A Systematic Literature Review on The Dimensions of Smart Cities

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Abstract. Smart city represents a new future framework which integrates multiple information and communication technology (ICT), which provides solution to cope with urban challenges and at the same time to improve the quality of life of the citizens. However, it is still an unclear concept with no standardised nomenclature that could be effectively describing itself and lacking in standardised criteria and framework to visualise the concept. This paper aims to review smart city literature to achieve the understandings on the fundamentals of smart city. The research procedure focuses on the dimensions of the smart city. The studies selected from two major databases; Scopus and Science Direct. The selection process involves searching for literature sources and screening and filtering the studies based on titles, abstracts, and full-text reading. Final 28 documents are selected and adopted in this study. Based on the review, it is identified that there are 11 dimensions that contributes to the development of smart cities; smart economy, smart governance, smart people, smart environment, smart infrastructure, smart technology, smart living, smart mobility, smart water and waste, smart security and smart agriculture. Thus, the findings provide insights for scholars researching on the subject, and the parties considering applying them into practice.

1. Introduction
In the recent years, information and communication technology has been widely used in daily activities with the establishment of Internet of Things (IoT) which resulted from the extension of conventional networks that connects zillions of connected devices and it is being incorporated in the urban strategies [1]. This technological advancement is said to be important as it is use to provide solutions to the problems that arise in the cities [2]. Moreover, the use of digital information also covers in other aspects, such as human health, mobility, energy use, education, knowledge transfer and the governance [3-4]. Thus, the concept of smart city, which is the successor of previous concepts (i.e. digital city and intelligent city), was introduced with the rise of information and communication technologies in the urban planning activities [5].

The term smart city has been introduced long since the late 1990s, however only in the mid-2010s where this concept bloomed and being discussed thoroughly, both in industries as well as in literatures [6-7]. This concept was derived from five different aspects, which are the sustainable cities, smart cities, urban ICT, sustainable urban development, sustainability and environmental issues, and urbanization and urban growth [7-8]. Although the concept has been introduced and being discussed since a few years ago, some researchers have agreed that currently there is still no definite definition of the smart city term.
itself [6, 9–12]. Chourabi et al. [13], stated that there is a lack of consistent understanding of the concept among the practitioners and academia.

Smart city is still an unclear concept with no standardised nomenclature that could be effectively describing itself. Furthermore, there is still lacking in standardized criteria and framework that contributes to a smart city, which causes most of the smart cities being developed were based on self-regulated framework. The parties who are involve in the development of the smart cities would not be able to properly deliver the concept of smart city itself without understanding the fundamentals of the concept. Moreover, there is the need to have a standardised framework in order to be used as a guideline for smart city projects in the future. It is important to establish a comprehensive and concise understanding about smart city concept as it serves as a common ground of what smart city is all about. It will facilitate especially the practitioners, policy makers and academia to have better insight of the concept and to ensure that the initiatives being made are in line with the concept as well as to establish better strategies to conduct the initiatives.

Therefore, this study aims to understand the fundamentals of the smart city concept and also to determine the important elements of a smart city. Later, with the determination of the smart city elements, it will aid in the development of a conceptual model where future studies will be able to refer it as a guideline to further understand the concept.

2. Research method

2.1. Research strategy

This study conducted by implementing systematic review of literatures. According to Khan et al. [14], there are five steps in conducting a systematic review. The five steps include; developing research questions; searching for relevant sources of work with establishing inclusion and exclusion criteria; assessing the quality of selected studies; summarizing the data from the studies; and interpreting the results. The systematic review was based from two major databases: Scopus and Science Direct. Science Direct and Scopus are both largest research databases which provides reliable and wide range of topic. The keywords used for the searching were “smart city framework” and the synonyms of the terms including “digital city framework”, “intelligent city framework and “sustainable city framework”.

2.2. Inclusion and exclusion criteria of the articles

Below are the inclusion criteria in selecting the articles being used in the study:

- Studies conducted on the fundamentals of the smart city concept, where they discuss the important elements, such as the definition, the categories and the domains of smart city.
- The article is in an English journal and/or a conference paper.
- The publication period is between 2010 to 2019.

Therefore, this study excluded book chapters and the articles published before 2009.

2.3. Selected studies

The initial round of the article collected through searching databases resulted a total number of 171 documents (i.e. 78 articles from Scopus and 93 articles from Science Direct). Through the filtering process, 8 out of the documents were duplicates and 12 of them being excluded as there were no full access of the documents. Next, after reading the titles and abstract, 57 were excluded due to unrelated topic being discussed and the result becomes 94 articles. After reading these articles, considering which of them provided information about the fundamentals, the domains or frameworks adopted in smart cities, 28 documents were selected for the final analysis.
3. Findings and discussions

3.1. Findings
This section discusses the findings obtained from the review of the 28 journal articles. Through the review, 11 dimensions were determined; smart economy, smart governance, smart people, smart environment, smart infrastructure, smart technology, smart living, smart mobility, smart water and waste, smart security and smart agriculture. Therefore, Table 1 below shows the main dimensions of smart cities and the involved researchers of each dimensions.

