Benchmarking City Smartness: Towards Developing a Robust Multi-dimensional Evaluative Framework

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Declaration

I affirm that this research work is my own and was conducted by me, excluding where due acknowledgement has been made in the text, and that it has not been submitted in part or full for any other award than the degree of Doctor of Philosophy of the University of the West of England. Materials from other sources have been duly acknowledge and referenced in line with ethical standards, and the list of publications made from the thesis have been provided.

Signed: KABIR O. KADIRI

Signature … ……………………….

Date……18th March 2023………………………

Abstract

With increasing urbanization globally, the rapid growth in information and communication technology (ICT), the ubiquity of the internet of things (IoT) vis-à-vis the rising depletion of the natural habitat and biodiversity, there has been tremendous pressure on cities to transform to a smart city. However, despite efforts to benchmark smart cities coming into full swing, existing frameworks have not taken cognisance of all relevant dimensions of a smart city and had been criticised for lack of robustness and disparate measurement approaches. This study therefore sets out to explore and develop a robust multi-dimensional framework for benchmarking of smart cities, using the UK as context. Using exploratory sequential mixed methodology approach, the study harnessed literature review, documentation, and interviews with experts in private and public sectors as data collection sources, to unearth one hundred and twenty-four city smartness indicators across diverse dimensions of smart cities (i.e., smart mobility, smart governance, smart living, smart people, smart economy etc.). Wider applicability and validity of each smartness indicators were confirmed through a questionnaire survey where a larger audience of experts were sampled. Series of statistical tests were conducted on the data generated from the questionnaire survey like, Descriptive and Reliability Analysis, and Fuzzy Synthetic Equation to develop a robust city smartness benchmarking tool. After normalizing all the variables of each dimension by a factor of 0.5, it was possible to evolve the seventy critical success criteria/factors (CSFs) which underlie the development of the smart city benchmarking framework/model. The study produced a framework which considered the physical, economic, social, and political dimensions of smart city development. Theoretically, the framework is comprehensive and very robust to benchmark the smartness of cities taking into cognisance the economic and social indicators, technological advancement, sustainability, liveability and governance. Additionally, the framework is flexible and context-sensitive, as cities differ in term of their size, population, resources and other characteristics. Professionally, the framework would assist in the benchmarking and ranking of smart cities by providing the different dimensions and indicators for assessing the smartness of cities. The framework would be of utmost value to the government, city councils, policy makers and stakeholders from different organizations to measure the level of smartness of cities, measure

the complex relationships and interactions among smartness indicators in cities, compare the level of smartness of cities and understand strategies to achieve the desired level of smartness.

Dedication

First, I love to dedicate this PhD to Almighty Allah for His infinite mercies and favours for this research effort to be successful. In addition, I also wish to dedicate this project to Alhaji Dayo Aderibigbe for his fatherly love, unflinching supports, and encouragement and for loving me for who I am and my father, Alhaji. A. A. Kadiri for instilling discipline and focus on me, I will not forget to mention my children, Aishat, Nasrullah, Yusrollah and Muhammed for their fervent prayers to see me through this journey. And finally, to my wives Mrs Risikat O. Kadiri and Mrs Mujiidah O. Kadiri for their fervent prayers, encouragement, support, and endurance.

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List of Publications from the Thesis

1. **Kadiri, Kabir,** Oyedele, Lukumon; Owolabi, Hakeem; Akinade, Olugbenga; Akanbi, Lukman; Gbadamosi, Abdul-Quayyum (2019) Smart city implementation: Challenges in Nigeria. Presented at CIB World Building Congress 2019

2. Olawale, O., Oyedele, L., Owolabi, H., Kusimo, H., Gbadamosi, A., Akinosho, T., Abioye S, **Kadiri, K** and Olojede I. (2019, July). Complexities of smart city project success: A study of real-life case studies. Presented at CIB World Building Congress 2019

3. **Kadiri K**., Oyedele L., Owolabi H., Akanbi L., Akinade O., Olojede I., Otukogbe G., Ojo R., Muhammed-Yakubu N., (2021) Smart City: Definitions, Dimensions and Evaluation of current benchmarking systems. Presented at IDoBE International Conference on Uncertainties in the Built Environment: How can we build a resilient future in the new normal? London South Bank University, UK 22-23 November 2021

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Chapter One

1 Introduction

The chapter explores the background to the study with a critical review of existing studies into city smartness and benchmarking literature and tools. This is followed by the justification for the study leading to the aim and objectives of the study. The chapter also laid out the research questions and is immediately followed by a discussion of the unit of the study. The scope and limitation of the study was also discussed, after which the contribution of the study i.e., contributions to academic knowledge, Professional practice and policy are discussed.

1.1 Background to the Study

Recent data from the United Nations has projected that 66% of the world's inhabitants will live in cities by 2050 (United Nations, 2015). This important forecast raises huge concerns about the world's environmental, and social sustainability (OECD, 2012); especially because cities currently consume about 70% of the world's resources and contribute massively to greenhouse gases with negative impact on the climate (Silva et al., 2018). As a result, the idea of a Smart City emerged as the favoured next-generation urban-solution, amongst other city models like telicity, knowledge city, digital city, eco-city, etc. (Cowley and Tomozeiu 2013; Mohanty et al., 2016). According to Bibri and Krogstie (2017), a smart city describes an advanced modern city that leverages Information and Communication Technologies (ICT) networks, embedded devices, and other technologies to enhance the quality of life, competitiveness, efficiency of urban systems, whilst also ensuring sustainable socio-economic and environmental aspects of future generations. With the increasing rise of ubiquitous and ambivalent computing, sentient computing, and internet-of-things (IoT) (Bibri and Krogstie, 2017), more scholarly investigations have emerged on the concept of smart cities (Albino et al., 2015; Kylili and Fokaides, 2015; Kitchin, 2015; Mohanty et al., 2016; Bibri and Krogstie, 2017; Silva et al., 2018). Many scholars believe city smartness has potential to change the urban environment into a vibrant and dynamic centre of creativity, entrepreneurship and creativity. However, despite the earlier studies, a major gap within existing smart city literature remains the lack of a robust benchmarking framework for measuring the level of smartness of cities accurately.

According to Anand and Kodali (2008), benchmarking is a complex concept, with more than 49 definitions currently existing in the literature all which involve vital themes like comparison, unravelling best-practices, measurements, including implementation and enhancement. However, Blackstock et al. (2012, pp.8) defined benchmarking "as the process of self-evaluation and self-improvement through the systematic and collaborative comparison of practices and performance with similar organizations in order to identify strengths and weaknesses, to learn to adapt and to set new targets to improve performance". In the current study the definition of benchmarking adopted was the practice of comparing and evaluating the performance of different cities in terms of their smart city initiative, such as governance, economy, mobility, environment, infrastructure, services, people, living and overall development. According to the authors, benchmarking could also be described as a transparent and collaborative assessment of programmes, processes, and goals with the overall aim of learning from best practices.

Benchmarking is a widely used management tool for providing organisations with external standard of evaluating quality within processes or practices in order to ascertain opportunities and areas for improvement (Alstete, 2000; Castro and Frazzon, 2017). Earlier introduced for the first time in the USA in early 1990s, which later led to the establishment of National Association of Colleges and University Business Officers by Benchmarking Projects (Alstete, 2000), benchmarking has become the most successful tool for driving quality assurance, process cum performance assessments and improvements among others (Dong et al., 2018). Thus, its critical role and relevance within the current study which focuses on city smartness benchmarking and evaluation.

1.2 Critical Review of Existing Studies and Knowledge Gaps

Within the smart city's literature, benchmarking city smartness has become a challenging issue (Greco and Cresta, 2015), particularly amid the rising plethora of different urban indicators. These indicators include competitiveness, quality of life, urban services (Kitchin, 2015; Bibri and Krogstie, 2017), smart city components i.e., human capital, ICT, knowledge economy, pro-business environment, built environment and city infrastructure, etc. (Balakrishna, 2012; Letaifa, 2015; Greco and Cresta, 2015) including dimensions such as smart mobility, smart living, smart governance etc. (Lazaroiu and Roscia, 2012; Boes et al., 2015). According to Greco and Cresta, (2015, pp.564), the "fuzzy nature of smart city concept" has not only contributed to the absence of a uniform framework for benchmarking city smartness, but also intensified the conceptual contradictions that typify new urban forms. Anthopoulos et al. (2019) in a recent study criticised studies on smart cities as a mere vendor-hype, with most studies on its benchmarking focusing on attributes and components (please see Figure 1.1 for current attributes of smart cities) (Lazaroiu and Roscia, 2012; Walravens, 2015; Hara et al., 2016; Khatoun and Zeadally, 2016).

According to Kitchin et al. (2015), many smart city benchmarking projects are quite confined in nature, with the underlying data, adopted methodology and results inaccessible to the public, with most organisations aiming to sell the data along with the software. From the perspective of Giffinger and Gudrun (2010), public attention on smart city benchmarking through city rankings has majorly concentrated on the ranks themselves, whilst completely overlooking its strategic planning significance. Other similar studies on smart city benchmarking have also focused solely on isolated case studies of smart cities (Caird, 2018; Alzaabi et al., 2019; Madakam et al., 2018; Anthopoulos et al., 2019), with limited wider applicability at international scale, especially in developing economies.

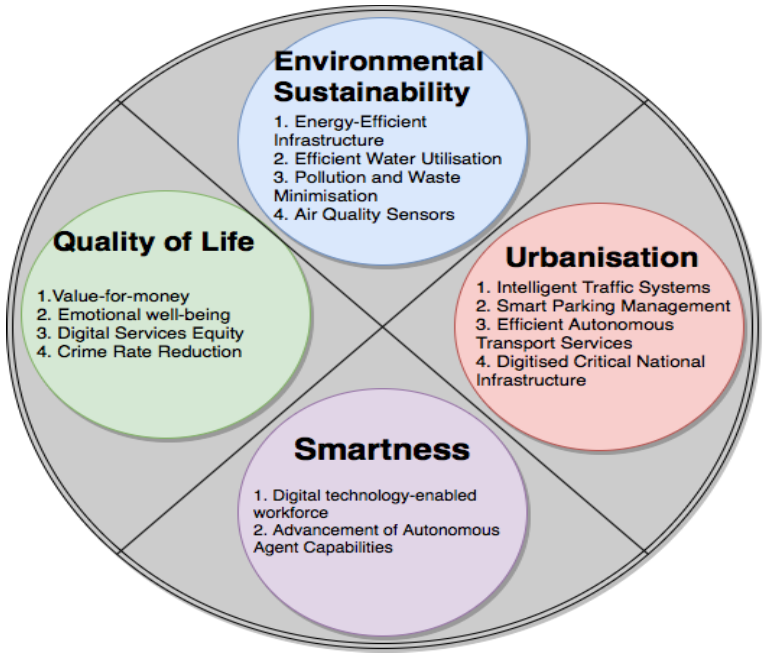

Figure 1. 1 Attributes of Smart Cities

Amidst the rising public interest and academic literature on benchmarking smartness of cities, several existing studies have suggested diverse frameworks and standards for evaluating smart cities, but with no robust measurement scale. For instance, according to Greco and Cresta, (2015) the "European Smart City" benchmarking project, also known as ESPON 2013 is currently the reference model for identifying indicators of a smart city. The study leveraged data from strategic planning reports of EU and other member states, including secondary literature to identify key features of smartness along six dimensions i.e., smart economy, smart environment, smart mobility, smart governance, smart people, and smart living. The project concluded by ranking 70 European cities in terms of smart city implementation (Greco and Cresta, 2015). Despite the comprehensiveness of this project, the model offers no usable scale to define the smartness of cities accurately nor a taxonomy for classifying the level of smartness of cities.

