

The Contextual Mapping of Smart City Characteristics with their Dimensions through Content Analysis Method

Hemalata Vasudavan
School of Graduate Studies
University Tenaga Nasional, UNITEN
Kajang, Malaysia
hemalata6@gmail.com

Saraswaty Shamini Gunasekaran
Department of Graphics & Multimedia
University Tenaga Nasional, UNITEN
Kajang, Malaysia
SShamini@uniten.edu.my

Salama A Mostafa
Faculty of Computer Science and
Information technology
Universiti Tun Hussein Onn Malaysia
Johor, Malaysia
salama@uthm.edu.my

Jaspaljeet Singh Dhillon
Department of Informatics
University Tenaga Nasional, UNITEN
Kajang, Malaysia
jaspaljeet@uniten.edu.my

Kok Hua Chua
Department of Civil Engineering
University Tenaga Nasional, UNITEN
Kajang, Malaysia
Ckh@uniten.edu.my

Abstract—Transformation of city into a Smart City is multifaceted which involve dynamic processes and various stakeholders work together to accomplish strategic aims. A working definition of a smart city is produced by analyzing the common components available in the existing smart city definitions. A set of popular smart city characteristics and dimensions for initiating smart city development is identified by a reviewing current literature articles. The identified smart city characteristics are mapped with the respective smart city dimensions of smart governance, smart mobility, smart living, smart people and smart environment. The contextual mapping offers a strategic ideologies aligning the five smart city characteristics (sustainability, livability, technology, governance and urban aspects) with the dimensions for drawing more insights towards studying smart city success factors.

Keywords—dimensions, characteristics, smart governance, sustainability, smart city.

I. INTRODUCTION

The United Nations predicted that more than 60 percent of the world population will be living in cities by 2030, mostly in Asia and Africa due to rapid urbanization. [1]. The process of urbanization involves the migration of people from rural to urban areas to improve living standard in terms of job opportunity, mobility, sanitation, safety and eco-friendly environment [2]. However, the growing population in the city, tend to face many difficulty such as traffic congestion, air pollution, climate change, inadequate resources and poor governance of infrastructure. Therefore, it is important for the city government, policy makers and experts from academia to adopt a strategy to tackle urbanization issues in order to cater citizens with a safe and sustainable living standards [2, 3]. The concept of smart city is an urban strategy adopted globally to convalescent the living standard of citizens in urban areas [3, 4, 5]. The term ‘smart city’ add more value by using Smart Computing to provide core services to citizens in

an innovative and efficient ways [6]. Smart Computing describes the integration of computing tools and networking technology that deliver citizens with agile real time city’s environment system and deep analytics to make intelligent decisions regarding cities core services. The core services consist of citizen’s basic necessities for water, resources, energy, government activity, health care and public safety [5]. Hence, adopting a smart city initiatives will resolve challenges from the rapid urbanization process as well as for supporting resilient urban development [7]. Information technology is an enabler factor for smart city to sense, examine and integrate all important information in a city’s infrastructure and growth. The research on smart city is a popular topic among many scholars, firms, IT vendors, and government around the globe because the volume of published articles related to smart city has been tremendously growing to date [7, 8]. Nevertheless, different scholarly articles contribute different definition and also various conceptual overview of a smart city [9, 10]. This is because various cities transformed differently in the process of urbanization depending on the city’s location, soil, weather, cultivation, natural resources and socioeconomic structure [11]. Many smart city initiatives around the globe shows different implementation strategies [11, 13]. As cities evolve over a long period of process that each city can find its own strategy to become smarter assuming cities have different stage of smartness as some cities are more advanced and others are still in the initial stage towards this trajectory transformation [13, 14, 15]. To implement a common smart city definition, characteristics and dimensions the researcher need to study various conceptual relations of smart city and distinguish the terms popularly used.

The following sections of this paper are structured as follows: section 2 explains the research objectives, followed by

section 3 describes the research model, section 4 provides related work discussion of the smart city definition, characteristics and dimensions, followed by contextual mapping of smart city characteristics with the dimensions in section 5, while section 6 consist of conclusions and future work.

II. RESEARCH OBJECTIVES

The research objectives consist of:-

1. To identify commonly used smart city characteristics and dimensions through systematic review.
2. To align ideologies of smart city characteristics with the dimensions through contextual map.

III. RESEARCH METHODOLOGY

A content analysis method is adopted for the purpose of this research. The authors performed an independent and detailed literature wide study to obtain desired outcomes. Firstly, a working definition of smart city definition is raised by studying regularly used key components in the existing smart city definitions. Next, some commonly cited smart city characteristics and dimensions are discussed to give a general view to the reader. The literature identifies five commonly cited smart city characteristics and six regularly cited dimensions [18]. In this study, each of the smart city characteristics are contextually mapped with the smart city dimensions to understand the elements that shape up the smart city initiatives. And their implementation.

