactive and internet-based applications.	Lee and lee, 2014, p. 93
A smart city is an ultra-modern urban area that addresses the needs of businesses, institutions, and especially citizens.	Khatoun and Aeadally, 2016, p.46
The *smart cities* are using digital technologies to enhance the quality and performance of urban services.	Hussain et al., 2015, p. 253
A city that is running efficiently, sustainably and intelligently.	Huang et al., 2016, p. 891
Smart city is an urban development vision to integrate multiple ICT solutions in a secure fashion to manage a city's assets. It includes E-home, E-office, E-health, E-traffic and so on.	Guo et al., 2016 p. 1249
A smart city is a city that uses advanced ICT to optimize resource production and consumption.	Gretzel et al., 2015, p. 559
A city is smart when there are actions taken towards innovation in management, technology, and policy, all of which entail risks and opportunities.	Gil-Garcia et al., 2016, p. 524
A smart city is an umbrella term for how information and communication technology can help improve the efficiency of a city's operations and its citizens' quality of life while also promoting the local economy.	Gascó-Hernandez, 2018, p.50
Smart cities are all about networks of sensors, smart devices, real-time data, and ICT integration in every aspect of human life.	El-Haddadeh et al., 2018, p. 1
Smart cities seek to leverage advanced communication technologies and IS in order to improve all areas of city administration, enhance citizens' quality of life, engage citizens and provide more sustainable and resilient public services.	Corbett and Mellouli, 2017 p. 428
A city that uses ICT to be more interactive, efficient and making citizens more aware of what is happening in the city.	Cilliers and Flowerday, 2017, p. 16
Smart city is an integration of infrastructures and technology-mediated services, social learning for strengthening human infrastructure, and governance for institutional improvement and citizen engagement.	Chong et al., 2018, p. 10
Smart cities mean modern cities equipped with all modern facilities basically depending on ICT.	Chatterjee et al., 2018a, p. 349
A smart city is a high-performance urban context, where citizens are more	Calderoni et al.,

aware of, and more integrated into the city life, thanks to an intelligent city information system.	2012, p.74
A smart city is a city that uses technology-based innovation in the city's planning, development and operation.	Breetzke and Flowerday, 2016, p. 1

The plethora of *smart cities* definitions listed in Table 1, highlights the large variance in understanding and application of the term. Some of the common elements and terms from the definitions are: ICT, interaction, sustainability, citizens and quality of life. We bring these core elements together with a more encompassing definition retaining the critical aspects and purpose of *smart cities* by adapting the definitions from: Caragliu et al. (2011); Piro et al. (2014); Lee and Lee (2014). The definition positions the IS component as central to the definition to reflect the systems perspective. The interaction component of the definition, highlights the requirement for *smart cities* to be designed and developed to ensure citizens can easily interact and use its services. This study presents this as a more cohesive and inclusive definition taking account the key points from the existing literature:

> *Smart cities use an IS centric approach to the intelligent use of ICT within an interactive infrastructure to provide advanced and innovative services to its citizens, impacting quality of life and sustainable management of natural resources.*

A number of studies have focused on the various categories of *smart cities*. Giffinger et al. (2007) and Schuurman et al. (2012) proposed dimensions of smart living, smart governance, smart economy, smart environment, smart people and smart mobility. Other studies have proposed: smart health, smart security systems, smart building, smart government, smart tourism, smart grid, smart transportation, smart environment, smart home and smart lifestyle (Caragliu et al. 2009; Pramanik et al. 2017). Peng et al. (2017 discussed: smart aspects of: transportation services, healthcare services, energy services, public services, building management services, waste management services and education services. Keegan et al. (2012) proposed that a city will be an effective functioning entity when it integrates disparate elements such as traffic monitoring, public transportation, utility distribution, health service management, leisure and tourism, entertainment, e-government, emergency response and commerce. Studies define these services as needing to be fully integrated within a holistic system either partly or fully accessible by the general public (Chong et al. 2018; Keegan et al. 2012). Schuurman et al. (2012) focused on technology and citizens in the context of collaborative digital environments and how these factors can facilitate the development of innovative applications with an emphasis on human capital rather than an expectation that digitalization alone can transform cities.

3.2 Evolution of Smart City Research in the IS Literature

In the past two decades, various aspects relating to *smart cities* have been examined in line with emerging technologies. Prior to 2008, studies generally used terms such as: wired cities, digital city and information city. The use of the term *smart cities* appeared for first time in a study by Tan, (1999). However, the literature failed to incorporate the wider use of the term until 2010 where an increasing number of studies started using the *smart cities* terminology. Analysis of the 104 articles from selected IS journals, suggests that prior to 2004, studies were focusing only on technological aspects of *smart cities* (Tan, 1999; Targowski, 1990). After 2012, studies tended to take a more holistic view - referencing various dimensions and people aspects of *smart cities*. The largest number of studies referencing *smart cities* were published 2017 where 31 studies appeared within the literature. Figure 1 depicts a chronological view by volume of articles on *smart cities* in the IS literature.

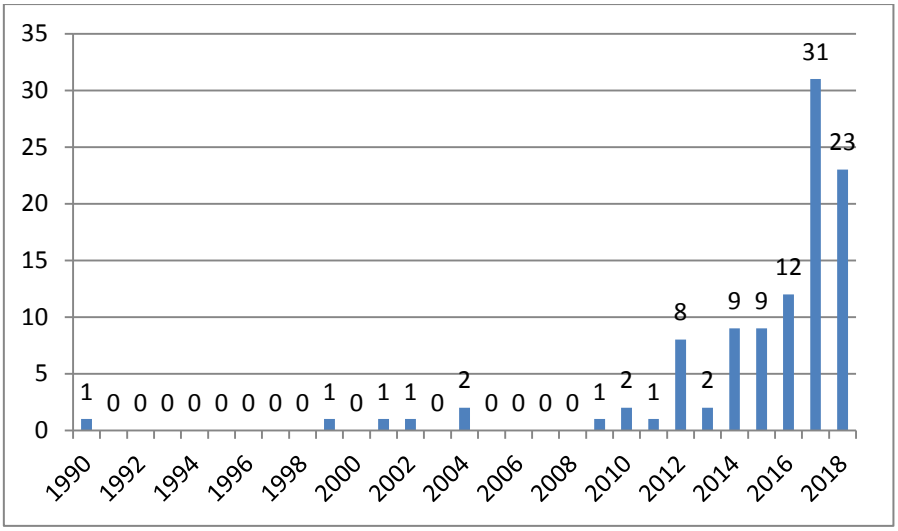

Figure 1. Publications of *Smart Cities* articles within in IS research - 1990 to 2018

Table 2 provides a list of themes (with corresponding citations) emerging from analysis of articles included in this review. These themes are explored and discussed in the context of the wider literature.