In another recent study, Escolar et al. (2018) criticised the use of ranking approach for smart city benchmarking. The study revealed excessive focus on urban development indicators, whilst neglecting ICT-led criteria. Relying on 38 relevant ICT indicators, the study applied a new methodology named, Multiple-Attribute Decision Making that leverages technological criteria for smart city designs. The methodology was then used to examine three major cities namely, Seoul, New York, and Santander. The study concluded that technology is the driving force of transforming cities, hence a methodology prioritising ICT factors provides deeper insights into city smartness measurement, as against mere ranking. However, a major shortcoming of this study, was the wrong premise that ICT is the hallmark of city smartness. The study clearly aligns with the technology-oriented stream of a smart city but completely ignore the people-oriented stream which is an essential component of defining the smartness of cities. The study also like some earlier studied did not provide a taxonomy for classifying the level of city smartness. (Please note that more critical review of existing literature can be found in the literature review section).

Overall, a major limitation of existing studies is that most of them fall short of providing a robust and usable City Smartness Benchmarking model and framework that can harness metrics from various dimensions to benchmark the smartness of existing and future smart cities on a taxonomy that provide the level of smartness of the cities. The need for a comprehensive benchmarking tool for evaluating the smartness of cities cannot be overstated. Such a tool is important for several reasons:

> **Standardization:** A comprehensive benchmarking tool ensures that smart city initiatives are evaluated using standardized metrics and criteria. This makes it easier to compare different cities and assess their progress towards their becoming smart cities.
>
> **Accuracy:** A comprehensive benchmarking tool provides accurate and reliable data on the performance of smart city initiative. This helps decision-makers make informed decisions about where to allocate resources and how to improve smart city strategy.

Transparency: A comprehensive benchmarking tool promotes transparency in the evaluation of smart city initiatives. This enable citizens, stakeholders, and investors to have a better understanding of how smart city projects are progressing.

Innovation: A robust benchmarking tool encourages innovation by identifying best practices and areas of improvement. This can help cities learn from each other and create more effective smart city strategies.

Investment: A inclusive benchmarking tool helps cities attract investment for smart cities projects by providing evidence of their success and potential for growth.

Overall, a comprehensive benchmarking tool is crucial for evaluating the smartness of cities as it ensures, standardization, accuracy, transparency, innovation, and investment opportunities for successful smart city initiatives.

This remains a huge and noticeable knowledge gap within smart city literature which this study intends to address. Hence, in order to implement this study, the overall research question that this study addresses is:

"How can a robust evaluative model be developed to ensure accurate benchmarking of smartness of cities by leveraging all possible indicators and dimensions?"

1.3 Justification for Study

Several studies on smart cities benchmarking abound but with no robust and concrete scale for determining the level of smartness of these cities (Kong and Woods, 2021; Yigitcanlar and Kamruzzaman, 2018; Angelidou, 2017).This lack of a clear and widely usable benchmarking model makes it difficult to compare or measure the level of smartness of cities on a global scale (Huovila, Bosch and Airaksinen, 2019; Afonso et al., 2015). Few examples of studies on benchmarking are smart governance (Kaja et al., 2017), City in Motion Index (Berron and Ricart, 2016), Smart transport (Debnath et al., 2014), smart health in European medium-sized cities (Giffinger et al., 2007), and Smart City Index (Sikora-Fernandez, 2018). However, a comprehensive study on benchmarking the entire city for a holistic dimension is lacking, particularly with regards to measuring the comprehensiveness to evaluate and measure the smartness of a city.

The United Nations projected that 66% of the world population will be urban by 2050 (United Nations, 2014), and a large portion of the world resources (70%) will be consumed by the cities (Mohanty et al., 2016). Some of the challenges arising with drastic urbanisation include waste management, air pollution, traffic congestion, resource scarcity, health effects, ageing infrastructure (Toppeta, 2010), all of which have posed great challenges to the economic, social and environmental sustainability of the city. The significant potential of the proposed model is to allow governments and researchers to compare cities and explore policies and initiatives to plan, optimise and improve cities' resources and processes (Steels, 2015). Additionally, the model will serve as a framework for identifying gaps and areas where improvements will be needed. Based on the above background and justifications, this study emerges from benchmarking theoretical lens and sets out to fulfil the overall gaps articulated above.

1.4 Aim and Objectives

The aim of this PhD study is to develop a robust city benchmarking framework/model for accurate measurement and scaling of smartness of cities across selected smartness dimensions. The following are the specific research objectives that have been identified to achieve the aim for the study:

1. To examine the concept and dimensions of smart cities.
2. To identify a comprehensive list of smart indicators relevant for measuring the smartness of a city.

3. To examine the concept benchmarking especially within the concept of smart city benchmarking.
4. Develop a robust smart city benchmarking framework for evaluating the smartness of cities.
5. To validate the developed smart city benchmarking framework using real-life test-cases of two smart cities in the UK, namely Bristol & Milton Keynes.

1.5 Research Questions

Whilst relying on the above aim and objectives, this study sets out to answer the following research questions:

1. What does smart city mean as a concept and what are its various components and dimensions?
2. What are the various indicators or attributes used for measuring the smartness of a city?
3. What are the shortcomings of existing frameworks for measuring/evaluating the smartness of cities?
4. How can the proposed smart city framework from this study help address existing shortcomings or improve on existing smart city measurement models?

1.6 Unit of Study

According to Babbie (2013), a unit of analysis describes the primary object of research which is carefully examined in order to arrive at generalizable conclusions and a unit of observation is entity described by the collected data. Unit of analysis or observation include individuals, groups, phenomenon, organisations, institutions, cities, and the state (Babbie, 2013; Kumar, 2018). Going by the description of Babbie (2013), the primary focus of analysis in this study is “Cities”. As such, the study will explore the perspectives and expectations of relevant individual practitioners (i.e., city planners, construction and infrastructure practitioners) to unearth key information about how cities smartness is decided in the UK to identify the critical drivers and indicators of smartness in cities.

1.7 Scope of the Study

The scope of this study is the UK smart cities, most of which describe themselves as smart cities (Brown, King and Goh, 2020; Michalec, Hayes and Longhurst, 2019; Okai, Feng and Sant, 2019). The study also focuses on exploring the opinion of UK's public and private sector experts, with five-to-twenty-year experience, on issues relating to smartness of cities. The experience of the expert which was between 5-20 years was because the issues about smart city in the contemporary dispensation gained momentum around the 1990s.The responses aided in the development of the framework for the evaluation of smartness in cities. As UK smart cities were used in this study, the data collection was also limited to the UK environ.

1.8 Contribution of this Study

This research is expected to contribute to the body of knowledge in two ways based on the gaps identified in the literature and findings from the study. These contributions include – (1) contribution to academic knowledge and (2) contribution to Professional practice.

1.8.1 Contribution to Theories and Academic Knowledge

This research contributes to existing benchmarking theories in following ways. Firstly, the study confirms the assertion of Camp (1989), which states that benchmarking is the search for industry best practice that leads to superior performance. In line with Camp's views, this study presents a reference framework that provides the detailed facilities and services required for a smart city of repute and upon which improvements can be benchmarked. Havingen explored the various dimensions of a smart city i.e., smart governance, smart people, smart living, smart mobility, smart economy, and smart environment, this study leverages findings from experts in the field to provide a more updated version of the various smart city dimensions by the addition of "smart infrastructure" and "smart services" to the list of existing smart city dimensions. Also, the use of the Fussy Synthetic Evaluation (FSE) to develop a model for the smart city is a new statistical approach for objectivising the benchmarking of smart cities, which will provide a good reference for other benchmarking projects.

1.8.2 Contribution to Professional Practice

The developed framework would assist in future benchmarking and ranking of smart cities by providing the different dimension and indicators for assessing the smartness of the cities. The framework would be of utmost importance to the government, city councils, policy makers and stakeholders from other organisations to achieve the following: (1) measure the level of smartness of cities (measuring smart city capacity and smartness across several dimensions), (2) measurement of the complex relationships and interactions among smartness indicators in cities, (3) compare the level of smartness of cities, (4) understand the strategies to achieve the desired level of smartness. These can be achieved through the framework which incorporates some dimensions and their respective indicators. The level of smartness of each city can now be clearly defined as the framework is explicit about different levels and their associated indicators.

1.8.3 Implication for policy

With the development of this framework/model, policy makers in the sphere of smart cities would be able to assess their policy vis-à-vis the framework to see the different facilities and services to be put in place to achieve the smart cities of their desire and to bridge the digital divide between the rich and the poor within the city. This suggest that appropriate facilities needed for the city optimal performance can easily be identified, making the process of fulfilling city needs transparent and unquestionable. Also, the framework will serve as an evaluative framework for auditors and external assessor to carry out a detailed evaluation of the progress made toward the smartness of cities. In the area of budgetary provisions, the framework will be useful to budget for the detailed budgetary estimation of the facilities and services that are peculiar to achieve level of smartness that can be accommodated in their budget. Also, smart city administrators will be able to assess the level of development in the smart city direction and the details of the items to be met for the city to attain the desired level of smartness and also the detail budgetary requirements to cater to these requirements.

1.8.4 Chapter Summary

The challenges of the cities led to the emergence of the smart city paradigm which is the use of of ICT, embedded devices and other technologies to improve efficiency, administration and enhances the quality of life of the citizen and also to ensure social, economic and environmental sustainability of the city. Many scholarly concepts of the smart city have also emerged, and this has resulted in the challenge of what constitute a smart city. This has also made it imperative to carry out a benchmark on these smart cities in order to assess their level of smartness. For this to be achieved there is need to produce a robust framework as the existing benchmarking tools are inadequate due to the different gap, such as, the inaccessibility of the underlying data, adopted methodology and results, identified in the literature.

The scope of the study is the UK smart cities where the opinions of public, private and stakeholders with experience of between five to twenty years in smart cities were explored and synthesized in the development of the benchmarking framework. This framework has confirmed the Camp, (1989), theory, which states that benchmarking is the search for industry best practice that leads to superior performance and also contributed to professional practice by providing clarity on the dimensions and indicator that can be used for measuring the smartness of cities.

Chapter Two: Smart City

2 Chapter Summary

This section looks at the background of smart cities followed by the concept of smart city and then defined the smart city. It goes on to discuss the dimensions of smart city and rounded up the chapter with a critique of the smart city paradigm.

2.1 Smart city Background

Cities in the world occupy less than 2% of earth surface but as they are seat of political and economic power, they harbour huge socio-economic activities that attract people from the hinterland to make a living (Petrişor *et al.*, 2020). Cities also consume 75% of globally available natural resource and thus produce 80% of global emission that is reported to be one of the causes of climate change (Dodman, 2009).The urge by people to search for greener pasture in order to live safely and comfortably has necessitated the influx of people into the cities which has resulted in unprecedented rapid urban growth which demand greater agility from city and local government as they work to provide services and to serve those who live and work in the city (Sottoriva and Nasi, 2022). Following this trend of most world cities, the United Nations has estimated that 68% of the world population will be living in the city by the year 2050 (Saba *et al.*, 2020; Sulemana *et al.*, 2019) while a corresponding 85% of EU population will live in city at the same time (Vinod Kumar & Dahiya, 2017)

As a consequence of this rapid urbanization, city authorities are facing an increasingly complex set of risks, growth, performance, competitiveness, concerns and problems such as environmental challenges like deterioration in the air quality, scarce resources, waste management, traffic congestion, aging public infrastructure inadequacy such as over-stretched and aging transportation systems, power theft, insufficient power generation capacity, higher power transmission loss, frequent power outages, and socio-economic problems like unemployment, inadequate housing, educational challenges and resident livelihood security (Wassie, 2020). To be able to overcome these challenges resulting from urbanization of the cities, the smart city concept emerged as one of the possible solutions.

