CHAPTER 7: Urban Data Science for Smart Settlements

Abstract

This chapter seeks to explore and discuss how urban data and science can be used in the development of smart cities. The background of the argument emanates from the observation that in recent years, the development of smart cities has proven to be the best solution in dealing with different problems faced by urban areas. Indeed, missing in the literature is the analysis that how can urban data be useful in the development of smart cities and how can it be implemented together with scientific methods that can be used to develop and manage smart cities throughout the universe. There is a void that needs to be filled as previous studies on the development of smart cities have left out the necessity of using urban data and science that is explored by this chapter. Both qualitative and quantitative methods were used to extract information used to compile this chapter. Results indicate that the use of urban data and science can bring quick and more sustainable smart cities throughout the whole components of the urban structure.

INTRODUCTION

In recent years, the world has developed the idea of smart cities that has far been implemented in the developed countries in Europe, Asia and some parts of the United States of America. It is noted that the development of smart cities takes different strategies with regards to the city and the available problems to be addressed. This chapter, therefore, seeks to explain the question of how urban data and science can be useful in the development of smart urban settlements that are known as smart cities (Kurcheeva and Klochkov, 2019). It also unveils the type of data that is regarded as urban data, also known as urban informatics, and how it is extracted and what scientific methods can be applied in the development of these cities. There are four categories of urban data that Space Syntax (2018) puts forward: the data concerning the people, urban form, resources and the environment. The study intends to fill the gap that exists in the techniques used in the development of smart cities as many policies, theories and strategies have been put forward but little attention has been raised in how urban data and science can be useful in the creation of these cities around the world.

Recent studies were used to dig the information used in this study with several research methods such as data mining, triangulation, among others. Secondary and tertiary data were been gathered to justify the problem that is intended to be solved in this chapter. The results indicate the cruciality of urban data in the development of smart settlements as it exposes all the dimensions of the urban sphere that needs attention and to be resolved for the successful implementation of this idea. Conclusively it can be said that urban data form the basis of smart settlements as there is so much information contained in it that can be used to develop and manage smart settlements around urban areas.

BACKGROUND OF THE STUDY

The development of smart cities has been a result of adverse circumstances faced by cities, including the rise of urbanisation, environmental issues and resource management in these urban areas. It is argued that smart settlements are oriented to solve specific problems of an urban area and these strategies differ from one city to the other due to the differences in the problems being solved, hence there is no single technique in the creation of smart settlements worldwide. Though there are policies and strategies that have been used before, not every one of them suits all situations. Rumi (2016) affirms this discovery, explaining that the development of smart settlements is meant to formulate and apply smart resolutions to the various problems faced by urban areas such as service delivery, provision of shelter and environmental stewardship as implemented in India. It is believed that the development of smart cities is one of the strategies that has gained popularity in recent years as it is used to resolve the structure and outlook of the city and innovating it with new technologies.

Smart cities are identified as all urban settlements that make a conscious effort to capitalise on the new Information and Communication Technologies (ICTs) landscape strategic ways that aim for environmental sustainability, quality of life of urban dwellers, urban system functionality, community-driven developments and knowledge-based developments (Angelidou, 2014). In this case, smart cities are places where innovation into new smart technology and the participation of the people is advocated for with the effort of increasing the educational standards of the city's citizens, protection of the natural environment and the provision of quality services. It is also defined as

a city with smart people, smart living, environment, economy, government and mobility (Anthropolous and Vakali, 2012). This implies that for a city to be identified as smart, all its characteristics should be standard. A smart city is also regarded as an urban setup with smart inhabitants who are well educated and full of information technology (Giffinger *et al.*, 2007).

The smart settlement has been described as a settlement that is convenient for the life of the population. As observed by Giffinger *et al.* (2007), the phrase “smart city” does not have a distinct meaning but its definition varies with different circumstances. Therefore, the idea of smart settlements should be an overall view of that particular settlement where the focus is on all aspects that formulate that settlement. Worldwide the idea of smart cities is still new and fresh with lots of strategies being put in place to formulate and define what is the basic outlook of a smart city. It is acknowledged that there have been efforts to create smart settlement throughout the world using different strategies as said above.