Table 2: Themes in *smart cities* research.

Themes	Relevant Studies
Smart Mobility Refers to the use of sustainable and innovative ICT in modern transport technologies to improve urban traffic, transport, logistic and communication systems with local and national accessibility (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014)	
Traffic management	Adart et al. (2017); Calderoni et al. (2014)
Vehicle tracking	Lee et al. (2017)
Route stability	Zhang et al. (2017)
Smart metro	Kumar et al. (2017)
Internet of vehicles	Zhu et al. (2018)
Smart Living Refers to the use of ICT for achieving quality of life in liveable and safe setting (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014)	
Public safety	Breetzke and Flowerday (2016), Cilliers and Flowerday (2017)
Healthcare	Hussain et al. (2015), Pramanik et al. (2017), Thibaud et al. (2018)
Smart education	Ortiz-Fournier et al. (2010), Waheed et al. (2018)
Smart tourism	Gretzel et al. (2015)
Smart buildings	Boukhechba et al. (2017), Peña et al. (2016)
Smart Environment Refers to the use of ICT efficiently to take care for natural resources and the planetary culture (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014)	
Monitoring of city trees	Al-Hader et al. (2011)
Air pollution, quality	Castelli et al. (2017), Miles et al. (2018)
Water quality	Corbett and Mellouli (2017), Sun et al. (2017)
Green spaces	Corbett and Mellouli (2017)
Weather	Mone (2015), Niforatos et al. (2017)
Emission monitoring	Park et al. (2013)

Waste collection, management	Anagnostopoulos et al. (2015), Oralhan et al. (2017), Rybnytska et al. (2018)
Energy efficiency	Zhang et al. (2017), Peña et al. (2016)
Smart Citizens Refers to social and human capital and the level of qualification of women and men with different backgrounds, who are motivated to learn and participate in the co-creation of public life (Staffans & Horelli, 2014)	
Adoption of technology, privacy and security	Belanche-Gracia et al. (2015), Chatterjee et al. (2018ab), van Zoonen (2016), Yeh (2017); El-Haddadeh et al. (2018),
Citizens engagement	Chong et al. (2018), El-Haddadeh et al. (2018), Peng et al. (2017), Salim and Haque (2015), Sauer (2012), Teli et al. (2015)
Crowdsourcing	Mone (2015); Niforatos et al. (2017), Schuurman et al. (2012)
Social interactions, communications	Sproull and Patterson (2004), Sun and Poole (2010)
Smart Government Refers to political strategies and policies, including expanded urban planning, which enable the co-production of public services, and tries to achieve democracy and transparency (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014)	
Social media	Díaz-Díaz and Pérez-González (2016)
Planning process of developing *smart cities*	Axelsson and Granath (2018), Gascó-Hernandez (2018), Lee and Lee (2014), Rana et al. (2018)
Websites	Fietkiewicz et al. (2017)
Open data, open government	Dittrich (2017), Gagliardi et al. (2017), Matheus et al. (2018), Pereira et al. (2017), Vieira and Alvaro (2018)
Smart governance–public services	Guetat and Dakhli (2016), Stolfi and Sussman (2001); Cledou et al. (2018); Sakurai and Kokuryo (2018), Walravens (2012)
Dimensions of smart government	Gil-Garcia et al. (2016), Nam and Pardo (2014)
Sustainable governance	Truong and Dustdar (2012)
Smart collaboration	Viale Pereira et al. (2017)
Smart Economy Refers to the use of ICT in promotion and production processes by companies (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014)	
Smart business	Johnson et al. (2014)
M-commerce	Keegan et al. (2012)
Smart Architecture and Technologies Refers to numerous sensory devices working together through larger infrastructures, focusing on data processing, exchange, storage and security (Voas, 2016)	
Data exchange	Aguilar et al. (2017), Carvalho et al. (2014), Chen et al. (2015), Goyal et al. (2018), Guo et al. (2017), Hawryszkiewycz (2014), Piro et al. (2014)
Improving cybersecurity and privacy of data	Chatterjee et al. (2017 ; 2018b), Song et al. (2017), Wang and Xu (2017), Xu et al. (2017), Zhang (2018), Li et al. (2017), Li and Liao (2018); Shen et al. (2017); Albalas et al. (2018)
Data processing	Hashem et al.(2016), Honarvar and Sami (2016), Hsu and Li (2018), Janssen and Kuk (2016), Russell (2012), Saggi and Jain (2018), Okwechime et al. (2017), Oßner et al. (2016), Pandithurai and Suresh Kumar (2016), Lazerson et al. (2018)

Data storage	Huang et al. (2017)
Technologies for *smart cities*	Ishida (2002), Kukka et al.(2015), Ng et al.(2018), Tan (1999), Targowski(1990), Shin (2009), Zhuhadar et al. (2017), Khatoun and Zeadally (2016), Guetat and Dakhli (2013), Schaffers et al. (2012), Papageorgiou et al. (2014)

A limited number of studies refer to the smart mobility aspect of *smart cities*, discussing the use of sustainable and innovative ICT in modern transport technologies to improve urban traffic, transport, logistics and communication systems (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014). The majority of the studies referencing smart mobility were published in 2017 and 2018, with the exception of one study on traffic management which was published in 2014 (Calderoni et al. 2014). Studies in this category focussed on several aspects including traffic management, vehicle tracking, route stability, smart metro and internet of vehicles.