2.2 The concept of smart city

The smart city made its first appearance in the mid-1800s in the American West self-governing cities (Yigitcanlar *et al.*, 2018). The attention to smart city became more pronounced by the 21st century due to the adoption of innovative technology (Angelidou, 2015). The concept which re-emerge into limelight about three decades ago is not a recent breakthrough (Palmisano, 2008). In the late 1990s, the smart city movement emerged with the aim to conceptualise and promote the principles of sustainable, socio-economic development and intelligent urban growth of cities. With the emphasis being placed on building infrastructure and maximising commercial opportunities during the evolution of the cities which coincided with the commencement of the industrial revolution which, resulted in rapid urbanization leading to pollution, health and safety concerns, and leakage of limited resources within the city. Consequently, many practitioners and researcher began advocating for "smart growth" instead of the haphazard urbanization that may be dangerous to the existence and sustainability of the cities. The idea of a smart growth was capitalised on by giant in the telecommunication industry like IBM and CISCO, to expound their visions of cities wherein all the system and process are to be automated. This, they referred to as the "Smart City". The engagement of the giant multinationals in the different project about smart city around the globe have enabled them to develop competences and resources in the area of smart city (Linde *et al.*, 2021). There is still a vacuum in the definition of smart city, and this has resulted in the difficulties in the implementation and interpretation of the smart city concept.

"Smart" and "City" are the two wards that are the component of smart city. The ward 'smart' means "using a built-in microprocessor for automatic operation or "operating by automation", for data processing, or for achieving greater versatility. On the other hand, a city is defined as a large area with high population density and built-up infrastructure inhabited by people earning livelihood through white-collar jobs (Singh and Singla, 2020).

Similarly, the early concept of smart city as noted by (PWC, (2012), involve the building of infrastructure to maximize commercial opportunities, this was later replaced by the protection of human health, safety and increased operational efficiency. The final phase was the use of technology to make city more sustainable, attractive and adaptable. In the current state of affairs, technology is seen as a dominant tool for smart city, however, Nam and Pardo, (2011), have propose three dimensions to the concept of smart city. These are technological, human and institutional dimensions.

2.3 Definition of smart city

Several scholars have observed that the smart city lacks a universally accepted definition (Kabir Kadiri *et al.*, 2021; Kadiri Kabir *et al.*, 2019; Couchman, et al 2008; Hollands, 2008; Chourabi, 2012; Cordella and Iannacci, 2010). The label smart city is a fuzzy concept and is used in a way that are not always consistent (Albino, Berardi and Dangelico, 2015)(Albino, Berardi and Dangelico, 2015). There is no single framework or template to formulate a smart city. Depending on the conception of the smart city the definition vary from city to city, region to region, depending on the willingness to change and reform, level of development, aspirations and resources available to the city administration (Prasad and Alizadeh, 2020)(Prasad and Alizadeh, 2020).

The smart city definition is categorise based on the main theme of the definition. They are categorised as Technology; Human and Technology; Institution and Technology; Human, Institution and Technology; Human and Institution; and Human centred definitions. These are shown in Table 2.1.

Some scholars believe that the smart city is powered by technology through the information and communication technology. These include multinational telecommunication giant such IBM, (2010), who viewed the smart city as one that use information and communication technology to sense, analyse and integrate the key information core systems in managing the city. Other scholars like Harrison, et al, (2010), Komninos, (2011) are of the opinion that the smart city is driven by human and technology by defining the smart city as a city connecting the physical infrastructures, the IT infrastructures, the social infrastructure and the business infrastructure to leverage the collective intelligence of the city. Some scholar shares a different opinion by arguing that the smart city is powered by institution and technology. One of such view is that of Cretu, (2012), who opined that the smart city does everything related to governance and economy using new thinking and which integrate network of sensors, devices, real-time data and ICT in all spheres of the citizen life. Other researchers, like Correia, et al., (2011), have defined the smart city pivoted on human, institutions and technology. They defined the smart city as one that is able to link physical capital with social capital and to develop better services and infrastructure. It is able to use technology, information and political vision to improve services and enhance urban activities. Some scholars have also defined the smart city on the basis of human and institution. These include Kourtit and Nijkamp, (2012), who defined the smart city as one with promising human capital, infrastructure capital, social capital and entrepreneur capital with the goal of enhancing the socio-economic, ecological, logistical and competitive performance of the city. The last group are those that view the smart city from purely human angle (Giffinger, 2007). They defined the smart city as a well performing city built on the smart combination of endowments and activities of self-decisive, independent and aware citizens (Giffinger, 2007).

A wholistic appraisal of these definitions suggest that each and every one of these definitions contribute to the realisation of the smart city goal. Considering the plethora of these definitions, there is a need for a unification of these definitions in order to be able to specify what a smart city must be so as to be able to evaluate any given smart city. Hence, this study therefore proposes a smart city as one that uses institution, human and technology to improve efficiency and performance and the socio-economic and environmental sustainability of the people thereby creating a secure and sustainable milieu with real-time monitoring and synchronization of every activity taking place in the city.

Table 2. 1 Categorization of the definitions of Smart City

Authors	Definition	Dimension
IBM, (2010)	*A smart city is defined the use of information and communication technology to sense, analyse, and integrate the key information of core systems in running the city*	*Technology*
Su et al., (2011)	*A smart city is the product of digital city with the internet of things*	*Technology*
Dameri, (2013)	*A smart city is a well-defined geographic area, (govern by a well-defined pool of subject that are able to state the rules and policy for the city government and development), 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, intellectual development;*	*Technology*
California Institute, (2010)	*A smart community is one that has made a conscious effort to use ICT to transform life and work within its region in significant and fundamental rather than incremental ways.*	*Technology*
Griffith (2001)	*A smart city is a city that monitors and integrates the conditions of all of its infrastructures, including road, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens*	*Technology*
Setis-Eu, (2012)	*A smart city is a city which integrates diverse technology such as water recycling, energy grid and mobile communications in order to reduce environmental impact and to offer its citizens better lives*	*Technology*
Hall, (2000)	*A smart city is a city that monitors and integrates the conditions of all its critical infrastructure including roads, bridges, tunnels, rails, subways, airports, seaports, communication, water, power, major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.*	*Technology*

Washburn et al (2010)	*A smart city is one that uses smart computing technology to make the critical component and services of a city-like education, healthcare, transportation, real estate, public safety, utilities and city administration- more intelligent, interconnected and efficient.*	*technology*
Woods and Goldstein, (2004)	*A smart city is the integration of technology into a strategic approach to sustainability, citizen well-being and economic development.*	*technology*
Nam and Pardo (2011)	*A smart city infuses information into its physical infrastructure to improve conveniences, facilitate mobility, add efficiencies, conserve energy, improve the quality of air and water, identify problems and fix them quickly, very rapidly from disasters, collect data to make better decisions, deploy resources effectively, and share data to enable collaboration across entities and domains.*	*Technology*
Marsal-Llacuna et al. (2014)	*Smart Cities initiatives try to improve urban performance by using data, information and information technologies (IT) to provide more efficient services to citizens, to monitor and optimize existing infrastructure, to increase collaboration among different economic actors, and to encourage innovative business models in both the private and public sectors.*	*Technology*
Lombardi et al., (2012)	*A smart city is one that uses ICT to improve human, social, educational, and environmental aspects of the city*	*Technology*
Chen (2010)	*A smart city is a city that capitalizes on communication and sensors capabilities embedded into the city infrastructures to optimize electrical, transportation and other logistical operations supporting daily life, in order to improve the quality of life for everyone.*	*Technology*
Bakıcı et al. (2012)	*A smart city is a technology intensive and advance city that connect people, information and city infrastructure using the latest ICT in order to create a sustainable, greener city, competitive and innovative commerce and increased life quality*	*Technology*
Lazaroiu and Roscia (2012)	*A community of average technology size, interconnected and sustainable, comfortable, attractive and secure.*	*Technology*

IDA (2012)	*A smart city is a city which holistically employ information technologies with real-time analysis that encourages sustainable economic development.*	*Technology*
ITU, (2013)	*A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.*	*Technology*
Harrison et al., (2010)	*A smart city is a city connecting the physical infrastructures, the IT infrastructures, the social infrastructures, and the business infrastructures to leverage the collective intelligence of the city*	*Human and Technology*
Komninos, (2011)	*A smart city is a territory with high capacity for learning and innovation, which is built-on the creativity of their citizens, their institution of knowledge creation, and their digital infrastructure for communication and knowledge management.*	*Human and Technology*
Northstream, (2010)	*A smart city is one where the citizens, objects, utilities etc connect in a seamless manner using ubiquitous technologies, so as to significantly enhance the living experience in the 21st century urban environment.*	*Human and Technology*
Caragliu et al., (2007)	*A smart city is one wherein investment in human and social capital and tradition (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with wise management of natural resources, through participatory governance*	*Human and Technology*
Eger (2009)	*Smart community – a community which makes a conscious decision to aggressively deploy technology as a catalyst to solving its social and business needs – will undoubtedly focus on building its high-speed broadband infrastructures, but the real opportunity is in rebuilding and renewing a sense of place, and in the process a sense of civic pride. [. . .]* *Smart communities are not, at their core, exercises in the deployment and use of technology, but in the promotion of economic development, job growth, and an increased quality of life. In other words, technological propagation of smart communities isn't*	*Human Technology*

	an end in itself, but only a means to reinventing cities for a new economy and society with clear and compelling community benefit.	
Logvinov and Lebid; 2018)	*"Smart City is a city management system, based on the use of innovative technologies in the field of ICT, networking, computer communications, big data and spatial planning, implemented (embodied) in the form of a specific model of the organizational structure of city management, which ensures the participation of society (citizens and all stakeholders) in the decision-making processes in key issues in city development".*	*Human Technology*
Cretu (2012)	*A smart city is a city that does everything related to governance and economy using new thinking and which integrates network of sensors, devices, real-time data and ICT in every aspect of human life*	*Institution, and Technology*
Toppeta (2010)	*A smart city is one that combine ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help identify new, innovative solutions to city management complexity, in order to improve sustainability and livability*	*Human, Institution and Technology*
Correia et al., (2011)	*A smart city is one that is able to link physical capital with social one and to develop better services and infrastructure. It is able to bring together technology, information and political vision into a coherent program of urban and service improvement.*	*Human, Institution and Technology*
Thuzar (2011)	*The smart city is a sustainable city of the future that invest in human capital, social-economic capital and traditional and modern ICT, manage its natural resources through participatory policy, and has a sustainable urban policy where the citizens can live a good quality life*	*Human, Institution and Technology*
Barrionuevo et al. (2012)	*A city that harnesses all available technology and resources in an intelligent and coordinated manner in order to develop an urban centre that are integrated, habitable and sustainable*	*Human, Institution and Technology*
International Standards Organization	*A smart city is one that ...dramatically increases the pace at which it improves its social economic and environmental*	*Human, Institution and Technology*