CONCEPT FRAMEWORK

The notion of smart settlements has gained massive popularity, especially in developed countries, where it has been implemented. From previous studies, it has been discovered that smart settlements have been created using several strategies and policies put in front of different planning authorities, stakeholders and governments. Some of these strategies include strategic planning. Urban data are defined as a resource that is the basis for an informed decision in daily administrative business on optimising urban processes, the usage of urban resources in strategic decisions on urban development (Lammel, Scieferdecker and Tcholtchev, 2016). It is in understanding urban data that the development of smart cities is effective because it is the tool for the decision-making process. Data management is the crust of smart cities.

The purpose of this study is to explore and discuss the usefulness of urban data and science in the development of smart urban settlements. It seeks to fill the gap that exists between previous studies with regards to the information that can be used to formulate techniques and strategies be used in the development of smart cities in both the developing and developed countries that is more suitable in all circumstances. The use of data, though has been applied before, using

GIS for instance in the City of Ayang in Korea where it has been used to identify dangerous and accidents prone zones that have been used to create safety maps for the citizens. Urban data are an important data type that is vital in all spheres of urban development. This chapter sought to reveal how each type of urban data and science can contribute to the development of policies, strategies and other decisions to be followed in developing smart settlements in urban areas throughout the whole universe. In the precedent studies, it is noted that much focus was on the development of information and technology. This study also seeks to explain the connection that exists between urban data and science together with urban development. Therefore, the development of smart settlements is linked to urban data and science since it provides basic knowledge on the ground that guides the policies and strategies employed in the development.

There is no agreed definition of smart settlement (Dhingra and Chattopaudhayay, 2016). Therefore, this chapter describes the smart settlements as the urban living space produced through the analysis of existing urban data and science that is the core information to development and management as it simply unveils the lagging and well-developed areas of the settlement. Therefore, urban data helps find a conclusion on how to reach the expected indicators of smart settlements and the way to develop and manage these settlements.

THEORIES UNDERPINNING THE STUDY

There are several theories related to this study. A theory, by definition, is a model used to represent a real-world phenomenon. Theories linked to this study are the theory of organisation, a theory of communication, a theory of spatial functionality, a theory of modernisation and a theory of connectedness.

THEORY OF ORGANISATION

This theory is used to study organisational behaviour and has four schools of thought (Lydman, 2001). One of the schools of thought developed by Taylor (1880), suggests a framework for improving labour efficiency and production. It sees human beings as machines that deliver the outputs which are Scientific Management. As observed by this school, human beings were meant to be efficient and productive. This was dismissed due to its lack of consideration for humans. Another school of thought is the Administrative Theory in which a top-down approach to the organisation is advocated for the

success of the organisation (Krenn, 2017). Taylor developed this theory and argues that this hierarchy will result in quality management of the organisation. The third school of thought is the Bureaucratic Management Theory by Weber which describes how organisations can become ideal bureaucratic entities (*New World Encyclopedia*, 2017). In this case, the theory applies to both the private and public sectors in their operations. The last school of thought is the Administrative Behaviour put forward by Herbert Simon. This theory argues how organisations can move on in the direction of their goals with multitudes of decision-makers.

The Theory of Organisation clarifies how organisations operate daily. This theory has been used in many organisations to assess the relationship between co-workers and to analyse the direction the organisation is taking in delivering its outcomes. Though this theory reveals the way the organisation operates, it still lacks an explanation of how different organisations are linked to other organisations operating around them and their connection with the real world, the environment and the society in which they are operating. It is imperative to formulate a path in which the organisation theory addresses the issue of how it is connected with other factors around it and how it can be used in addressing the development of smart settlements throughout the whole universe. This theory is related to this study in a way that it analyses and explains how different organisations are working towards development through its hierarchy and other factors that are considered in them, hence the information contained in these organisation can be used in the development of smart settlements as the theory equips directors of different organisations with ideas that lead to sustainability, thus the smart operation of the organisation and the city at large.

THEORY OF COMMUNICATION

The Theory of Communication helps in the understanding of how things look like in the real world of communication. Communication describes a process by which people interactively create, sustain and manage to mean (Conrad and Poole, 1998). This theory is used to clarify, observe, predict communication behaviour and generate both social and personal change. This theory has been implemented in a business organisation to study the communication patterns within the organisation and with the outside world in making better communication decisions. The theory is applicable in the development

of smart settlements in the real world as communication is a key factor used in the implementation of strategies and their formulation.