Smart living refers to the use of ICT for achieving quality of life in a liveable and safe setting (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014). The following studies have addressed a number of issues relating to smart living: public safety (Breetzke & Flowerday, 2016; Cilliers & Flowerday, 2017), healthcare (Pramanik et al. 2017; Thibaud et al. 2018) and smart tourism (Gretzel et al. 2015). Further studies have discussed the smart environment utilising ICT to efficiently use precious natural resources (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014). In this category, more recent studies focus on energy efficiency, waste management, quality of water, green spaces, and the problems relating to air pollution. The oldest study referencing the smart environment focused on the monitoring of city trees in 2011 (Al-Hader et al., 2011).

The concept of smart citizens is referenced in a number of studies and refers to social and human capital that are motivated to learn and participate in the co-creation of public life (Staffans & Horelli, 2014). Many of the studies that reference *smart cities* focus on the adoption of *smart cities* related technology by citizens and their engagement with public services. Most of the publications in this category have appeared between 2015-2018. Just two publications before 2012 focused on the social communications of smart citizens (Sproull & Patterson, 2004; Sun & Poole, 2010).

The role of government within *smart cities* is analysed in a number of studies including political strategies and policies, expanded urban planning that enable the co-production of public services in the achievement of democracy and transparency (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014). In this category, most of the recent studies discuss open data and open government related issues (Dittrich, 2017; Gagliardi et al. 2017; Matheus et al. 2018; Pereira et al. 2017; Vieira & Alvaro, 2018). Studies from 2001-2016 cover the dimensions of smart government, social media, sustainable government and public services.

The term smart economy refers to the use of ICT in the promotion and production processes by organisations (Al-Nasrawi et al. 2015; Staffans & Horelli, 2014). Just two studies from the literature review are focused on the smart economy. These were published during the period 2012-2014 and have more specifically addressed issues relating to smart business (Johnson et al. 2014) and m-commerce (Keegan et al., 2012).

A number of studies discuss the technology aspects of *smart cities*. Researchers have referenced smart architecture and technologies within *smart cities*, referring to the numerous integrated sensory devices working together through larger infrastructures, focusing on data processing, exchange, storage and security (Voas, 2016). Recent studies have examined issues relating to cybersecurity and privacy of data (Albalas et al. 2018; Chatterjee et al. 2017; Li et al. 2017; Li & Liao, 2018; Shen et al., 2017; Song et al. 2017; Wang & Xu, 2017; Xu et al. 2017; Zhang, 2018) and data storage (Huang et al. (2017). Studies published during the period between 1990-2015 generally address issues relating to

technologies for *smart cities* (Ishida, 2002; Kukka et al., 2015; Tan, 1999; Targowski, 1990; Shin, 2009; Guetat & Dakhli, 2013; Schaffers et al. 2012; Papageorgiou et al. 2014).

3.3 Literature Synthesis - *Smart Cities* Themes.

This section elaborates on the key themes from Table 2 and discusses some of the relevant topics from an overall IS context.

3.3.1 Smart mobility

Cities are facing ongoing challenges on how to manage levels of vehicle capacity, a situation exacerbated by increasing levels of urban congestion (Adart et al. 2017). Researchers have discussed this issue in the context of intelligent transportation systems (ITS) and how these can benefit *smart cities* (Adart et al. 2017; Dimitrakopoulos & Demestichas, 2010). The term Internet of Vehicles (IoV) has been referenced in some studies were the concept is described as playing a crucial role within an ITS, by providing a number of applications aiming to improve road safety and traffic efficiency (Checn et al. 2015). By using IoV, Zhu et al. (2018) proposed a Hybrid Emergency Message Transmission (HEMT) system that has better network compatibility and scalability making network management easier. Several studies on *smart cities* focused on traffic management (Adart et al. 2017; Calderoni et al. 2014). The Adart et al. (2017) study discussed urban traffic management and proposed a solution to help road users reach their destination by avoiding road congestion. The proposal was successful in testing simple cases of modelling, but does not cover all complex scenarios faced by road users. Calderoni et al. (2014) presented the city kernel, a system able to collect information from a number of sensor networks and expose multiple service data gathered from sensors networks. The study identified two services: 1) mobile traffic control, which allows citizens to avoid queues and traffic jams by proposing the fastest path and 2) Wise Traffic Controller (WTC) which provides a web interface and is designed for the use on the big screen. These services will allow the government or company controlling the traffic flow to improve the design of the urban road infrastructure and traffic management policies. The services were successfully tested in the areas around Bologna, Italy.

Some other researchers have focused on vehicle tracking. Lee et al. (2017) proposed a new method that allows tracking of moving vehicles robustly in real time. By using simulations, the study proposed that this method can effectively track multiple vehicles by predicting the next probable centroid area of a tracker. Another study by Zhang et al. (2017) focused on route stability. The study proposed a novel routing algorithm titled: Power Controlled and Stability-based Routing protocol (PCSR), that helps to enhance energy efficiency and route stability. The smart metro proposed by Kumar et al (2017) used secondary data to explore the competitiveness of four metro cities in India: Delhi, Kolkata, Mumbai and Chennai. One limitation of many of the studies on smart mobility aspects, is the extensive reliance on simulations rather than live data from users of smart mobility services or *smart cities* based infrastructure.

3.3.2 Smart living

Smart living comprises areas such as city: public safety, healthcare, education, tourism and smart buildings all of which enhance the quality of living for its citizens. Public safety is a big area of concern in growing urbanisation especially in developing countries. Studies investigated how to enhance public safety by using ICT tools (Breetzke & Flowerday, 2016; Cilliers & Flowerday, 2017). Breetzke and Flowerday (2016) proposed and tested a crowdsourcing model based on voluntary participants of citizens in South Africa. The paper tested the usability of an Interactive Voice Response (IVR) system, concluding that it can be an effective channel for people to report any safety issues. The study highlighted that usability was dependent on the system being: effective, safe to use, easy to learn and be efficient. The study by Cilliers and Flowerday (2017) also discussed the factors affecting usability of an IVR system. By collecting data from 361 citizens of East London (South

Africa), they found that efficiency, effectiveness and perceived satisfaction significantly influenced the intention to interact with the IVR system.