Technical Management Board, Strategy Advisory Group (2015)	*(sustainability) outcomes, responding to challenges such as climate change, rapid population growth, and political and economic instability … …by fundamentally improving how it engages society, how it applies collaborative leadership methods, how it works across disciplines and city systems, and how it uses data information and modern technologies …. … in order to provide better services and quality of life to those in and involved with the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment.*	
Kourtit and Nijkamp (2012)	*A smart city is one with promising human capital, infrastructure capital, social capital and entrepreneur capital with the goal of enhancing the socio-economic, ecological, logistical and competitive performance of the city*	*Human and Institution*
Guan (2012)	*A smart city, according to ICELI, is a city that provides for a healthy and happy community under the challenging conditions that global, environmental, economic and social trend may bring.*	*Human and Institution*
Thite (2011)	*A smart city is a city that nurtures a creative economy by investing in good quality of life in order to attract knowledge worker to live and work therein*	*Human*
Rios, (2008)	*A smart city is a city that gives inspiration, share culture, knowledge, life, motivates its inhabitants to create and flourish in their own lives.*	*Human*
Giffinger, (2007)	*A smart city is a well performing city built on the smart combination of endowments and activities of self-decisive, independent and aware citizens*	*Human*

With no standardized identity that could effectively describe the smart city, the concept of smart city lacks clarity. Coupled with this is the lack of standardize criteria and framework to guide the stepwise establishment of a smart city. Hence, it is not feasible for anyone who embark on the development of a smart city to deliver on the project as without a sound understanding of its fundamental concept. This has justified the need for a standard framework that could be used as a guideline for smart city project and also this provide a comprehensive and concise understanding about smart city concept which serve a baseline of the smart city execution (Wahab et al., 2020).

One of the basic fundamental cardinal points to understand the smart city are the dimensions of the smart city or the elements of the smart city which will aid in the development of conceptual model for the smart city. Four dimensions of the smart city had been identified by Giffinger, et al., (2007). They are industry, education, participation and technical infrastructure. In another project conducted by the Centre of Regional Science at the Vienna University of Technology, Giffinger and Gudrun, (2010), expanded the dimensions to six. These are smart governance, smart economy, smart mobility, smart environment, smart living and smart people. The traditional and neoclassical theories of urban growth and development which include regional natural resources, human and social capital, competitiveness, transport and ICT economics, quality of life, and participation of society members are the basis of Giffinger and Gudrun, (2010) six dimensions.

In another vain to delineate the features of an intelligent city, Komininos, (2002) indicated that there are four dimensions which are the application of a wide range of electronic and digital technologies to create a cyber, digital, wired, informational or knowledge-based city; the second is the use of information technology to transform work and life; the third is to embed ICT in the city infrastructure; and fourth is to bring ICT and people together to enhance innovation, learning and knowledge. In creating a smart city there should be an organic integration of the various subsystems like education, transportation, energy, healthcare, buildings, physical infrastructure, food, water and public safety. (Dirks and Keeking, 2009). This was corroborated by Kanter and Litow, (2009) who noted that the infusion of intelligence into each subsystem of a city, one by one, is insufficient to create a smart city, as the city should be treated as an organic whole. For the ease of managing the smart city, many researchers have justified the decision to divide the city into dimensions for the ease of administration.

The key components of a smart city listed by Nam and Pardo, (2011) are the technology, the people (creativity, diversity, and education), and the institutions (governance and policy). There is a connection amongst the three components as a city is smart when investment in human, social capital and ICT infrastructures, promote sustainable growth and enhances the quality of life. This implies that the ubiquitous presence of ICT to facilitate this connection. Jonathan et al., (2018),Jonathan et al., (2018), in Mckinsey Global Institute (MGI) (2018) have identified eight dimensions of smart city which are smart mobility, smart security, smart healthcare, smart energy, smart water, smart waste, smart economic development and housing and smart engagement and community. Drawing on the rich varieties of the conceptual definition of smart cities, Chourabi, et al., (2012) noted that there are eight dimensions of a smart city. They are as follows: (1) management and organization, (2) technology, (3) governance, (4) policy, (5) people and communities, (6) the economy, (7) built infrastructure, and (8) the natural environment.

Silva, et al., (2018) suggested that the components of a smart city are sustainability, Quality of life (QoL), Urbanization and Smartness. Each of these components can be further subdivided as follows: sustainability (infrastructure and government, pollution and waste, energy and climate change, social issues, economics and health); QoL (emotional and financial well-being of urban citizens); urbanization (technological, economical, infrastructural, and governance) and smartness (this is defined as the desire to improve social, environmental, and economic benchmarks of the city and its inhabitants.

Mohanty et al., (2016) have identified nine dimensions of smart cities which are smart infrastructure, smart buildings, smart transportation, smart energy, smart health care, smart technology, smart governance, smart education, and smart citizens. They further emphasized that different smart cities have different levels of these smart components, depending on their focus. For a city to be smart each and every one of these dimensions of smartness must be available as a whole at a scale that is substantially receptive to the growth and development of a smart city. Table 2 shows a summary of the dimensions of the smart city.

Table 2. 2 The Dimensions of Smart Cities (Source: Literature Review 2021)

Author	***Dimensions***	***Remarks***
Giffinger and Gudrun, (2010)	*Smart mobility, smart economy, smart government, smart environment, smart people and smart living*	*These dimensions are the most popular*

Kumninos, (2002)	*Using IT to create cyber, wired and knowledge city; using IT to transform work and life; embed IT in city infrastructure; and using IT and people to achieve innovation, learning and knowledge*	*IT has achieved all the forgoing objectives*
Nam and Pardo, (2011)	*Technology, the people (creativity, diversity, and education), and institutions (government and policy).*	*This is a broad classification of a smart city*
Silva, et al., (2018)	*smart community, smart energy, smart transportation, smart healthcare, smart disaster management, smart waste management*	*The economy that unite the citizen is not emphasized*
MGI, (2018)	*(1) management and organization, (2) technology, (3) governance, (4) policy, (5) people and communities, (6) the economy, (7) built infrastructure, and (8) the natural environment.*	*Silent on mobility*
Mohanty, et al, (2016)	*smart infrastructure, smart buildings, smart transportation, smart energy, smart health care, smart technology, smart governance, smart education, and smart citizens.*	*Adequate and comprehensively describe a smart city.*
Chourabi, et al., (2012)	*(1) management and organization, (2) technology, (3) governance, (4) policy, (5) people and communities, (6) the economy, (7) built infrastructure, and (8) the natural environment.*	*Mobility a salient aspect of smart city is excluded.*

2.4 Dimensions of Smart City

This section further elucidates some elements of the smart city dimension which include the following: smart governance; smart environment; smart mobility; smart economy; smart living; smart people; smart infrastructure and smart services.

2.4.1 Smart Governance

Participatory governance and citizen involvement (under different stakeholder roles) are key concepts in many smart city frameworks (Albino et al., 2015; Caragliu, Del Bo, & Nijkamp, 2009; Chourabi et al., 2012; Giffinger et al., 2007; Lombardi et al., 2011; Meijer & Rodrıguez Bolıvar, 2015; Misuraca, Reid, & Deakin, 2011; Nam & Pardo, 2011b). According to Belissent (2010), governance is the core of smart city initiatives. Even researchers who do not give governance such a central role, at least include it as one of the dimensions that should be targeted by smart city initiatives. Governance is fundamental to bringing smart city initiatives to citizens. It keeps the process of decision-making transparent (Albino et al., 2015) and enables better citizen participation in implementing, monitoring, and evaluating these initiatives (Misuraca et al., 2011). Washburn et al. (2010) observe that many of the obstacles to delivering the smart city vision result from a lack of governance that ensures multistakeholders' collaboration throughout a project, not just at the design and implementation stage but also post-implementation.

In the smart city literature, governance is often seen as referring to citizen participation (Caragliu et al., 2009; Giffinger et al., 2007; Lombardi et al., 2011) and to collaboration among stakeholders (Baccarne et al., 2014; Batagan, 2011; Chourabi et al., 2012; Nam & Pardo, 2011a, 2011b; Scholl & Scholl, 2014). This could mean that government structures and operations need to be transformed to some extent (more or less radically) to create a smart city (Meijer & Rodrıguez Bolıvar, 2013). Although participation and collaboration are often used synonymously in the smart city context, Bartenberger and Grubmuller-Regent (2014) suggest using the more restrictive concept of collaborative governance in order to keep smart city governance distinct from the broader concept of participatory democracy. Ansell and Gash (2008, p. 544) define collaborative governance as ''a governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets''. In the context of smart city governance, this includes the definition and implementation of the policies that aim to make cities smarter, and which require sharing visions and strategies with the relevant stakeholders (Nam & Pardo, 2011b). It also includes the management of the implementation of smart city initiatives targeted at making the various city dimensions/components smarter (Chourabi et al., 2012). Human assets (Lombardi et al., 2011), and other immaterial capital (social and relational capital, intellectual capital and innovation, and knowledge and information) that are considered vital for achieving smart, sustainable and inclusive growth (Batangan, 2011). Other indicators for smart governance include public value creation, vision and strategy formulation (Castelnovo, et al., 2016), asset management, financial and economic sustainability (Ruhlandt, 2018), social inclusiveness (Fernandez-Anez, et al., 2018), and multistakeholders' participation. These are the building blocks for the assessment of initiatives that aim to make cities smarter.

Similarly, smart governance involves the use of ICTs to systematically simplify and improve the internal administrative operations of government; simplify public service interaction between government, citizens, and other stakeholders; facilitate citizen participation, and guarantee inclusiveness and equal opportunity for all (Misuraca, 2010). A smart government is the coordinator of the smart city as it constantly innovates e-government for the benefit of the citizens using big data, spatial decision support system and related geospatial technologies in urban and regional governance (Kumar, 2017). Furthermore, a smart government is expected to exhibit accountability, responsiveness, transparency and democratic among other indicators. It must be participatory in policymaking, planning, budgeting, implementation monitoring while delivering public services efficiently and effectively. Anttiroiko, Valkama and Bailey, (2014) noted that a smart government must guide and control urban growth. Smart governance also involves harnessing and coordinating the enthusiasm and capabilities of residents to directly and more accurately represent themselves (Bibri, 2021), rather than depending on their representatives to aggregate and articulate their interests (Anttiroiko, Valkama and Bailey, 2014).

2.4.2 Smart Environment

The smart city environment is the harbinger of the smart city and it is expected to be clean and green (Cohen, 2015), with clean air (Ericsson, 2014; ESCI, 2010) water (Ericsson, 2014; ESCI, 2010), unpolluted land (Ericsson, 2014) preserve the natural heritage (Kumar & Dahiya, 2017), provide abundant public open space with smart resource management (Govada et al, 2019), ensuring cohesive community with physical, social, psychological and mental health for the people (Govada, Cheng, & Chung, 2019), reduced CO2 emissions (Ericsson, 2014; IBM, 2009), pollution free (Giffinger, et al., 2007; Ericsson, 2014). A smart environment is an environment with unique natural resources, biodiversity; conserved and preserved ecological system, (Kumar & Dahiya, 2017), while also keeping a vibrant neighbourhood that encourage neighbourliness and a spirit of community, efficiently and effectively manage its natural resource base (Silva, et al., 2018). Smart environment creates a recreational opportunity for the people of all ages (Thite, 2011), and ensures government in collaboration with the people implement and monitor environmental protection policies (Govada, Cheng, & Chung, 2019). There is an integrated and efficient management system for the collection, transfer, transportation, treatment, recycling, reuse and disposal of municipal, hospital, industrial, and hazardous solid waste. (Kumar, 2017).