THEORY OF CONNECTEDNESS

The concept of connectedness is characterised as a sense of keeping in touch, being involved and updated with others within ongoing social relationships (Romero, Markopoulos, Baren, Ijsselsteijn, 2007). It is a sense of having company, a feeling of belonging. This theory argues that everyone is an individual, but every person is also connected to others and his or her environment. It focuses on things that bind people together in time and space. Connectedness is experienced in three ways, which are physical connection, emotional connection and cognitive connection. Superable (2014) used this theory in her study to investigate the effects of digital and non-digital forms of social connection on senior citizens. It has been discovered that connectedness is very crucial in human life both face to face or via social networks. The theory of connectedness has been used in the field of communication to understand how people relate to one another. It can be argued that understanding the Theory of Connectedness is beneficial to the creation of smart settlements as the connection is one of the key factors that determine the smartness of a city.

The use of smart technologies to connect with people from different parts of the world is a fundamental to smart settlements. This connection can not only be linked to different individuals but also the connection of different businesses and other economic sectors, leading to the development of an urban area. This connection is crucial in bringing together people's ideas expeditiously, thus prompting quick responses and decision-making. In some scenarios, lack of vibrant technology such as access to the internet, emails and other social media platforms, limits the connection of people mostly in the developing world where internet data are still expensive. The Theory of Connectedness is a key factor to this study as we understand that the successful collection and management of urban data are through the connections that exist between people of different sectors within an urban sphere as it allows for the compiling and proper management of information as there are frequent updates. Therefore, it can be noted that the Theory of Connectedness does not apply only in casual connections, but is also a main player in the gathering and preparation

of urban data used in the analysis and development of urban smart settlements in both developed and developing countries.

THEORY OF MODERNISATION

The Theory of Modernisation explains how an economy grows over time, going through a number of different stages. It is believed that it explains the development of societies. This theory was put forward by Rostow (1960) who believed that for modernisation to be realised, the economy starts as a traditional society in which the community relies more on agriculture in which technology is far backward. The second stage is the precondition to take-off stage, where the conditions for this are met through appreciation of technology and the development of surrounding societies using different techniques and innovations. The third is the take-off stage which breaks the bridges that act as barriers to the modernisation of the society and its economy due to new investments and innovative technology. The following stage is the drive to maturity in which the economy starts to flourish and older industries fade and are replaced with new industries. The last phase is the age high mass consumption and at this stage, the development is at its full capacity.

As observed by this theory, for full development to be attained, it is imperative to go through all the stages laid down in this concept, following each stage as it is, up top. This theory has been used to determine the development of regions and also in the field of planning, for instance, in the development of the African continent. However, the theory is more Western, suiting the developed world, hence some of the facts laid in it do not apply in the African context. This theory is ideal for the development of smart settlements. Because of its nature, explains the stages which an area goes through for it to be well developed. Apart from that, the theory does not explain how these stages are reached and how development takes place in them. Tracing this theory's stages is of great value as they are linked to a certain city in which smart development is to be implemented. This helps in indicating the stage in which the city is and hence the formulation of the steps to be taken to reach the ultimate goal.

NOTE: TEXT **ON THEORY OF FUNCTIONALITY** IS MISSING

EVOLUTION OF SMART CITIES

The origin of smart settlements is linked to the development of ICT in most developed countries that were later implemented in urban space (Anthropolous and Vakali 2012).

LITERATURE REVIEW

On a global scale, the development of smart settlements in many developed countries has been through smart cities. The idea of creating smart settlements has been adopted by the European Union Ten-Year Strategic Plan of 2010 to 2020. It has been noticed that the European Union has developed a partnership in the implementation of smart cities through the European Union Partnership (United Nation Economic Commission for Europe 2014-2015). It is noted that in Europe, the use of development sustainable goals, indicators as the guideline for the development of smart cities, was effective during the housing development project that was set to bring about smart settlements (UNECE, 2015). Austria adopted the smart cities development programme to eliminate the causes and effects of climate change, thereby developing clean energy provision, resulting in smart environments (Backhouse, Karuri-Sebina and Guya, 2020). It is noted that the European Union, through the program has managed to set its smart settlement goals by tuning into background data to guide them produce their research guidelines.