The healthcare aspects of *smart cities* are considered an important indicator of the quality of life for citizens (Hussain et al. 2015; Pramanik et al. 2017; Thibaud et al. 2018). The Hussain et al. (2015) study researched the healthcare of elderly and disabled citizens of *smart cities* and proposed a framework to support people-centric health management, developing an approach that focussed on real-time monitoring. The study discussed the potential for monitoring the health of people needing continual special care provide them with the emergency support as needed and structuring the solution within a virtual community where people could establish and maintain people networks. Another study by Pramanik et al. (2017) proposed a Big data enabled Smart Healthcare System Framework (BSHSF). The BSHSF proposal included data sources, big data analytics, smart service-based architecture, logistic support and knowledge discovery services to provide theoretical representations of a healthcare related business model. BSHF allows automation of business processes to minimise health costs, improve contact management and achieve service of better quality.

Studies have argued that the quality of cities can be dependent on education and the quality of schools in the context of local development (Vincent 2006). A study by Ortiz-Fournier et al. (2010) study proposed the integration of the educational institutions via the municipal government strategic plan in Caguas (Puerto Rico). The study presented an integrated model where the educational infrastructure (municipal government, the high schools, the community colleges and universities) are integrated to form an overall strategic solution to develop the necessary intellectual human capital to solve many of the regions problems.

A Smart Tourism Ecosystem (STE), can take advantage of smart technology in creating, managing and delivering intelligent touristic services (Gretzel et al. 2015). The proposed ecosystem outlined in Gretzel et al. (2015) is characterised by intensive information sharing and value co-creation from a network of tourism stakeholders. The ecosystem is positioned as offering significant benefits for visitors to the city but also for local businesses. STE is positioned as providing enormous opportunities for technological innovation and new business models as well as contributions to the environment for value co-creation.

The smart buildings aspect of *smart cities* has been discussed in some studies where key content is communicated to citizens using their mobile phones. Boukhechba et al. (2017) introduced the NomaBlue prototype, which is based on intelligent nomadic data collection and user collaboration by employing smart Bluetooth technologies. NomaBlue usage can be marketing via a personalised shopping experience with associated navigation capability. One of the advantages of the NomaBlue system prototype is that it is not reliant on a continuous internet connection and does not need a pre-defined geographical databases.

3.3.3 Smart environment

Smart environment is an important characteristic of *smart cities* and has received strong attention from researchers. The smart environment consists of quality of air, water, green spaces, emission monitoring, waste collection management, energy efficiency and monitoring of city trees (Al-Hader et al. 2011; Anagnostopoulos et al. 2015; Castelli et al. 2017; Corbett & Mellouli, 2017; Niforatos et al. 2017; Park et al. 2013; Zhang et al. 2017). Al-Hader et al. (2011) focused on the problem of monitoring of city trees in *smart cities*. City trees might cause damage to cables which will lead to power disconnections. The research utilised the dynamic laser scanning system for progress monitoring and spatially locating the well-recognised and accessed trees located in the city.

Cities are facing many environmental challenges relating to air pollution (Castelli et al. 2017). According to the report provided by the Word Health Organisation (WHO), around seven million people die each year due to the effects of air pollution. Studies have focused on monitoring and

predicting air quality using sensor based traffic monitoring (Castelli et al. 2017; Park et al. 2013). The Castelli et al. (2017) study proposed a system for the prediction of pollutant levels based on the concentration of various pollutants collected by sensors located in different areas of the city. The suitability of the proposed system was tested by using the data from Yuen Long (China). The proposed system was able to forecast the ozone level with greater accuracy in comparison with other techniques but is limited by the slow speed of the convergence process. The study by Miles et al. (2018) proposed a prototype IoT-based Decision Support System (DSS), that combines atmospheric pollution monitoring from multiple heterogeneous data sources with efficient pollution reduction strategies. The DSS used an underlying traffic model as the input to an atmospheric model in order to forecast traffic-related atmospheric pollution levels and simulate how these levels could impact mitigation strategies.

The safe management of drinking water within crowded cities is problematic (Hrudy et al. 2012; Polenghi-Gross et al. 2014). Nowadays cities are faced with challenges such as aged water infrastructure, prohibitive maintenance costs, new contaminants and increasing demand due to rising population levels (Hou et al. 2013; Polenghi-Gross et al. 2014). These factors highlight the need for an effective water management system and associated infrastructure. Researchers have reasoned that advanced ICT based systems can improve the quality of drinking water around the world (Corbett & Mellouli, 2017; Sun et al. 2017). The study by Corbett and Mellouli (2017) developed a conceptual model that expands the role of IS in building sustainable *smart cities*. The model explains the interactions between three interrelated spheres - administrative, political and sustainability. Weather pattern prediction within *smart cities* has featured within a number of studies (Mone, 2015; Niforatos et al. 2017). The Niforatos et al. (2017) study created Atmos - a crowdsourced weather app that combined automated sensor readings from smartphones and manual input by citizens to estimate current and future weather conditions. The 32 month study demonstrated a high level of accuracy in estimating actual weather conditions, highlighting that hybrid participation sensing can greatly increase weather condition estimation and prediction.