IV. THEORETICAL BACKGROUND

A. Smart city definition

The existing literature studies reveals that smart city concept comprehend different social, economic, urban, institutional, technological and environmental aspects in an exceedingly general approach [11]. The idea of smart city is still emerging and many working definitions proposed to date by smart city experts. The smart city definition is diversified with some cohesive components exist in the respective definitions. One of the common components in the definition is technology because many cities acknowledging their city as smart by incorporating ICTs in delivering city services [19]. The definitions also emphasizes on critical infrastructure such as physical infrastructure and network infrastructure as the devices in the city has to be inter-connected to deliver a cohesive output [20]. Providing a quality services to the population is the next most regularly mentioned component [10]. Many authors have also defined integration of systems and infrastructure interconnection is an important characteristic of a city to be called smart [21, 22]. In some of the definitions, the use of networked infrastructure plays a role to cater social, environmental, economic and cultural development [15]. There are several authors envisioning a smart city as a well performing city in a forward looking manner and a city that gives inspiration [22]. Lastly, several definitions mentions a better vision and future for city development, although in a different form [23]. The initial review of smart city definitions reveals many related phrases and terms, it is apparent that many refer to the same or very similar situation but within the context of the authors proposing research area and setting. Interestingly, what

different authors realize and digest the term of smart city is significant and important in this research field. Table 1 illustrated the principal ideas and similar component identified in the existing smart city definitions. The Table 1 shows conceptual variances and similar components used in most of the definitions is a clear indication for a more integrated, specific and clear understanding of smart city is essential. [13]. The important aspect in a smart city is the citizens. Catering citizen's needs is vital component in the smart city definitions [19]. Besides that, technology implementation only does not guarantee the success of smart city implementation and technology is an enabler component for smart city [8]. Importantly, is to use technology or smart computing to create quality public value that benefits the people. In this research, the authors have reviewed many articles of smart city definitions and some of the widely used smart city definition is illustrated. The definition review also identifies some of the collective components appear across the smart city definitions.

TABLE I. Commonly cited definitions of smart city

Smart City Definitions	Key Component
1. "We believe a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure, fuel sustainable, economic growth and a high quality of life, with a wise management of natural resources, through participatory governance." [20]	*People *Technology *Infrastructure *Economy *Quality of Life *Governance
2. "Smart cities are all urban settlements that make a conscious effort to capitalize on the new Information and Communications Technology (ICT) landscape in a strategic way, seeking to achieve prosperity, effectiveness and competitiveness on multiple socio-economic levels." [11]	*Technology *Social *Economy *Urban *Strategy
3. "Smart Cities have to consider a global vision to develop and implement a set of policy-mechanisms through an alternative institutional governance model to change this scenario." [23]	*Vision *Mission *Governance
4. "A Smart City is a well-defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development" [12]	*Technology *Social *Economy *People *Urban *Governance *Eco-friendly
5. "Smart City concept goes beyond the focus of ICT vendors on digitalization, and also takes into consideration some of the aspects that are related to soft components that have crucial importance on the urban, social and economic development of a city, such as human capital". [8]	*Technology *Social *Economy *People *Urban *Sustainability
6. "The smart city concept is no longer limited to the diffusion of ICT, but it looks at people and community needs. People are the protagonists of a smart city, who shape it through continuous interactions and the community of a smart city needs to feel the desire to participate and promote a (smart) growth." [10]	*Technology *People *Sustainability *Growth *Quality of Life

7. "Smart cities are not only an aggregation or a merger of some applications, they represent a new cultural idea of cities. Technology is a driver, a facilitator for the city development, but if there is not a strategy and a purpose that technology must follow, the risk is disorder." [21]	*Technology *Integration *Strategy *Culture
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The similar component in smart city definitions are: governance, people, integration, technology, eco-friendly environment, urban, quality of life and sustainability. Therefore, the smart city definition should contain necessary components that build and understand the concept [24]. For the purpose of this research, a working definition for a smart city can be defined as:

"The notion of smart city embraces quality of life, eco-friendly environment and sustainability by using smart technologies in order to integrate the city's core services to provide flexible urban infrastructure and connected governance model."