In Asia, this idea has also been adopted by Singapore, China and India. In India and China, national plans were introduced as strategies to guide the development of smart urban areas with the aid of industrial policies put in place by the governments (Vu and Hartley, 2018). India as a country has launched a Smart Cities Mission that ran from 2015 to 2020 in that the selection and development of cities have been done to reach this goal of urban smart settlements (Aijaz, 2016). Dhingra and Chattopaudhayay (2016) argue that the idea of smart settlements was done in India by first studying and analysing the environmental, social and economic planning paradigms of the old cities within the country. It is noted that some cities in the United States of America have welcomed the idea of smart settlements and have started to implement them.

The City of Ayang in the Republic of Korea is one of smart settlements, as it has managed to curb the crime rate in the city by using recent technologies, setting up CCTVs around the whole city through the

Intelligent Transport System Programme as a way of limiting blind spots and securing the safety of its citizens. This was also done in Glasgow, Scotland, where CCTV cameras were installed in all public space to increase safety within the urban area. In Barcelona, Spain, the development of smart settlements has been achieved through public participation, whereby people within the city identified the areas where there was the need for development and renovation, thus achieving a smart settlement in the city (Backhouse, Kariri-Sebina and Guya, 2020).

Regionally, the concept of smart settlements has been adopted by few countries. This is a result of lack of financial support in the region of Africa. It is believed that Nairobi, Kenya, and Cape Town in South Africa are the top smart cities in Africa. In South Africa, the issue of smart settlements has been adopted with a different agenda from that of the whole world that not focus on the use of technology and global competition, but rather their main focus is value-driven and focuses on smart city principles. It has been noticed that urban data has been used also in the South African context where the government examined urban data as the foundation for the building of smart cities (Academy of Science of South Africa, 2020). This has worked in the shaping of the country's cities governance and decision-making.

Locally, Zimbabwe has taken steps to make its cities smart by the year 2030. This has been done through presidential campaigns such as the clean-up campaign, which aims at creating smart urban environments and liveable cities. Though the idea of smart settlements is a noble one, the situation in Zimbabwe is an obstacle in the implementation. The prevailing backwardness in technology and the economic crisis are the major effects that affect the implementation of smart settlements as there is a lack of funding for projects. Apart from that, the increased rate of urbanisation and informal settlements have resulted in so many unplanned settlements, hence there is a lot of work that needs to be done to provide good services for the growing urban population.

RESULTS

The results indicate that urban data and science are very crucial in the development of smart settlements as they give a guideline to the type of technique, strategy and policies that must be taken to develop and manage this smartness of the settlement in all aspects. As argued by

some scholars, smart settlements require ITC and the availability of urban data for a particular settlement can help identify the strategy to be used to develop and manage a fully smart city with full information communication technology capacity. Acquiring information about the people and their social life is also important in the development of smart cities as this helps to know the welfare of the people hence the services needed to maximise their standards of living in terms of health, education, leisure and recreation, among others. Aijaz (2016) argues that the understanding of the notion of the city is reached through the study of the demographic patterns, economic and social structure of that urban settlement. The information on the employment rate of the people residing in the city is very crucial as it aids the creation of policies to be used to boost the economy through job creation, investment in new technologies and innovation. This also helps to understand the lifestyle of the people and gives clues on how to set strategies and policies that transform it.

The understanding of urban data concerning the people helps to develop and manage settlements patterns, taking into account the current patterns. It is noted, therefore, that the use of urban data and science through understanding the demographics of the urban settlement rewards the planning authorities and policy-makers with only favourable results. This will help them reach the definition put forward by Kurcheeva and Klochov (2019) in that they describe it as a certain system of communicative and information technologies. The purpose is to improve the living standards of citizens and reduce the costs of workflow through automation that does not require the use of analytical skills. This simply means that for one to increase these standards of living of the urban settlers, one must understand the current situation and where it is lagging, to know what needs to be improved.

It is noted that obtaining information about urban form is a key factor in the development of smart settlements in both developed and developing regions. Urban form is one of urban data type that contains information regarding the transport system, land use, infrastructure, among other components. The results from this study show that the creation of smart urban settlements has a connection to the set of the city. This guides the development of infrastructure. Mobility is a key aspect of urban smart settlements, hence knowledge of the state of the transport infrastructure, connectivity from one place to the other and

the frequency of movement within the urban settlements, helps bring a reasonable smart solution that can solve the transport problems around the settlement. Besides mobility logistics, the availability of urban data on the urban form also results in the designing of the urban settlement, whereby land-use, layout of the settlement and housing programmes are done in such a way that they follow the standards and policies prepared by the urban planner leading to smart settlements. This is important because it provides the layout of the city that can be used to amend the existing outlook and transform it into a new and more attractive design that is more sustainable and delivering the best quality of life for the people of the area.