Another important challenge of for sustainable *smart cities* is waste management. This aspect can have a significant impact on the quality of life and safety of its citizens. IoT based waste management systems can offer significant opportunities to effectively manage waste via the integration of a number of technologies (Anagnostopoulos et al. 2015; Oralhan et al. 2017; Rybnytska et al. 2018). The Anagnostopoulos et al. (2015) study proposed a dynamic waste collection architecture based on the data provided by sensors. The research focused on exploring the potential of real-time collection of waste from high priority areas such as: schools, hospitals and universities, where the presence of dangerous waste can negatively impact quality of life. The study by Oralhan et al. (2017) designed a waste container with integrated sensors able to measure a variety of parameters such as: containers capacity, temperature and carbon dioxide levels inside the containers to calculate an effective waste collection route. This IoT enabled smart collection management system was successfully tested in Kayseri (Turkey). The results showed that the proposed system significantly reduced: transport costs, carbon emissions, traffic congestion, noise pollution, and required labour hours. The Rybnytska et al. (2018) study created a decision support tool that coordinated drivers to select the optimal path for garbage collection. The results highlighted the potential for a reduction in distance covered and associated CO2 emissions.

Energy efficiency is a critical factor for the efficient operation of *smart cities*. Pena et al. (2016) proposed a new method to solve the problem of energy efficiency anomalies in smart buildings. The proposed rules based solution was created using data mining techniques to develop a decision support system for improving energy consumption and detection of anomalies in smart buildings. Zhang et al. (2017) proposed a Power Controlled and Stability-based Routing protocol (PCSR) to improve energy efficiency and route stability. The results highlighted the benefits of PCSR in the reduction of energy consumption, efficiency and extension of network lifetime.

3.3.4 Smart citizens

One of the key aims for *smart cities* is to provide citizens with an improved living environment and increase their overall quality of life (Yeh, 2017). Citizens are users of smart services, thus it is crucial when planning and designing services, that the citizen perspective is considered to ensure full adoption of new changes and services (Belanche-Gracia et al. 2015; Chatterjee & Kar, 2018; Chatterjee et al. 2018a; van Zoonen, 2016; Yeh, 2017).

The Chatterjee et al. (2018a) study attempted to predict factors that can influence citizen IS usage within *smart cities* highlighting the critical aspects of perceived information and system quality. Citizen privacy and security concerns were discussed in Belanche-Gracia et al. (2015) where the study investigated the factors affecting the intention to use smartcard services for public facilities and public transport, arguing that complexity is a barrier to smart card adoption. A privacy framework was developed by van Zoonen (2016) to identify citizen concerns when interacting with smart technologies. The study identified areas of concern relating to: impersonal data and personal data used for surveillance purposes. A study by Yeh (2017) found that acceptance of ICT based *smart cities* services is affected by innovation concept, service quality and perceived privacy. From these studies it can be concluded that privacy plays a crucial role in acceptance and usage of service and technologies in *smart cities*. Thus, citizens should be educated about the laws and policies which are used in the environment of information processing. Also, social networking services can help to educate citizens about *smart cities* services, providing the information regarding the benefits of these services, its improvements and how they can satisfy needs of society (Yeh, 2017). It is important to pay attention to these factors as they directly impact the adoption of smart services, all of which have influence on the quality of life of citizens.

The engagement of citizens as potential service users is discussed in a number of studies (Chong et al. 2018; El-Haddadeh et al. 2018; Peng 2015; Peng et al. 2015, 2017; Salim & Haque, 2015; Sauer, 2012; Teli et al. 2015). Within *smart cities* the citizen engagement model moves toward the co-design and co-production of government functions, using user-generated content (Bertot et al. 2016; Lim et al. 2018). Studies have highlighted the potential of user generated content and analytics that can be used to generate predictive models, enabling local government to be more strategic and proactive in its responses to citizen requirements (Chong et al. 2018). The perceived value of IT enabled smart devices in public services can influence citizens engagement with public services, highlighting the criticality in raising awareness of how technology can improve engagement and outcomes (El-Haddadeh et al. 2018). Understanding how users interact with technology and the emotional aspects of changing human behaviours is critical to the adoption of new processes within *smart cities*. These issues are highlighted by Peng et al. (2017), where the study analysed the success of the smart parking initiative in London UK. The local authority failed to engage with citizens effectively and despite a successful deployment of the system, few benefits were realised.

It is important for citizens of *smart cities* to have the opportunity to connect and communicate with each other in the context of exchanging mutually meaningful social experiences online and in a shared physical space for users (Sun and Poole 2010; Sproull and Patterson 2004). In *smart cities* citizens can not only interact and engage with services but also provide data for these services via crowdsourcing. The study by Niforatos et al. (2017) presented Atmos, a crowdsourcing weather app that combines automated sensor readings from smartphones and manual input by citizens to estimate current and future weather conditions. Relying on citizens to interact in a crowdsourcing context requires communication on the potential value proposition. The cycling route crowdsourcing based study by Mone (2015), reinforced the citizen value element by highlighting potential long-term benefits for cyclists. The data was used by city planners to analyse traffic and improve urban infrastructure by adding racks or widening lanes, all of which could be of benefit to cyclists (Mone 2015). The study by Schuurman et al. (2012) investigated crowdsourcing as a tool of ideas generation in the context of

urban innovation. The authors argued that crowdsourcing is a useful and effective tool in the context of *smart cities* innovation.

3.3.5 Smart government

Social media can be successfully used by government to encourage value co-creation and citizen participation within *smart cities*. Díaz-Díaz and Pérez-González (2016) analysed the platform: Santander City brain - managed by the city council of Santander in Spain. The study concluded that social media is an effective tool for civil society but success is dependent on government involvement, clear communication, security, privacy and ease of use.

Innovative planning approaches are needed for successful *smart cities* (Axelsson and Granath 2018; Lee and Lee, 2014). The study by Gascó-Hernandez (2018) demonstrated this aspect in the case of Barcelona and its evolution toward becoming a smart city. The study emphasised the criticality of citizen partnership when designing, implementing, and evaluating potential *smart cities* related projects (Gascó-Hernandez, 2018). Rana et al. (2018) examined barriers that affect development of *smart cities* from an Indian context. The study found that governance is the most significant category of barrier and recommend policymakers promote e-governance services to bring accountability and transparency to the decision making process in the development of *smart cities*.