In another vain, a smart environment is a knowledge based environment that develops special capabilities to be self-aware (Dutt, Jantsch and Sarma, 2016), functioning all-round the clock and interconnect, selectively, in real time knowledge to resident end users for an acceptable way of life with easy public supply of services (Turok, Seeliger and Visagie, 2021), comfortable mobility, conserve energy, environment and other natural resources (Nguyen and Aiello, 2013), and create energetic face to face communities and a vibrant urban economy. Smart environment is made smart using ICT and IoT (Bessis and Dobre 2014).

2.4.3 Smart Mobility

Transportation and connectivity are the main focus of smart mobility (Govada, Cheng, & Chung, 2019). One of the major dimensions of smart city is mobility (Giffinger and Gudrun, 2010). Smart mobility is one of the consequences of changes in the way people move in the urban settings due to the rise of e-commerce, e-business and other online services (Kaluarachchi, 2019). The fast advances in ICT and subsequent ICT-enabled transport services have created new urban mobility systems which can help to reduce the volume of motorized traffic. Connection of traffic, communication and analytics is becoming increasingly vital. Transportation infrastructures are pushed to their boundaries thereby necessitating smart adaptive means of transporting and routing policies to improve existing systems. In return, mobility requires data analysis systems to be able to deal with mobile data sources. Tosi and Marzorati, (2016) and Corradi, et al., (2015) initiated real-time mobility patterns detection system able to describe how people move around point of interest (POI). Policy maker and journey planners use the POI to provide final users with accurate travel planning and can exploit these mobility patterns. Smart mobility is best achieved through urban planning (Corradi, et al., 2015) which moves the focus from individual to collective mode of transportation through the extensive use of ICT (Batty, et al., 2012) and also the integration of high-mobility systems linking residential areas, workplaces, recreational areas, and transport nodes. Its aims to move people through mass rapid transit system (MGI, 2018), such as metro rail, light metro, monorail, or skytrain for high-speed mobility (Newman, 2013).

In addition, efficient and sustainable movement of human and goods as well as the enhancement of regional and international integration are some of objectives of Smart mobility (Govada, Cheng, & Chung, 2019). Public transit, walking and cycling are the sustainable means of promoting smart mobility. Although multi-modal public transit should be the fundamental to address the mobility needs to support the large number of people movement within the urban setting Cottrill *et al.*, 2020), it should be supported by clean non-motorised transit (NMT) options that will be the basis for last mile connectivity for all transport choices (Ghosh, Kanitkar and Srikanth, 2023). Furthermore, the usage of information and communications technology (ICT) services integrated with public transportation (MGI, 2018) such as the provision of traffic and transport information technologies including schedules, routing and real time tracking is essential (Govada, Cheng, & Chung, 2019). Zero-carbon emission strategies like electric vehicles for cars, taxis and buses, driverless electric vehicles (IDC, 2013) should be promoted by cities thereby enhancing the walking routs for pedestrians. MGI (2018) noted that cities that embark on smart mobility are likely to reduce commuting time by 15-20 percent by 2025 and it may be more for other cities.

2.4.4 Smart Economy

An economy is smart when it has a diverse economy that is open and transparent (Govada, Cheng, & Chung, 2019) and is characterised by digital business licensing and permits (MGI, 2018) multi-sectoral, flexible market opportunities for business and employment (Giffinger, et al., 2007), in addition to promoting entrepreneurship (Giffinger, et al., 2007; Cohen, 2015; Ericsson 2014), innovation (Giffinger, et al., 2007; Ericsson 2014) and higher productivity (Giffinger, et al., 2007; Cohen, 2015; Ericsson 2014) through local, regional and global collaborations (Giffinger, et al., 2007; Ericsson, 2014). Effective and efficient business environment (ISO, 2015) is promoted in a smart economy for the entrepreneurs and promotion of innovation in the industry. Smart economy ensures availability of stable skilled labour force with rich resource and ability to transform the city (Giffinger, et al., 2007) as well as adapt to the livelihood of its citizens (Giffinger, et al., 2007). Similarly, smart economy is one of the dimensions of smart cities (Giffinger et al., 2007) where human capital i.e., knowledge, skills, creativity are combined to transform ideas into valuable process, product and services (Giffinger, et al., 2007; Firoz and Kumar, 2017) so as to build a green economy with green companies (Schaffers, et al., 2011). According to UN-HABITAT (2013) and Dahiya (2012), smart economy dominates the local and national economy and also function as the engine of economic growth. Smart economy is people-driven, designed and implemented in a manner that strengthens local collaborative advantage through entrepreneurship (Giffinger, et al., 2007; Cohen, 2015 and Ericsson, 2014). This is done in an atmosphere of openness to unforeseen opportunities, and thus add to the competitiveness of the smart city (Kumar and Dahiya, 2017). Smart economy is characterised by the significant use of ICT in all aspect of economic activities and has a clear long-term economic vision, which is agreeable to the general public, private sectors, civil society and other important stakeholders. It builds and nurtures a knowledge-based economy through the active sharing of tacit and explicit knowledge for economic benefit of all the citizens, in order to be able to manage urban infrastructure, services, environment, natural resources and urban liveability. This in turn leads to increased productivity (Giffinger, et al., 2007; Cohen, 2015 and Ericsson, 2014) of land, labour and capital and consequently the achievement of a good quality of life for all its citizens.

2.4.5 Smart Living

Pathan et al., (2019) noted that man is always in search of making his living smart and easy as much as he can. In times past, the advent of telephone was considered the smartest at that particular point in history. However, the emergence of wireless technologies with the use of internet as a medium of operation, has made the real impact of smart communications become felt amongst the people. Lu, et al., (2019) in a recent study stressed the improvement to the quality of life for the smart city residents. According to Lu, et al., (2019), people now manage their house with IoT sensors, and this provide them with a more pleasant, safe, healthy and quality of life. Similarly, Gupta, Mustafa, & Kumar, (2017) see smart living as being distinguished by variety of cultural services that are open to all kinds of religious denomination, whether they belong to large or small groups. Thite, (2011) also suggested that smart people require education facilities through establishment of world-class colleges and universities. Availability of tourist attractions as well as world class hospitals with state-of-the-art technology-enabled devices and equipment is also considered to give every resident a healthy lifestyle (Ribera, et al., 2016). High-quality housing as well as social cohesion of citizens of the city is also considered a feature of smartness (Stratigea, et al., 2015). Weiser and Brown, (1995) described smart living as the act of distributing computing into our everyday environment. Smart living also encompasses improving the quality of lives of the citizens in terms of services (Buhalis and Amaranggana, 2013), enhancing attractiveness for tourists (Silvestrelli, 2013), promoting social cohesion and safety (Cramm and Nieboer, 2013), celebrating and promoting arts, culture and natural heritage in the city (Kumar, 2017). Smart living thrives on security for everyone particularly women, children, the vulnerable and the elderly (Mokomane, 2013). In addition, since 2014, 34 Organisation for Economic Cooperation and Development (OECD) countries have attempted to collect data about people's well-being several times a year. Comparisons have been made using nine criteria—these include access to services, civic engagement, the environment, individual incomes, employment, and education—with open data being made available to researchers and citizens (Dotti, 2016).

2.4.6 Smart People

By stressing the fundamental role played by ICT in making cities smarter, the approaches that conceptualize smart cities as primarily a technical issue incur the risk of technological determinism. They underestimate the factors involved at the societal, organizational, individual, and cultural levels (Gil-Garcia, Vivanco, & Luna-Reyes, 2014). According to Meijer and Rodrıguez Bolıvar, (2013), researchers in the human resource strand focus on people as being central to the operation of smart cities. For Chourabi et al. (2012), addressing the topic of people and communities as part of smart cities is critical, although traditionally this topic has been neglected. The social infrastructure, such as intellectual and social capital, is an indispensable part of smart cities (Albino et al., 2015) since it contributes to creating a climate suitable for an emerging creative class that is a fundamental asset for smart cities. Indeed, creativity and social innovation are considered key drivers for smart cities, and thus people, education, learning, and knowledge have central importance in this process (Nam & Pardo, 2011b; TEPSIE, 2015). From this point of view, making people smarter can be considered as one of the objectives of smart city initiatives. Smart people are a fundamental asset for smart cities as they provide a relevant resource on which initiatives can rely to make cities smarter. In fact, besides contributing to a city's competitiveness, which is an engine for economic growth, smart, educated, and informed people can become active users and engage with smart city initiatives. They can make these initiatives a success or a failure, by both adopting and using the (smart) services made available to them and by participating in the governance and the management of the city (Chourabi et al., 2012).

Smart people with high Human Development Index is central to the smart city because without the active participation of the people and their involvement in a smart city, the system will not come into being and be operational (Kumar, 2015). The next most important attribute is the enrolment rate for the graduates (Gupta, Mustafa, & Kumar, 2017). The third most important quality is skill level (Gupta, Mustafa, & Kumar, 2017). The zeal to learn should be of interest to smart people and there should be social and ethnic plurality in the system (Gupta, Mustafa, & Kumar, 2017; Giffinger, et al.,(2007; Berger-Schmitt and Noll,2000*)*. Open-mindedness is another characteristic of smart people, as is having the ability to respond to environmental change, as well as the imagination to contribute to education. Smart people are egalitarian in character and engage in public life (Gupta, Mustafa, & Kumar, 2017).

Earlier research has shown that qualification levels, lifelong learning interest, imagination, versatility, engagement in public life and good decision-making are important qualities that make people smart (Giffinger, et al., 2007) and increase their productivity and efficiency. Smart people appreciate the value of people around them who they seek to collaborate with in order to create a healthy environment. Smart people can create a pleasant city environment with a positive workforce. People face reality by making smart decisions in different situations and judge themselves fairly to overcome problems. Being smart is majorly about constantly working to better the capability of various tasks with the use and understanding of technology and not only being intelligent, logical reasoning, critical thinking and scientific in approaches (Norman, 2014). Smart people attract high human capital while integrating its universities, colleges and research institutions into all aspects of the city life. It is driven by social capital which result from ethnic and social diversity, tolerance, creativity and engagement (Lateifa, 2015).

2.4.7 Smart Infrastructure

One of the backbones of any smart city are the physical infrastructure which include public realm and sensor (Govada, Cheng, & Chung, 2019), roads, bridges, railways, ports, airport, hospital, school and the power generating system including non-physical infrastructure such as data, information, communication, social and knowledge capitals (Hall, 2000; Metos, et al., 2017; Caragliu, et al., 2009; Dameri and Ricciardi, 2015). Emerging from both hard and soft infrastructure is the Information and Communication Technology (ICT) which combines both physical and soft characters of infrastructure to produce system such as internet (Su et al., 2011); Web 2.0 (Toppeta, 2000); IoT (IBM, 2010); cloud computing and Wi-Fi (Thuzar, 2011), which on their own do does not make a smart city without the infusion of knowledge from human and social capitals. These capitals took part in urban transformation of the smart cities to make them to significantly affect people's daily life (Bolici and Mora, 2012; Cocchia, 2014).