The results indicate that urban resources are vital to the development of smart settlements. This provides information on food production in that urban settlement and is used to identify the gaps that need attention and further development for a balanced diet and also help eradicate hunger and starvation. Knowing food chains helps the manufacturing industry within the settlement. Knowing the way, an urban settlement is set up and the type of people occupying different parts of it, is important as it helps to identify the quantity and quality of different goods required in the settlements and again helps in the management of resources such as freshwater supply, the importation of additional goods if local suppliers fail to reach the required quantities. Thus, results indicate that the availability of urban data are vital since it is used in resource management and services provided within a settlement through analysing the available resources and how to distribute them among the dwellers in such a way that all benefit and reach the standards of life that are considered to be smart.

The creation of a smart environment is one of the goals of smart settlements. Green infrastructure has become the key issue of development due to the rise of climate change. It is believed that air quality, landscape and climate, among others, are the key components to the smart environment. It has been recognised that available information on the state of the environment regarding waste management, both solid waste and wastewater, has given a start pointing in that strategies could be formulated to reach the standards of smart environments where urban settlements have zero litter and clean.

CASE STUDIES

MASDAR CITY

Masdar is located in the United Arab Emirates, in the Middle East. This is believed to be one of the first smart cities in the world with a zero percent emission rate, thus the use of clean energy and waste management, whereby recycling and re-use have been done to reduce and monitor waste disposal around the city. Smart city strategies were used to increase the quality of life in the urban space by improving the environment and service delivery using technology. GIS and GPS technologies have been used in the development of transport systems.

AMSTERDAM

The City of Amsterdam, Netherlands, is one of the most popular smart settlements around the world. This city used smart cities strategies to achieve its goal of becoming a smart city. The strategy applied in this city was the Amsterdam Smart City Programme in which several phases were developed to guide the process. This strategy was developed in 2007 and has been successful through the support of political personals (Baron, 2012). The use of technology became common in solving environmental problems and climate change adaptation and mitigation (Brinkman and Meuwissen, 2010). It is noted that there has been cooperation in the development of this city between different stakeholders such as the planning authorities and the climate sector. Therefore, strategic urban planning principles were used to attain a smart city of Amsterdam and the indulgence of the stakeholders and their participation were the key factors that lead to the success of this development.

DISCUSSION

Though the use of urban data might be effective in the development of smart settlements, it should be acknowledged that in some cases the data is inaccurate. This is more profound in data regarding people where migration continues to be a cause of changes in the informal settlements. Though the data are available, other factors that may affect the proper implementation of smart cities financial incapacitation may fail to meet the standards of smart settlements, especially in the developing world. In some cases, the absence of valid data (and their collection) results in the development of similar areas while others are left out. there are some areas without updated information due to lack of resources for data collection and also distorted data due to some

political reasons and other reasons hence the development of smart settlements in such areas becomes difficult due to biases.

Economic instability may work as a barrier for development even with the availability and understanding of urban data. lack of modern technology and investing in these technologies, may hamper the creation of smart urban settlements regardless of the availability of urban data, especially in many developing countries where they cannot afford recent technologies that speed up the growth of the economy. Though the availability of urban data can be considered as the first step towards smart settlements, other factors need to be considered as they also contribute to a successful implementation of smart settlements in both the developed and developing countries. Data alone cannot lead to the achievement of the goal.

CONCLUSION AND POLICY OPTIONS

Urban data and science are the key contributors to the development of smart cities, therefore policy-makers should acknowledge the available data and science in that the settlement is developing, before they formulate policies and strategies used in developing smart settlements. Urban policy-makers and developers, together with the planning authorities, must assess the proper collection of urban data and introduce other methods of data collection that are more reliable in providing valid information that is used to assess the state of the city. It is noted that though there are a lot of policies that have been introduced to create smart settlements, some of these are not applicable in some cases, hence the understanding of urban data for that particular urban settlement or country can be useful in formulating strategies that result in the specified development.