Open data is a mechanism designed to help smart government enhance their communication with stakeholder data and make it more accessible (Vieira and Alvaro, 2018). Citizens and government should be able to decide how, where and when to use any collected data (Dittrich, 2017). Gagliardi et al. (2016) presented UrbanSense and discussed how open data can be used to provide new and updated services to citizens within *smart cities*. The study by Pereira et al. (2017) found that open data initiatives can enhance the delivery of public value in terms of: economics, strategy, politics, stewardship and quality of life. Matheus et al. (2018) investigated the challenges connected to open data by using two *smart cities* cases (traffic dashboard and public transport dashboard).The study highlighted the key challenges: insufficient data quality, lack of understanding of data, poor analysis, wrong interpretation, confusion about the outcomes and imposing a pre-defined view. These challenges can lead to misconnects, incorrect decision-making and less trust in government.

The success of *smart cities* is highly dependent on its provision of services to citizens, the channels used, availability of smart mobile services, value networks and integration of services and quality of information architecture (Cledou et al. 2018; Fietkiewicz et al. 2016; Guetat and Dakhli, 2016; Stolfi and Sussman, 2001; Walravens, 2012). The study by Sakurai and Kokuryo (2018) cited the case of Panasonic in Japan where sustainable communities are focused on the benefits of linking IS for the provision of services and social aspects of *smart cities*. Smart government should be not only advanced in using technology but also have government management and policies which will make the government smart. Nam and Pardo (2014) proposed metrics for assessing the smartness of government initiative: efficiency, effectiveness, transparency and collaboration. The dimension of smart government namely: integration, innovation, evidence-based decision making, citizen centricity, sustainability, creativity, effectiveness, efficiency, equality, entrepreneurialism, citizen engagement, openness, resiliency, and technology savviness were discussed in Gil-Garcia et al. (2016) in the context of critical elements of successful *smart cities*. Cloud based IS services can support requirements for sustainable governance of facilities within *smart cities* (Truong and Dustdar 2012). IS and associated services can promote collaborative governance and improve the participation and engagement supporting information sharing and integration between government agencies and external stakeholders (Viale Pereira et al. (2017).

3.3.6 Smart economy

The literature references the concepts of smart economy, smart business and m-commerce within *smart cities* (Johnson et al. 2014; Keegan et al. 2012). The predictive, probabilistic architecture

modelling framework presented by Johnson et al. (2014) proposed a risk based approach to managing changing market conditions within ebusiness in a *smart cities* context. Studies have reviewed many of the potential commercial benefits relating to the smart economy and its interaction with citizens. Keegan et al. (2012) illustrated how m-commerce services operate in a digital city environment by helping retailers to attract more customers. The study developed and tested EasiShop - a mobile shopping system that allows a prospective shopper to provide information about product in which they are interested using their mobile device. Challenges remain on how to balance innovation and user experience within the smart economy and respect the privacy concerns of users in *smart cities*.

3.3.7 Smart architecture and technologies

The seamless integration of technology and architecture facilitating cross cultural communication is critical to the operational effectiveness of *smart cities* and key to its economic growth (Kukka et al., 2015; Tan, 1999; Targowski, 1990). This requires the processing of large amounts of data as well as accommodating the range of interaction technologies and associated information security issues (Ishida (2002; Khatoun and Zeadally, 2016). The use of advanced technologies is not enough for cities to become smart. The Shin (2009) study of *smart cities* within South Korea highlighted the criticality of solving problems within: social infrastructure, market restrictions, political quagmires and vested financial interests. By their nature *smart cities* have enormous and multiple source of information and studies have reviewed these complexities and the challenges of information exchange between different sources. These complexities can be communication between devices where trust is a key factor (Guo et al. 2017), collaborative spaces and handling big data within the cloud (Aguilar et al. 2017; Goyal et al. 2018; Hawryszkiewycz, 2014). Carvalho et al. (2014) presented a case study of company Living PlanIT that develops, test and sells *smart cities* software that helps to process real-time information collected through sensors embedded within building infrastructure. Chen et al. (2015) proposed a city-level data exchange system (citizen-card system, intelligent transportation system, and urban regional health system), that was successfully implemented and applied in Zhenjiang city (China). Piro et al. (2014) suggested an information centric network which process real-time data according to information stored within them and efficiently transmit content-oriented data. The study plans to test the proposed platform with real experiments and implement prototype software applications that can be applied to perform services in real life urban situations.

The increase in connected devices within *smart cities* results in significant levels in growth of data. This data needs to be communicated, processed, stored in adherence with data protection guidelines and in compliance with government laws regulations. Studies have reviewed the impact of these areas on the operational effectiveness of *smart cities* highlighting the day to day issues of use of digital signatures, encryption and privacy within location based services (Li et al. 2017; Wang and Xu 2017; Xu et al. 2017). Studies have discussed the potential of an increased cybersecurity threat within *smart cities*. Li and Liao (2018) presented new strategies to improve cybersecurity by focussing on a shared risk economic style of model between vendor and government to reduce vulnerabilities and improve security.

The growth of data within *smart cities* requires significant resources for cloud storage from the myriad of IoT sources of communicated data. This big data issue needs to be accommodated within the *smart cities* infrastructure with associated capacity planning to account for planned growth and likely citizen interaction. The study by Hashem et al. (2016) discusses the applications of big data in *smart cities*. Applications such as smart healthcare and analytics can use big data for health monitoring using IoT technologies such as sensors and smart wearable devices. The associated life signs monitoring aspect of smart health care in the context of big data within *smart cities* is a factor is discussed in Hsu and Li (2018), where the study highlights the year on year increases in advancement of this technology and importance for citizens.

The concept of a smart grid has been analysed within some aspects of the literature in the context of big data within *smart cities*. Smart grid can help to manage the power supply by using smart meters and smart readers to more efficiently manage usage and future needs estimation on capacity. The study by Honarvar and Sami (2016) extracted sequence patterns from real appliances' big dataset demonstrating the importance of extracting sequence patterns to decrease CO2 and greenhouse gas emission by more efficiently managing energy usage. A smart grid will ensure that power supply and usage is efficiently matched and users are able to easily assess their energy needs. Pandithurai and Suresh (2016) proposed a cluster power efficient IS that allowed efficient data transmission and processing using cloud computer environment to demonstrate the efficiencies of effectively managing the energy grid within *smart cities*.