2.4.8 Smart Services

Smart services are completely different entity from the service offering of the past because it depends on machine intelligence (Fadlullah et al., 2017). They are primarily pre-emptive rather than reactive or even proactive. Pre-emptive means that their activities are based upon hard field intelligence(Asghar et al., 2017)(Asghar et al., 2017) ; smart services are based on actual evidence that a machine is about to fail, that a customer's supply of consumables is about to be depleted or the paper in a photocopy machine is about to run out and needs replacement (Hasan et al., 2022). A new type of value is created whereby the customers are saved the unpleasant surprises on sudden depletion of their consumables and the organization gain unprecedented research and development feedback and insight into customers' needs and can provide greater ongoing value (Allmendinger & Lombreglia, 2005). Georgakopoulos & Jayaraman, (2016) described smart services as a federated internet-based ecosystem that is comprised of billions of diverse IoT devices and software services that are owned, administered, and operated by independent providers. These different providers had deployed their IOT devices for their own purposes (which may not be known to other), but they have also made them accessible to other IOT application. Any IOT application that needs to use IOT devices and their data to provide an IOT service or support an IOT product may have to discover the IOT devices that can provide that data it needs; integrate these IOT and their data; analyse the integrated data as needed.

Smart services in home incorporates a home loaded with electronic gadgets that are communicating, cooperating and exhibiting some behaviour for the good or bad of the homeowners (Wang et al., 2021). The growth of these smart services has been exponential. The salient issue in smart services is digitization. With three-quarter of the world's population projected to live in cities by 2050 (UN, 2011), this will produce a huge and very complex human, societal, scientific, and environmental challenges, including how people will live and travel around the city and receive services (Anttiroiko, Valkama and Bailey, 2014). Hence, the necessity to employ technologies to deliver information and facilitate community growths and social cohesion within increasingly intensive urban setting is increasingly obvious. Smart services are therefore a new paradigm that could be used in education to enhance educational efficiency, effectiveness and productivity (Tantatsanawong, et al., 2011). It is an integrated system that include network infrastructure services, education information services and learning services (Li et al., 2021b), which facilitates high-order thinking skills (Zain, Sailin and Mahmor, 2022), support learner-centred (Kusmin and Laanpere, 2022), self-directed learning, tailored learning and decision supporting (Li et al., 2021a). Many smart service applications facilitate individual consumption or service use (Anttiroiko, Valkama and Bailey, 2014). The smart service concept depends on both behavioural and systemic dimensions that reflect the two interrelated categories of consumption and production.

2.4.9 Concluding remarks on the Smart City Dimensions

The dimensions of smart city explained above details out the constituent of each dimension of smart city. It details what each dimension is made of and this facilitate the definition of each dimension based on the view of different scholars. This could be seen as the building block of the smart city indicator. This suggests that the door for the interpretation of each dimension of a smart city is open and more meaning can be infused based on time and circumstance

2.5 Critique of the existing smart city paradigms

The concept smart city has come under heavy criticism by some notable scholars like (Söderström, Paasche and Klauser, 2014; Nam and Pardo, 2011)(Söderström, Paasche and Klauser, 2014; Nam and Pardo, 2011)) and (Brown, 2014). While Söderström, Paasche and Klauser, (2014), viewed the smart city as a marketing campaigns by tech giant and to enhance their business fortunes, Nam and Pardo, (2011), see the smart city as an urban innovation while Brown, (2014), questions the effectiveness of the smart city ability to provide solution to the whole gamut of urban challenges. Some other scholars are concerned about the smart adjective used to describe a city. For instance, Holland, (2008), noted that the use of ICT in the city, as most city are adopting ICT, is not enough to confer smartness on the city. This is the scenario where cities like Southampton, Edinburgh, Vancouver and Montreal are following in the foot step of some cities like San Francisco, Ottawa, Bangalore, Kyoto and Amsterdam. Also, Allwinkle and Cruickshank, (2011), noted the self-congratulatory nature of cities that claim to be smart and their over-reliance on characteristically entrepreneural route to smartness which they feel seem to be an avenue for commercial benefit of some tech-giants.

There is a feeling by Caragliu and del Bo, (2022), that the smart city paradigm is a purvayor of social inequalities in the city due to the wide digital divide between the poor and the rich and that it will lead to undemocratic practices where the city planners have been accused of engaging in digital convenience in favour of the rich who, in most cases, are in the minority. A poor implementation of smart city principles is also reported in some studies to lead to great income inequality between the poor and the rich as they are not able to afford the new technologies involved in the different activities going on in the city

2.6 The Challenges of Building Universal Indicators for Smart Cities Benchmarking

In order to assess and compare urban indicators and to build capacity for countries to evaluate urban policies, (Flood, 1997), the Unite Nations has committed a lot of attention to put in place standardize key indicators for cities through the Global Urban Observatory. Despite the absence of consensus around methodologies with no agreement on the best conceptual framework or standardized options to measure sustainable development ((Hammond et al., 1995)(Ramos and Pires, 2020)), there is a continuous growth in the diversity of sustainable development indicators. In urban sustainable development many different approaches have been developed: from the international ranking of cities based on different criteria such as quality of life , cost of living , innovation economy , city branding, personal safety or eco-city (Yigitcanlar and Lönnqvist, 2013a) to compendiums of best practices, the use of future scenarios (Boyko et al., 2012) or self-organizing map (Arribas-Bel, et al., 2013). The lack of international consensus produced growing inefficiencies in terms of our ability to develop, monitor, and benchmark progress towards goals and objectives (Pinter et al., 2005).

However, the prevailing standardized indicators, Sebastien and Bauler, (2013:9), like the GDP were developed by "institutionally appointed experts upon specific demand by policy makers facing specific policy situations". On the other hand, and justifying this lack of consensus, standardized indicators for sustainable development have mostly been proposed by non-governmental actors (e.g., universities, think tanks, non-governmental organizations) – generally known as ''middle actors'' between civil society and political/institutional spheres – within a contested policy agenda and controversial vision for sustainable development (Sébastien & Bauler, 2013).

The Rio+20 conference, UN, (2013), supported the integrated assessments of sustainable development when it recommended the adoption of a Global sustainable development report that would bring integrated assessments together across sectors and territorial levels. This has substantiated the global challenges for a common effort and has open up vital questions, like the understanding of the challenges of a harmonized indicators at different territorial levels, the understanding of the expected outcomes of both standardized and context specific indicators for cities or the role of different types of institutions leading to the standardization process and its impacts.

Several authors (Ambienteltalia, 2003; Flood, 1997; Hommond et al., 1995; Luque-Martinez, 2005; Mascarenhas, et al., 2010; Pinter, et al., 2005) and international organizations have provided many arguments for finding ways to standardize indicators and framework to compare sustainable development. They claim that standardization is useful to assess and compare data, problems, contexts, cities and policy options regarding sustainable development and to synthesize highly complex issues in a simplified and compact manner to spark debate and guide further in-depth analysis and policy-making (Yigitcanlar and Lonnqvist, 2013). Other arguments in favour of standardization are also linked to the strengthening of the capacities of cities, facilitating the evaluation of sustainable development policies (Flood, 1997), enabling the benchmarking of key indicators, and reinforcing informed and strategic decision-making (Luque-Martinez and Munoz-Leiva, 2005).

On the other hand, other authors such as Bakkes, (1997); Dahl, (1997);Rydin, (2007); Miller, (2007), observed the fact that promises of standardization are usually grounded in a rationalistic and linear conception of the instrumental role played by knowledge in decision-making, where indicators are frequently conceived as consensus building tools that pacify controversy or serving a neoliberal political agenda supported by evidence-based governmental technologies (Rydin, 2007) ready to be used in any context. The classical discussion on the advantage of having an index to simplify and easily communicate a message versus the methodological disadvantage of aggregation and standardization options, portrays the prevalence of a rational discourse and takes attention from several other potential uses, impacts and discourses on standardized indicators. Dahl, (1997, p78) questions if standardized indicators are capable of covering the full spectrum of interest from the superpowers to the small island developing states, from indigenous subsistence to post-industrial communities, and from high-tech to no-tech situations. Bakkes (1997) argues that indicators must reflect their particular cultural, political and institutional context and Dhakal and Imura (2003) concorded that a single set of common indicators that is equally applicable to all cities is not possible. Nevertheless, they claim that the identification of a few common universal issues to provide useful international and interregional comparison is recommended.

The arguments presented in this critical debate are many and highly contested, which is why the issue of a universal indicator could be controversial to adopt. However, since a smart city is global and international by nature, to have a universal indicator that would cut across all smart cities is a welcome proposal. Such indicators must be global in nature, and not leaning towards any geographic region or giving any privileges such as access to the web and government portals, ease of doing businesses, privacy and security, ease of mobility and a good quality environment to live in.

2.7 Indicators for Smart city Benchmarking

According to Moonen and Clark, (2013), there are currently over one hundred and fifty city benchmarking initiatives that seek to compare and contrast hundreds of cities globally. Each of these initiatives benchmark cities across a range of indicators, some focus on particular sectors such as economic performance and may be directed at particular constituents such as economic investors, and some seek to provide a single composite score that are amalgam of a number of indicators. A good example is the Global City Indicator Facility (GCIF) (cityinicators.org), a joint project of the World Bank, UN-Habitat, the World Economic Forum, OECD, and the Government of Canada, that collect and compares indicators with respect to 20 themes centred on city characteristics, services, and quality of life for 254 cities across 81 countries.

The GCIF has also been responsible for creating an International Organization for Standardization (ISO) standard for city benchmarking indicators (ISO 37120, 2014) designed to produce standardized global urban data that would be seen as reputable and verifiable, thus providing confidence in their use for monitoring purposes and policy development (Hoornweg, et al., 2007; ISO,2014). The A. T. Kearney Global Cities Index (2012) which produced a single city benchmark score that blends five dimensions of the city is a good example. They are business activity (30%); human capital (30%) information exchange (15%) cultural experience (15%) political engagement (10%). Some benchmarking initiatives, like GCIF, are closed and only accessible through a fee or membership while others are open and supported by open-access websites including data visualizations. Each initiative has a different set of city comparator cities, with the rationale for inclusion varying across initiatives. In each case, however, for cities to be included comparable indicator data have to be available and this often means reliance on nationally produced statistical data. See Table 3.2 for list of Smart city indicators within existing literature.