B. Smart city characteristics and dimensions

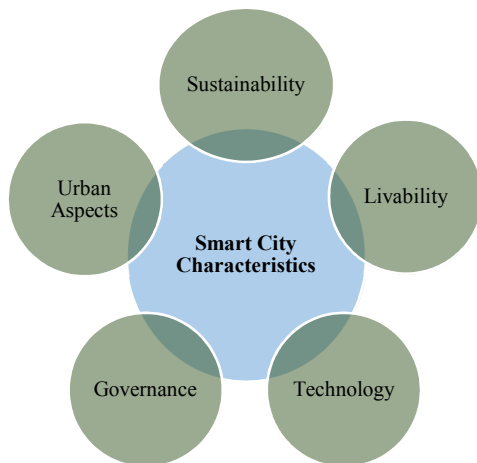


FIGURE 1. SMART CITY CHARACTERISTICS [18]

The literature study on the definitions indicated it is essential to approach the smart city from a complete view to appreciate and understand the characteristics of a smart city [7, 11]. Within this structure, smart city is a conceptual urban structural model consist of people, technology, infrastructures, policy, strategy and governance that lead to its development in urban agglomerations [14]. The smart city initiatives enable an ideal city implementation for an urban community. However, the unprecedented information on smart city concept is a major constraint in deriving smart city characteristics. This research has tackled the constraint because a smart city characteristics would visualize the opportunities and guidelines for smart city policy makers. The content analysis of the available literature were analyzed to derive the most cited smart city characteristics. Figure 1, shows the commonly cited characteristics of the smart city. The characteristics of a smart city consist of: sustainability, livability, technology, governance and urban aspects [18]. The characteristics of sustainability explains the conduct of economic and social development without disturbing the

surrounding environment. The viable development in the city can be classified into social, economic and environmental sustainability. This would be preserving the city's environments by reducing carbon footprints, sustaining water and energy, managing adequate food supplies and maintaining cities ecosystem. The second characteristics of livability explains the ability to establish communication channel for the citizens to interact with another citizens, government, organization and community to cater possible opportunity to play an active role in smart city implementation. The livability also relates to citizens emotional, social, financial strength and wellbeing that attributes to citizens quality of life living in a smart city environment. The technology characteristics denote the usage of smart computing, embedded in the city's structure to provide creative and innovate applications. The smartness in the computing architecture is to provide a new way of integrated hardware, software and network technologies that can display real time systems and proven analytics that can help firms, organization and businesses to make intelligent decisions to improve business processes that will increase profitability and productivity. Technology is an enabler for smart city developments that could integrate the functional administration in the city by using ICTs. The role is the ability of the local government adopting ICTs to transform into e-government to provide efficient services to citizens to improve their quality of life. A proper governance is essential in managing smart city projects by leading administration rules, laws, practices, government activities and delivery of product or services in the city. The capability of government or professional bodies to administer policies, strategies and to integrate other functional characteristic that unify the smart city projects. Urban aspects relates to a city's environmental backgrounds from the aspects of social, political, economic, cultural, landscape and demographic. This is because different cities around the globe is unique in terms of their environmental nature and socio-economic features. The urban aspects of a city varies and a clear smart city strategy should be adopted that is suitable in terms of city's environmental context.

TABLE II. SMART CITY DIMENSIONS [18]

Smart City Dimensions	
Smart Governance - Public Policy - Citizen centric - Electronic Admiration	Smart Mobility - Energy efficient Vehicle - Mixed Modal Transit - Connected Automobile
Smart Living - Healthy - Safe urban space - Peaceful and happy lifestyle	Smart People - Digitally enabled learning - Creative and Innovative - Computing Skills
Smart Environment - Green Environment - Green Energy - Ecological	Smart Economy - Innovative Entrepreneurships - Globally connected business - Productivity growth

The smart city dimensions consist of diverse views that build up the growth of smart cities [13]. The combination of different dimensions of smart city will enhance the smartness of a city [11]. Table 3, shows the six dimensions that are

constantly cited in literature studies. The six dimensions presented in Table 3 are: Smart Government, Smart Mobility, Smart Living, Smart People, Smart Environment and Smart Economy [18]. The smart governance is the connection of services in the city enabled by ICTs. This is to link public, private and civil organization so that city can function efficiently in implementing and managing smart city initiatives under a unified model. The next dimension of smart mobility provides safe, sustainable and interconnected transportation system in the city. Smart Living caters a happy, healthy and safe living in an ICT enabled city to improve living standard. Smart People dimension is citizens with adequate computing knowledge, able to adapt to technological advancement, having access to education and able to work in the ICT enabled environment. The smart environment consists of smart energy, smart grid, pollution control and monitoring, green building and to create a healthy environment for the people. Smart economy cater e-business and e-commerce and to increase productivity by using smart computing in manufacturing to innovate product and services.