4. Discussion

The review of the IS focussed aspects of the *smart cities* literature has revealed many factors and dimensions of the concept and how it has been applied. The range and depth of studies highlights the multiplicity of themes and how these disparate elements need to be integrated to ensure the success of *smart cities*. The integration aspect is key in that citizens need to seamlessly interact with this new IS technology. Adoption of these new services require ease of use and the communication of key benefits to users.

Efficient navigating around the city is a critical aspect of the success of *smart cities*. The topic of smart mobility includes many of the issues related to traffic management, vehicle tracking, smart parking, route stability, smart metro and internet of vehicles. Although many of the studies that have analysed this area rely on simulations, the study by Peng et al. (2017) used data collected from 212 drivers in London (UK) to analyse many of the issues within this topic. Studies on smart mobility were also conducted in Italy (Calderoni et al. 2014) and India (Kumar et al. (2017) highlighting the importance of geographical and cultural contexts when analysing the many issues relating to navigation within *smart cities*. Researchers are advised to consider navigation within established as well as emerging economies to ensure the levels of technological advancement and transportation infrastructure are taken into account for any proposed solutions.

The group of studies that discussed the themes of smart living: public safety, healthcare, education, smart tourism and smart buildings, highlighted the complexities of day to day aspects of living and working within *smart cities*. To date a number of studies have concentrated on specific geographical locations: Spain (Pena et al. 2016), Canada (Boukhechba et al. 2017), Puerto Rico (Ortiz-Fournier et al. 2010) and South Africa (Cilliers & Flowerday, 2017). This somewhat limits the findings in terms of disseminating key aspects to other global regions. Future research should focus on other countries and perhaps a comparison of *smart cities* across the cultural and geographical divide. The studies by Breetzke & Flowerday (2016) and Cilliers & Flowerday (2017) analysed the perception of services within *smart cities* from the citizen perspective including the safety and confidence of interaction aspects. Improving public safety, the safety of women and children especially in developing countries requires solutions integral to *smart cities* design and development.

Studies that investigated the smart environment discussed some of the key themes affecting *smart cities* such as: air pollution, waste management, water quality and energy efficiency. Studies predominantly focussed on systems and processes to enable reduction of time for waste collection, route optimisation and efficiencies relating to waste collection. Many of the studies within this category rely heavily on simulations to develop their findings. The study by Oralhan et al. (2017) was the exception in that the researchers obtained live date from waste management and collection processes within Turkey. More research is needed to evaluate the smart environment theme of implementing such systems in other cities particularly cities of various sizes and stages along the

smart journey. Future research should perhaps focus on the types of the collected waste in order to better optimise the systems and processes surrounding recycling in a smart environment.

The citizen and their interactions are an important dimension in the operational effectiveness of *smart cities*. Studies investigated the adoption of technology, citizens engagement with services, crowdsourcing and social interactions within the *smart cities* context. Success is dependent on the creation of services that will advance and improve the quality of living of citizens but is reliant on the level of adoption of smart services. Studies covering this specific theme focused on factors such as: perceived ease of use, perceived value and perceived efficiency (Belanche-Gracia et al. 2015; Chatterjee et al. 2018a; Chong et al. 2018; El-Haddadeh et al. 2018; Yeh, 2017). However, studies generally failed to test for the moderating effect of age, gender, level of education and knowledge and use of technologies. Future studies are encouraged to conduct research that includes these aspects to take account of generational and educational impacts of interacting with *smart cities* infrastructure.

Smart government and its role within *smart cities* is an active research area with a number of studies discussing this theme in the context of social media, the planning process, open data, public services, sustainable governance and smart collaboration. However, analysis of the literature suggests a lack of studies investigating citizens' perception of smart government. It is recommended that future studies should be conducted on this topic by employing primary data collections methods such as surveys for theory testing and interviews for theory building. These areas are critical to the efficient workings of *smart cities* in that the adoption of new services relies on the confidence from citizens (Dwivedi et al. 2016; 2017ab; Rana et al. 2015; 2016; 2017) that the changes initiated via *smart cities,* can engender significant benefits as they interact with smart government.

Only two studies from 104 studies utilised in focused on smart economy (Johnson et al. 2014; Keegan et al. 2012). The Johnson et al. (2014) study focussed exclusively on Sweden. This highlights a gap in the research where the advantages to the economy from *smart cities* could be explored in more detail to help organisations to improve engagement with customers, effective smart communications, as well as for improving consumers' attitude towards smart related products and services.

Smart architecture and associated technologies is an integral aspect of the efficient functioning of *smart cities* (Aguilar et al. 2017; Carvalho et al. 2014). This theme includes many of the issues related to information security, data processing and storage and many of the issues surrounding cloud computing and big data. Designers need to be cognisant of the many potential innovative mechanisms to engender interaction with users in the architectural context, whilst managing many of the complexities of integrating technology. *Smart cities* can substantially benefit from energy efficiency and capacity planning by the management of energy resources via a smart grid. Studies have highlighted the sustainability advantages of managing these aspects effectively (Pandithurai and Suresh 2016).

4.1 Smart Cities through the lens of the UN Sustainability Development Goals

The UN developed Sustainability Development Goals (SDGs) were established in 2015 as a shared agenda and blueprint for peace and prosperity for people and the planet, now and into the future. The UN established 17 SDGs, developed in partnership with the UN member states as an urgent call for action by all countries. The SDG emphasises that ending poverty and other deprivations must go hand-in-hand with strategies to improve health and education, reduce inequality, and engender economic growth whilst tackling climate change and preserving our forests and oceans (UN 2018). The set of SDGs are listed and described in Table 3 (see column 1).