Table 3. 1 Comprehensive List of Smart City Indicators: Identified from Academic, Policy and Industry Literature: Source: Author literature review

S/N	***Dimensions***	***Indicators***	***Authors/Source***
1	*Smart Environment*	*Intelligence distribution networks*	*Giffinger, et al., (2007),*
		Green planning and management of the city for sustainability	*Siemens (2009); Cohen, (2015),*
		Efficient waste management systems	*Ericsson (2014), ESCI, (2010), Kumar, (2017)*
		Energy conservation strategies in the city with the use of smart meters	*Ericsson (2014); ESCI, (2010; IBM, (2009); MGI, (2018)*
		Reliability of energy supply system to the citizens	*IBM, (2009)*
		Ensuring sustainability of materials from the natural environment	*Ericsson (2014); Giffinger, et al., (2007), Berger-Schmitt and Noll, (2000)*
		Good Air Quality in the environment	*Ericsson (2014), ESCI, (2010),*
		Clean sources and distribution networks for water supply	*Ericsson (2014), ESCI, (2010),*
		Ensuring contamination-free land	*Ericsson (2014)*
		Preservation of the heritage assets	*Kumar & Dahiya, (2017).*
		Preservation of the unique natural resources, ecological system, and biodiversity	*Kumar & Dahiya, (2017). Giffinger, et al., (2007), Berger-Schmitt and Noll, (2000)*
		Ensuring a cohesive healthy community and minimisation of exposure to health hazards	*Govada, Cheng, & Chung, (2019)*
		Remote health monitoring and intervention	*Szewcyzk, et al., (2009)*
		efficient and effective management of natural resource	*Silva, et al., (2018)*
		Provision of abundant public open space with smart resource management	*Govada et al, (2019)*

		Create a recreational opportunity for the people	*Thite, (2011)*
		Reduction of pollutant emissions in the environment	*Ericsson (2014), IBM, (2009) Giffinger, et al., (2007), Berger-Schmitt and Noll, (2000)*
		Ensuring environmental aesthetics for the city	*Giffinger, et al., (2007)*
		Collaboration between government and people to monitor and manage environment policies	*Govada, Cheng, & Chung, (2019)*
		State of the environment (quality of air, water, forest, soil)	*Berger-Schmitt and Noll, (2000)*
		Health hazards (e.g., by pollution, accidents, noxious substances in food)	*Berger-Schmitt and Noll, (2000)*
2	*Smart Economy*	*People with Innovative Spirit*	*Giffinger, et al., (2007), Ericsson (2014)*
		Entrepreneurship capacity in the citizens	*Giffinger, et al., (2007), Cohen, (2015), Ericsson (2014)*
		Good Economic image and trademarks	*Giffinger, et al., (2007)*
		Highly Productive people in the city	*Giffinger, et al., (2007), Cohen, (2015), Ericsson (2014)*
		Flexibility of the labour market	*Giffinger, et al., (2007)*
		International embeddedness of the labour market	*Giffinger, et al., (2007), Ericsson (2014)*
		Ability to transform ideas into valuable process, products and services	*Giffinger, et al., (2007); Firoz and Kumar, (2017)*
		Economic make-up of the people	*IDC, (2013),*
		Competitive skill of the people	*Ericsson (2014),*
		Management efficiency of the system	*ISO, (2015)*
		Digital business licensing and permitting	*MGI, (2018)*
		Open and transparent economic activities	*Govada, Cheng, & Chung, (2019).*
3	*Smart Mobility*	*Good Urban planning*	*Corradi, et al., (2015)*
		Use of ICT in transportation logistics	*(Govada, Cheng, & Chung, 2019)*
		high speed mobility	*Newman, 2013*
		Real-time public transit information	*MGI, (2018)*
		Digital public transit payment	*MGI, (2018)*

		Autonomous vehicles	*MGI, (2018)*
		Predictive maintenance of transportation infrastructure	*MGI, (2018); Hall, (2000)*
		Intelligent traffic signals	*MGI, (2018)*
		Smart parking	*MGI, (2018)*
		E-hailing (private and pooled)	*MGI, (2018)*
		(Inter-)national accessibility of the transport services	*Giffinger, et al., (2007)*
		Availability of ICT-infrastructure	*Giffinger, et al., (2007)*
		Availability of car-sharing, ride sharing, new biking systems	*Jeekel, (2017),*
		Electromobility (including low carbon)	*IDC, (2013),*
		Traffic intelligence	*IDC, (2013),*
		use of smartphones for facilitating mobility demand and ticketing.	*Jeekel, (2017),*
		Availability of pedestrian and bicycle path	*Joshi, et al., (2018)*
		Teleworking of the workers	*IDC, (2013),*
		enhancement of regional and international integration	*(Govada, Cheng, & Chung, 2019).*
		Availability of clean non-motorised transit	*(Govada, Cheng, & Chung, 2019); Mohan & Tiwari (1999).*
		collective mode of transportation through the extensive use of ICT	*(Govada, Cheng, & Chung, 2019), Batty, et al., 2012*
4	*Smart People*	*Diversity in the people's Age*	*IDC, (2013),*
		Level of educational qualification of citizens	*Giffinger, et al., (2007), Bhada, and Hoornweg, (2009),*
		Affinity to lifelong learning ambition of the people	*Giffinger, et al., (2007),*
		Social and ethnic plurality in the community	*Giffinger, et al., (2007), Berger-Schmitt and Noll, (2000) Gupta, Mustafa, & Kumar, (2017)*
		Attraction of high human capital into the system	*Lateifa, (2015)*
		Creativity amongst the people	*Giffinger, et al., (2007), Cohen, (2015)*

		Social innovation of the people	*Nam & Pardo, (2011b); TEPSIE, (2015)*
		Competitiveness spirit of the city inhabitants	*Chourabi et al., (2012)*
		Tolerance and engagement of the people	*Lateifa, (2015)*
		Imaginative people	*Giffinger, et al., (2007)*
		Versatility of the people	*Giffinger, et al., (2007)*
		Engagement in public life and decision-making	*Giffinger, et al., (2007)*
		Level of skill of the people	*Gupta, Mustafa, & Kumar, (2017)*
		Open mindedness of the people	*Gupta, Mustafa, & Kumar, (2017); Giffinger, et al., (2007)*
		Employment rate for graduate	*Gupta, Mustafa, and Kumar, (2017)*
		Cosmopolitanism/open-mindedness	*Giffinger, et al., (2007)*
		Participation in public life without discrimination	*Giffinger, et al., (2007), Berger-Schmitt and Noll, (2000)*
5	*Smart Living*	*Availability of Cultural facilities to the people*	*Giffinger, et al., (2007)*
		Availability of world-class health facilities to the people	*Giffinger, et al., (2007), PricewaterhouseCooper, (2010); Ribera, et al., 2016*
		Telemedicine availability to the citizens	*MGI, (2018)*
		Individual safety in the community	*Giffinger, et al., (2007)*
		High quality Housing availability	*Giffinger, et al., (2007), PricewaterhouseCooper, (2010); Stratigea, et al., 2015*
		Education facilities for the citizens	*Giffinger, et al., (2007), Berger-Schmitt and Noll, (2000)*
		Enrolment of young people in general education and vocational training	*Berger-Schmitt and Noll, (2000)*
		High level of Employment and low level of unemployment	*Berger-Schmitt and Noll, (2000)*
		Enhanced attraction to Tourist	*Giffinger, et al., (2007); Silvestrelli, (2013)*
		Promoting Social cohesion amongst the people	*Giffinger, et al., (2007); Cramm and Nieboer, (2013)*
		Remote patient monitoring for the vulnerable	*MGI, (2018)*
		Lifestyle wearables by the vulnerable	*MGI, (2018)*
		Infectious disease surveillance	*MGI, (2018)*

		Availability of world-class education	*Thite, (2011)*
		Promoting art and culture and natural heritage	*Kumar, (2017)*
		Place of security for women, children and the vulnerable	*Mokomane, (2013)*
6	*Smart Government*	*Participation of the citizens in government's decision-making*	*Giffinger, et al., (2007), GCIF, (2009), Albino et al., 2015; Caragliu, Del Bo, & Nijkamp, 2009; Chourabi et al., 2012;*
		Availability of public and social services for the citizens	*Giffinger, et al., (2007)*
		Transparency in governance activities	*Giffinger, et al., (2007), Cohen, (2015)*
		Transparency in decision-making process.	*Albino et al., 2015*
		Citizen's participation in implementing, monitoring and evaluating government's initiatives	*Misuraca et al., (2011); Caragliu et al., (2009); Giffinger et al., (2007); Lombardi et al., (2011)*
		Multi-stakeholder participation in decision making	*Washburn et al. (2010); Baccarne et al., (2014); Batagan, (2011); Chourabi et al., (2012);*
		Availability of Political strategies and perspectives	*Giffinger, et al., (2007)*
		Sustainable social behaviour of the people	*IDC, (2013), Bhada, and Hoornweg, (2009),*
		Achieving smart, sustainable and inclusive growth	*Batangan, (2011)*
		public value creation, vision and strategy formulation	*(Castelnovo, et al., 2016),*
		Social inclusiveness of the citizens	*Fernandez-Anez, et al., 2018*
		Clarity of environmental protection policy	*IDC, (2013),*
		Availability of e-Services for public engagement	*IDC, (2013), Cohen, (2015)*
		Availability of E-government for transactions with government	*IBM, (2009)*
7	*Smart Infrastructure*	*Availability of Good Road networks*	*Hall, (2000)*
		Availability of Utilities services	*MGI, (2018)*
		Enabling environment for human capital development, competition and innovation	(Mehmood et al., 2020)(Mehmood et al., 2020)
		Power generating systems	*MGI, (2018)*

		Availability of institutions for capacity buildings	(Mehmood et al., 2020)(Mehmood et al., 2020)
		Application of ICT in all aspects of life like mobility, education healthcare and others	(Mehmood et al., 2020)(Mehmood et al., 2020)
		Power generating systems	*MGI, (2018)*
		Preponderance of Computer literate personnel	(Mehmood et al., 2020)(Mehmood et al., 2020)
		Prevalence of 5g internet network	(Mehmood et al., 2020)(Mehmood et al., 2020)
		Availability of Web 2.0	*Toppeta, (2000)* (Mehmood et al., 2020)(Mehmood et al., 2020)
		Availability of IoT	*IBM, (2010),* (Mehmood et al., 2020)(Mehmood et al., 2020)
		Cloud computing and Wi-Fi	*Thuzar, (2011)*
8	*Smart Services*	*Provision of efficient Emergency services for the citizens*	*IDC, (2013),*
		Efficient Services for the community	*IDC, (2013),*
		Efficient Municipal waste disposal	*Siemens, (2009)*
		Waste recycling for resource re-use	*MGI, (2018)*
		Predictive policing to reduce crime	*MGI, (2018)*
		Real-time crime mapping to monitor criminal activities	*MGI, (2018)*
		Digital tracking and payment for waste disposal to ensure successful waste disposal	*MGI, (2018)*
		Gunshot detection in order to apprehend criminals	*MGI, (2018)*
		Smart surveillance of the city in order to pre-empt crime and pollution	*MGI, (2018)*
		Body-worn cameras to reduce police brutality	*MGI, (2018)*
		Disaster early-warning systems in order to save lives in emergencies	*MGI, (2018)*

2.8 Assessing performance of cities using indicators

To assess the performance of any city a range of discipline-specific activities is needed, like understanding commercial rental rates and business cycles (economics); measuring particulate matter to identify air pollution and designing, monitoring and managing sub-surface infrastructure. These activities can be translated into topic area-specific indicators that highlight progress in crucial regions for sustainable development that help in pinpointing how, when and where action may be needed (Hammond et al., 1995). Such indicators also can also assist to detect past trend; assess policy programmes (Grafakos et al., 2019); guide and mould policy decisions (Rydin, Holman and Wolff, 2003); add to the process of governance (Lien and Li, 2013)(Lien and Li, 2013); communicate with local communities undertaken by organizations that are using indicators (Fryer and Ogden, 2014); better understand opinions on city growth (Haider et al., 2018); impact individuals and their behaviour (Hagger, Chatzisarantis and Biddle, 2001); and construct a practical and reasonable evidence-base to enhance policymaker's decisions at a variety of scales relating to the city (Cash and Moser, 2000).