Table 1. Dimensions of smart cities.

| Dimensions                  | Researchers Involved |
|-----------------------------|----------------------|
| Smart Economy               | [9], [15–30]         |
| Smart Governance            | [9], [15], [25–34], [16], [35–38], [17–22], [24] |
| Smart People                | [9], [15], [24–31], [33], [34], [16], [35–41], [17–23] |
| Smart Environment           | [9], [15], [26–35], [16], [37], [40–42], [17], [18], [20–22], [24], [25] |
| Smart Infrastructure        | [15], [18], [37], [41], [20], [21], [28], [32–36] |
| Smart Technology            | [15], [18], [19], [21], [25], [28], [34], [35], [38], [39] |
| Smart Living                | [9], [16], [26–31], [33], [17], [18], [20–25] |
| Smart Mobility              | [16], [17], [28–34], [37], [41], [43], [18], [20–24], [26], [27] |
| Smart Water and Waste       | [21], [28], [43]    |
| Smart Security              | [20], [33], [41]    |
| Smart Agriculture           | [18], [34]          |

3.2. Discussions
Smart city concept is said to be one of the urban ideals nowadays in combating various urban challenges. However, since the term was being used a few years ago, it is still ambiguous and there is lack of consensus in defining the term itself. One of the most cited definitions found in the literature is proposed by Caragliu, A., Del Bo, C., and Nijkamp [44], where it stated that a city is considered ‘smart’ “when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance”. Budhiputra and Putra [33] explains a city can be acknowledge as a smart city if it is “capable of operating flawlessly as time goes in the aspects of economy, citizenships, governance, mobility, natural surroundings and living in general which built upon a smart combination between the said aspects which will develop an independent citizen individuals”. Most of the understandings could be viewed delivering the idea where innovation and advanced ICT are used in an established systems of network which are interrelated and it enables the city to control and monitor the available resources sustainably and efficiently, in order to improve the economic growth as well as the societal outcomes.

The result from the literature conducted in this paper pointed out that there are 11 dimensions that constitutes to smart cities. From the review, it was seen that, most of the authors had adopted the smart city framework developed by Giffinger et al. [45], in which it demonstrates 6 main dimension; smart economy, smart people, smart governance, smart mobility, smart environment and smart living. Out of the 28 articles, 10 of them has adopted the framework [16-17, 22–24, 26-27, 29–31]. Through this, the mentioned 6 dimensions are frequently cited in literatures to be some of the main dimensions that make up a smart city.
Smart economy is listed as one of the main domains in smart city frameworks. Lu, Chen and Yu [22] explains that entrepreneurship and innovation are important contributor in developing new products and services in which it enhances the productivity while at the same time it they influence the economic growth to increase the competitiveness. In taking consideration of the framework developed by Giffinger et al. [45], under the smart economic dimension, it explains that the factors that contribute to a smart economic including innovative spirit, entrepreneurship, economic image and trademarks, productivity, flexibility of labour market and international embeddedness. Thus, economic here can be seen in three perspectives in which the productions and innovations influences the economic growth, the smart city itself as an economic driver and also the economics behind the smart cities.

In terms of smart people, it emphasizes on building a lifelong learning environment for the people through ICT facilities and innovation [22, 27]. Here, smart cities is considered as a center of higher education and better-educated individuals and this influences the development of new creative culture which could extend to economic performance and social tolerance [46]. In the context of global knowledge economy, a smart city would have smart people who possessed skill in information and economy. Having a smart people dimension in the framework is important as it aims to improve the way of life, to increase human capital, increase the human development index, ensures that people are highly flexible and resilient to the changing circumstances [22, 24-25, 45].

Smart governance is the foundation towards smart, open and participatory platform which supports the collaboration in between the government and the stakeholders and citizens [47]. It is important as smart governance offers political participations, as well as providing services and having the role as the administration [19, 24, 27, 35]. Moreover, the laws or policy created and approved will be served as a guideline that covers different aspects such as the ethics that govern the social relation, legal instruments and also standards [35]. Giffinger et al. [45] suggested in the framework that smart governance should also involve a transparent governance in which it means that the government should act openly and with the citizen’s knowledge of the decisions being done.