From the wide ranging research analysed within this study, we assert that the concept and practice of *smart cities* has the potential to deliver many of the UN SDGs. Table 3 lists the individual SDGs and

the alignment with the *smart cities* approach in fulfilling the potential of each goal based on the discussion and results of this study.

Table 3: UN sustainable development goals (UN SDGs) vs *smart cities*

UN SDGs (Source: adapted from UN, 2018)	***Smart Cities* aim in delivering UN Goal**
No poverty: End extreme poverty in all forms by 2030	*Smart cities* - via the use of technology can highlight the underlying causes of poverty within cities, whether it's access to resources, education or services. The smart living theme aims to provide benefits to citizens in terms of smart healthcare and quality of living. Life-signs monitoring technology within the *smart city* context can enable monitoring of users and continual people centric health management.
Zero hunger: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	
Good health and well-being: Ensure healthy lives and promote well-being for all at all ages	
Quality education: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	The smart living theme of *smart cities* includes education and quality of life. The quality of cities can be dependent on education and the quality of schools in the context of local development and the integration of educational institutions and the *smart city*. Educational aspects of gender equality can be reinforced via *smart city* design and interaction.
Gender equality: Achieve gender equality and empower all women and girls	
Clean water and sanitation: Ensure availability and sustainable management of water and sanitation for all	*The approach to Smart cities* design focusses on the effective management of water and associated infrastructure as well as the concept of the smart grid where affordable energy can be made available to the city inhabitants.
Affordable and clean energy: Ensure access to affordable, reliable, sustainable and modern energy for all	
Decent work and economic growth: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	The smart government and smart economy themes of *smart cities* highlights the potential for economic growth via smart business, m-commerce and the advantages to an integrated environment. The design of *smart cities* where smart architecture and technology are aligned can benefit innovation and work environments.
Industry innovation and infrastructure: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	
Reduced inequalities: Reduce inequality within and among countries	The reduction of inequality within the *smart cities* context is engendered via the principle of non-discriminatory access to services by all citizens.
Sustainable cities and communities: Make cities and human settlements inclusive, safe, resilient and sustainable	Sustainability within *smart cities* is covered within the smart environment theme. This covers environmental aspects, waste management and sustainability of precious natural resources, all of which can benefit from the integration of smart architecture and IS.
Responsible consumption and production: Ensure sustainable consumption and production patterns	The smart environment themes with the increased use of technology to monitor consumption and better plan for future consumption within *smart*

Climate action: Take urgent action to combat climate change and its impacts	*cities*. The sustainable approach to *smart city* services including smart transport infrastructure can help in aligning with working toward climate goals.
Life below water: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	The life below water and life on land goals align with the focus on sustainability within the *smart city* where efficient and sustainable use of resources are designed as part of everyday living and education.
Life on land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	
Peace justice and strong institutions: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	This goal aligns with smart government as well as education within the *smart cities* environment. Citizen access and interaction to government institutions would be better catered for within *smart cities* freeing up scares resources to focus on critical issues and emergencies.
Partnerships for the goals: Strengthen the means of implementation and revitalize the global partnership for sustainable development	*Smart cities* can engender the key aspects of the partnership goal via the linking with other communities at a global level to share innovation and technology to benefit the lives of citizens.

5. Conclusions

This study provides a systematic review of literature based on the IS perspective of *smart cities*. A number of emergent themes have been discussed to improve an understanding of advances in bodies of knowledge on this important topic. The following are a summary of the key observations emerging from this literature review:

- The technological aspects of *Smart cities* have been extensively researched within literature but more recent studies have taken a holistic IS perspective focusing on aspects such as citizens, quality of living and sustainability.
- In reviewing the 104 publications on *smart cities* it was observed that many do not rely on case related empirical data. Studies generally seem to base their results on simulations and in some cases, survey sourced data.
- Majority of the studies were conducted in Spain, USA, India, UK and Italy.
- IoT, cloud computing and Bluetooth are the technologies discussed in relation to *smart cities*.
- The critical notion of integrating smart architecture and IS technology for effective operation of *smart cities* is an accepted consensus within the literature.
- The concept and practice of *smart cities* has the potential to deliver many of the UN's sustainable development goals.

The UN SDGs were aligned with aims of *smart cities* to identify how key themes, emerging technologies and potential benefits to citizens can fulfil the key aims of UN goals. However, there are certain missing aspects in scholars' engagement on *smart cities*, or potential future dimensions that require particular attention, which, if adequately addressed, would further strengthen the UN goals. One major missing link or inadequately addressed issue is the presence of migrants and how their

citizenship-rights could improve the sustainability of cities. Given the acceleration in transnational and inter-state migration, cities are becoming increasingly responsible for their own governance: therefore, fresh research on migration and cities would be most relevant. This is particularly true with respect to the global south as recent trends in global migration show higher scales of south-south global migration.

Another inadequately addressed theme concerns the planning process, either for building the city or for making existing cities smarter. It is important for scholars to address whether a top down approach, a bottom up approach or a combination of both modes of planning would be most appropriate for a particular city. As good governance is closely related to planning with people, often described as decentralized planning, a public engagement with processes involved in the planning would be of great importance. Yet another potential dimension that smart city scholars could engage with are the two inter-related processes that recur within the wider process of building a smart city: the contrived connections between technological and social infrastructure (and other infrastructures such as financial infrastructure) and the lack of adequate flowing connections between technological and social infrastructures, resulting in significant consequences. As countries also began to build institutional organizations such as *smart cities* missions, it is also worth investigating the vision of such initiatives and to what extent the marginalised, women, elderly and differently abled people are included in this larger mission of city improvement (retrofitting), city renewal (redevelopment) and city extension (Greenfield development) in a sustainable manner.

This study has a number of limitations. Only publications indexed with the AJG2018 journal ranking were included in literature analysis and synthesis. The net effect of this is that this study excluded any *smart cities* research published in journals outside the Information Management category of AJG2018. We position these findings as a comprehensive and up-to-date information framework for research on *smart cities* from IS perspective, beneficial for both academics and practitioners.

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