TABLE III. MAPPING OF SMART CITY CHARACTERISTICS WITH THE DIMENSIONS

Smart Governance	
Characteristics	Dimensions
<i>Sustainability</i>	To maintain a proper partnership and to create a reliable city services [2].
<i>Livability</i>	Enable open data, citizens can participate in decision making and co-create services [4].
<i>Technology</i>	Cater smart processes and interoperability to link city services with network structure [9].
<i>Governance</i>	To link public and private organization to operate efficiently under a unified model [11].
<i>Urban Aspects</i>	To oversee the security aspects in the open government and citizens data [1].
Smart Mobility	
<i>Sustainability</i>	Priority on modes of transport that is clean, safe and to reduce pollution [2].
<i>Livability</i>	Access to real time application to commute efficiently and to save cost [4].
<i>Technology</i>	ICT enabled and interconnected transport system with real time data [25].
<i>Governance</i>	To create policy and options on non-motorized transport to reduce pollution [9].
<i>Urban Aspects</i>	To analyze mobility congestion and to secure real time transportation data [26].
Smart Living	
<i>Sustainability</i>	To improve living standard by maintaining social cohesion and social capital [17].
<i>Livability</i>	Attribute of healthy and safe living in a culturally vibrant city [19].
<i>Technology</i>	ICT-enabled lifestyle and use digital devices to perform activity efficiently [27].
<i>Governance</i>	To authorize policy to improve living standard to cater quality lifestyle [28].
<i>Urban Aspects</i>	Incorporates good quality housing and space to large pool of population [11].
Smart People	
<i>Sustainability</i>	To provide access to e-skills, education, training, resources and ICT-enabled job [28].
<i>Livability</i>	To enable people to use ICT to learn, manipulate and personalize data [29].
<i>Technology</i>	To cater access to data analytics tools and dashboards to make relevant decisions [6].
<i>Governance</i>	To formalize ICT based education and to create awareness on knowledge on ICT [30].
<i>Urban Aspects</i>	Participation of citizens in public life [26].
Smart Environment	

<i>Sustainability</i>	To efficiently use natural resources and create renewable energy [29].
<i>Livability</i>	To cater citizens with eco-friendly space and control on pollution [30].
<i>Technology</i>	To monitor pollution index and ICT enabled energy grids [21].
<i>Governance</i>	To govern urban services to improve water and air quality [31].
<i>Urban Aspects</i>	To create urban services of street lighting and waste management [31].
Smart Economy	
<i>Sustainability</i>	To increase productivity, maintain market demand for new products and services [32].
<i>Livability</i>	To create job opportunity by involving in digital business [17].
<i>Technology</i>	ICT enabled innovation on new product, services and business models -e-business [5].
<i>Governance</i>	Strategize local and global business market to improve flows of goods & services [33].
<i>Urban Aspects</i>	To encourage digital business and entrepreneurship [34].

V. CONTEXTUAL MAPPING OF SMART CITY CHARACTERISTICS TO THE DIMENSIONS

The planning of smart city is an inevitable process and the current studies shows there is no full-fledged development of a smart city yet [16, 17]. The smart city environment is shaped based on city's priorities, characteristics, dimensions, local authorities, citizen's needs, global market demand and available ICT infrastructure. This paper has made a comprehensive study to cater ideologies of common smart city characteristics and dimensions that are crucial to understand smart city initiatives and projects. Table III, shows the mapping of each smart city characteristics with the respective smart city dimensions to display the inter-relationship between characteristics and dimensions. For instance, the characteristics of sustainability is mapped with each of the smart city dimensions to understand the purpose or role of this characteristics as a contributing factor in starting a smart city initiatives. The role of sustainability in the first dimension of smart governance is to administer policy that will grant economic stability, by establishing partnership and proven business models. This will lead to economic sustainability by improving business, capital and city infrastructures. As described in many scholarly articles, smart city involve multi-dimensional components with complex ecosystems and all these components have to work together for a successful implementation of smart city. The purpose of each smart city characteristics can be enforced as a basis to evaluate importance towards smart city dimensions implementation. In addition, this smart city characteristics and dimensions mapping can be used by policy makers, smart city experts and academicians to study and define success factors of smart city initiatives.

VI. CONCLUSION

The idea of smart city emerges to address challenges imposed by rapid urbanization. Smart city is the key to create a sustainable city that provide quality of life to the citizens. It is important to explore and critically study the concept of smart city in order to strategically implement this moves into city's infrastructure and service operations. In this research a working definition of smart city is identified to realize the critical components that shape up a smart city. Along the way,

the common smart city characteristics and dimensions are contextually mapped to understand the interrelationships within the scope of each dimensions. The importance of each characteristics can be further evaluated to comprehend smart city success factors.

FUTURE WORK

This research will continue by doing more in depth mapping of smart city characteristics with the dimensions by using statistical approach to find the impact factors of each characteristics that plays a major role in developing smart city.

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