Meanwhile, another prominent smart city dimension is the smart mobility. Smart mobility involves a few elements, including the transportation infrastructure, the transportation management and the integration of ICT in the systems [25]. According to Glasco [48], there are a few examples of solutions that contributes to smart mobility, this includes, (1) mobility as service in which this means the use a single interface in the media to be the platform that offers various modes of transportation services to the public; (2) sustainable travel behaviour where it increases the public awareness on supporting clean-energy transport use such as switching to cycling or public transport; (3) intelligent traffic management which provides decision in solving the problems related to the traffic. Thus, with these provided solutions, it ensures that the city will be able to provide smart services and also to improve the user experience.

The smart environment here represents the way of preserving the natural resources. This could be described by the attractive natural condition, reduced rate of pollution, environmental protection and sustainable resources management [45]. Aleta, Alonso and Ruiz [49], explains that smart environment involves the way of managing the resources and the prevention from exploiting them. For example, it involves the use of renewable energy, the implementation of smart grid, the management of pollution control as well as green urban management. While, as for smart living, it generally emphasizing on improving the quality of life of the residents. There are a few elements here that contributes to the smart living concept, including enhancing the social cohesion in which this means the willingness of the community members to cooperate with each other; the social equity; preserving the culture and heritage; maintaining the livelihood and also to provide convenience to the people [25].

This study has identified another 5 dimensions which are frequently cited in the literature and found to be important dimensions of smart cities. Smart infrastructure pointed out as one of the dimension. It explains on the importance in managing the built environment [17-18, 35]. Here, it ensures that the facilities being constructed in the city are practicing sustainable construction and operation in which in improves the quality of life of the occupants while at the same time involves the embedding of smart technologies in the infrastructure which enables data integration for decision making for the asset management [47].
While, smart technology dimension focuses on the digital infrastructure of the system. Achmad [9] explains that two elements which contributes to digital infrastructure which are the ICT infrastructure and ICT infostructure. The ICT infrastructure is important as it serves as instrumentation and monitoring systems which are related to the technology, tools and advanced ICT and also it is important to establish network infrastructure which associates the network and connectivity, internet broadband and network infrastructure. ICT infostructure however, is the platform that interrelated to open and integrated operating systems, virtual technologies and information systems architecture and also it is related to the real-time data management [9].

Smart water and waste was being listed as dimension by Ahvenniemi et al. [28], Silva, Khan and Han [43] and Allam and Dhunny [20]. This dimension is important as it involves the management of supplying clean water to the consumers and stormwater management. It is important for a city to have proper water distribution and management system which being equipped with monitory and networked systems to obtain information on the performance of the system [50]. While for the waste aspects, there are a few elements that should be taken into consideration while managing them, this includes the stages of collection, transport and the treatment [51]. Esmaeilian et al. [52] stated that there a need to have new form of waste collection and treatment which it should benefit from the use of intelligent and sensor-based infrastructure for proper separation and on-time collection of waste.

Smart security is being taken into account nowadays, as it could strengthen the public security and welfare by implementing integrated safety and security systems for the public [47]. The public safety is important and some of the solutions smart city could offer is by implementing advanced and secure video, sensor and communication systems to efficiently monitor public spaces and communities can benefit from increased trust in the law enforcement [53]. Lastly, as for smart agriculture, it is dimension which being discussed the least, but it has an important point that should be taken into consideration in smart cities planning today. Smart agriculture integrates the use of advanced ICT within the agricultural fields such as the use of precision equipment, IoT, sensor devices, geographic positioning systems, data collection method as well as the use of robotic devices [54]. With inclusion of technological aspect in the agriculture, it is expected that it could help in boosting the yield to meet up the growing demand from the public [47].

4. Conclusion
The review of literature conducted in this paper help to further understands the concept. Thus, in general, the smart city concept could be understood as a city that manages through information and communication technologies of the human and social capital while at the same time ensures the resources are being used wisely and having a systematic governance system and infrastructures which could support economic growth in order to enhance the quality of life of its inhabitants. Through establishing smart city, it could help to cope with urban challenges such as the exploitation of resources, climatic changes, increased in traffic congestions, inequality issues, lack of affordable housing and many more challenges [13]. Therefore, many parties have move towards to transform more cities to become smart cities. However, it is important to establish the indicators or dimensions that could be used as the guideline or benchmark which suits the smart city framework for each cases. Thus, through this study, 11 dimensions has been identified which have taken consideration in utilizing new technologies in providing solutions, adapting the environmental problem in the planning as well as having ability to meet the people’s need. With the identified dimensions, it will be able to support the existing framework and contributes to guide future study, especially for developing countries towards guiding the development of smart cities with focusing on the factors that could transform them into smarter cities.

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