Indicators measures may be either quantitative, for instance, distance in metres to the nearest hospital, pharmaceutical shop, or transport link to assess accessibility or qualitative like subjective perception of crowding to assess cultural values associated with density. They may be related with benchmarks such as specific standard state that the people living in towns and cities should have an accessible natural greenspace of at least 20, 000 square metres, no more than 0.3 km, 300 seconds walk from home; best practice guidance and even 'sustainability ranges', which are minimum and maximum threshold value for sustainability indicators.

Although indicators are being used increasingly to assess performance of cities and urban regeneration, some issues arise that call into question their universal acceptance. Some scholar are sceptical that a clear relationship exists between indicator development and real change in decision-making and policy (Sharifi, 2020a). This could be due to a paucity of strong, evaluating research and monitoring on indicators (Geng et al., 2012), as well as an over-emphasis on quantitative assessment at the expense of qualitative measurement (Abubakar Ghani, Suleiman and Onn Malaysia, 2016). To solve the challenge of quantitative-qualitative assessment, a mixture of quantitative and qualitative indicators that reflect the multidisciplinary issues being studied is adopted.

2.9 Critique of the Smart City Indicators

Through the Global Urban Observatory, the United Nations has committed great efforts to standardize key city indicators, to evaluate and compare urban indicators and to build capacity for countries to assess urban policies (Flood, 1997b). In spite of this effort, there is the proliferation of the smart city indicators, with no agreement on methodologies nor the best conceptual framework or a model to measure smart city (Hammond et al., 1995). For instance, many different approaches have been developed based on city branding, cost of living, innovation economy, quality of life, eco-city or personal safety for international ranking of cities (Yigitcanlar and Lönnqvist, 2013b) the use of future scenarios (Korczak and Kijewska, 2019), self-organizing maps (Arribas-Bel, Kourtit and Nijkamp, 2013) to the compendium of best practices (National Institute of Building Science, 2007). We have not been able to develop, monitor and benchmark progress towards goals and objectives because of the growing inefficiency that result from the consequent lack of international consensus. Upon certain demand encountered in specific situations, standard indicators like the GDP was developed by internationally appointed experts (Sébastien and Bauler, 2013). Due to lack of consensus, however, standard indicators for smart city have been largely initiated by middle actors who are mostly non-governmental bodies like think-tanks, non-governmental organizations and universities(Elsa, Nuno and Tomasz, 2011).

The universal challenge for a unified effort on standard indicators was highlighted by the Rio+20 conference. This include understanding the challenges of unified indicators at different territorial levels. The challenge to unify the indicators is global as it has to contend with different context and diversity as an interesting and productive feature of the smart city indicators (Gatto, 2020).

There have been several efforts by international organization and scholars to produces standardized indicators and framework to compare smart cities (Yigitcanlar and Lönnqvist, 2013b; Ramos and Caeiro, 2010; Luque-Martínez and Muñoz-Leiva, 2005). Their contention is that standard indicators are useful to evaluate and compare city and policy options, contexts, data, problems regarding smart city, and to synthesize highly complex issues in a simplified and compact manner so as to initiate discussion and shape policymaking in order to make a robust analysis (di Bella, Corsi and Leporatti, 2015). Other positive side of standardization is to bolster the capacities of cities, facilitating the evaluation of smart city policies, allowing the benchmarking of key indicators, and supporting informed and strategic decision-making (Sharifi, 2020a).

2.9.1 Challenges of selecting the right Indicators

Within the smart city domain indicators are developed based on diverse and peculiar needs, however this can create problem in selecting the right indicators. Some of the indicators and performance measure developed by some experts are peculiar to their own organizations and therefore make comparison between smart cities very inappropriate and biased (Tan and Taeihagh, 2020; Bosch et al., 2017). These customised indicators rarely help in the recognition of areas in which smart cities might perform better nor provide a framework for sustainable development. Unfortunately for smaller smart cities with challenges of quality manpower with specialised skills that may have the capacity to develop appropriate indicators and the wherewithal to adequately collect data on such indicators if they were developed (Marshall et al., 2016) are not available in these small smart cities. Even if these cities wish to hire such specialise manpower, their budgetary capacity may be inadequate to finance such a huge benchmarking venture (Marmolejo, 2016).

2.10 Selecting Indicators for Smart Cities

One of the indispensable constituents of a smart city assessment tools is the indicator. Pinpointing a set of relevant indicators is the first step towards developing an assessment tool. Indicators can be chosen using one or a combination of the following techniques: literature review, expert survey and stakeholder consultation. Based on their similarity, selected indicators are often classified into themes and subthemes (Sharifi, 2019).

Evaluating performance against the indicators is done using scorecards that are often available in the form of checklist, questionnaires, or other forms of score sheets. Performance assessment can be conducted by the tool user, by the developer or by external auditors. Many tools aggregate the score of individual indicators to obtain an aggregate index that can be used to indicate the overall performance. Since different types of variables may be used for assessing performance against the smartness indicators, obtaining aggregate index scores often requires normalizing the individual indicator scores. Commonly used normalization techniques are the “min-max” techniques and the “z-score” method (Wu et al., 2016). In addition, when calculating the aggregate index score, some developers assign different weight indicator to acknowledge their different levels of significance (Giffinger, Haindlmaier and Kramar, 2010). At the end of the assessment process various methods can be used to report and disseminate the results.

In order to select the most appropriate key performance indicators for smart cities, a conceptual framework has to be developed. To accomplish this, a study has to be conducted to among other thing to identify key issues related to smartness of cities which include economic, social, environmental and technological factors; next is to assess the perceptions of stakeholders and values of selected KPIs for smart cities; and finally the main objective of the new model in this study is to make the KPIs accessible to members of the planning authority in the city council, the stakeholder in the community, the members of the academic community, and industrial practitioners by providing empirical benefits on how they can influence and select their own indicators. (Alwaer and Clements-Croome, 2010).

In order to be able to effectively assess city performance and also evolve a meaningful ranking of cities, appropriate indicators need to be selected through research and exploration, evaluations and the selection of relevant databases (Mavrič and Bobek 2015). In a study carried out by Mavrič and Bobek, (2015), the indicators were selected based on the following assumptions including the concept of appropriate homogeneity: (1) interaction (economic, social, environmental); (2) measurability, relevance and reproducibility (quantitative, systematic observable); (3) accessibility (available databases, use of existing data); (4) statistical representativeness (at city level); (5) temporal stability and consistency;(6) flexibility (with the possibility of continuous improvement); (7) efficiency/performance (as decision making and local management tool); (8) validity (with the possibility of verification and data quality control); (9) objectivity (clear, easy to understand, precise and unambiguous); (10) comparability/standardization-longitudinal (over time) and transverse (between cities).

2.11 Chapter Summary

The nature of city as the centre of administrative power and a magnet for the population from the hinterland resulted in rapid urbanization leading to complex set of risks, performance issues, competitiveness concern and environmental challenges. To overcome these city challenges, the concept of smart city was developed with the main goal of promoting the principle of sustainable socio-economic, environmental development and intelligent urban growth of the cities. However, because of the multi-desciplinary nature of smart city, there has not been a unanimous definition of a smart city. The definition of smart city is classified under, Technology; Human and Technology; Institution and Technology; Human, Institution and Technology; Human and Institution; and Human centred definitions. In spite of this classification, the smart city, is agreed to be made up of six dimension which are smart governance, smart mobility, smart living, smart economy, smart environment, and smart people. However, in the course of my literature review two more dimensions have been added and these are smart infrastructure and smart services.

Numerous researchers have criticised the concept of smart cities, with Söderström, Paasche and Klauser, (2014) viewing it as a marketing campaign by tech giants, Nam and Pardo (2011) as an urban innovation, and Brown (2014) questioning its effectiveness in solving urban challenges. Holland (2008) noted that cities cannot be labelled as 'smart' simply by adopting ICT. Allwinkle and Cruickshank (2011) raised concerns about cities' self-congratulatory attitude and their reliance on entrepreneurial routes to smartness. Caragliu and Del Bo (2022) argued that the smart city paradigm could be a purveyor of social inequalities and lead to undemocratic practices resulting from the digital divide. Poor implementation of the smart city concept could also result in great income inequality.

Finally, the challenges of building universal indicators for smart city benchmarking and the indicators for smart city benchmarking were examined. In the case of the challenge of building universal indicators for smart city benchmarking, the United Nations committed enormous efforts to put in place standardized key indicators for cities through the Global Urban Observatory, though, there is no consensus around the methodologies and no agreement on the best conceptual framework, the growth of indicator has been on the increase, and they are also being standardized despite the different characteristics of each indicator. There are great deal of challenges in using the different indicators because of their method of development and the cost of manpower included.

Chapter Three: Benchmarking

3 Chapter Introduction

This section looks at the concept of benchmarking as a tool for improvement and how this can be used in the improvement of smart cities. This was followed by a critique of existing smart city benchmarking models, and subsequently the need for smart city benchmarking and the challenges embedded in smart city benchmarking and the subsequent look into the different type of indicators for assessing the smartness of cities. Then, the benefit of benchmarking was explored and followed by the procedure of benchmarking smart cities.

3.1 The Concept of Benchmarking

One of the vital tools for improvement that is brought about by comparing an organization with another one that is recognized as the best within it ranks is called benchmarking (Bhutta and Huq, 1999a)(Bhutta and Huq, 1999a). The principle of benchmarking presupposes that one should be able to recognize one's deficiencies and recognize that another organization is performing a better job, be willing to understudy them and implement the knowledge acquired in one's own organization (Bhutta and Huq, 1999b)(Bhutta and Huq, 1999b). The drive to benchmark has to be enshrine in the ethics of the organization so that the opportunity to benchmark is always seized as at when due. Benchmarking mostly guides to breakthrough thinking and forces an external focus in order to become competitive (Bhutta and Huq, 1999b)(Bhutta and Huq, 1999b). Benchmarking forces an organization to look at what its competitors are doing through an external focus. When benchmarking is well-done, it forces the organization to fucus on its area of strength, and also ensuring that its other processes matches those of its superior competitor.

3.2 Benchmarking of Smart Cities

The American Productivity and Quality Center (1999) defined Benchmarking as 'the process of continuously comparing and measuring an organisation against business leaders anywhere in the world to gain information that will help the organization take action to improve its performance. Hence, the purpose of benchmarking smart cities is to compare them with one another on many factors and construct in order to make the city perform better and to be sustainable economically, socially and environmentally. Extant literature on smart city benchmarking have produced different types of measurement that have assessed different city factors. These include smart city progress, smart city monitoring, smart city capacity, smart city performance, smart city sustainability and resilience and smart city policy (Anthopoulos, Janssennidas and Weerakkody, 2016).

Concerning the smart city progress, the Natural Resources Defence Council developed an index that measured environmental-related criteria (Albino, et al., 2015) while Forbes produced the smart city ranking regarding urban economic performance and concluded to a 72-measurement model (Basiri, et al., 2017). Data from the European Statistical Office (Eurostat) were analysed by Caragliu, et al. (2011), with regards to European smart cities. From the 250 indicators measured across several domains like demography, social aspect, economic aspects, civic involvement, training and education, environment, travel and transport, information society, culture and recreation, they focused on six of them such as Per Capita Gross Domestic Product (GDP) in Purchasing Power Standards (PPS), the Employment in the Entertainment (Creative) Industry, Multimodal Accessibility, Length of Public Transport Network, e-Government, and Human Capital. Caragliu, et al., (2011) carried out several statistical analysis whereby they discovered the positive association between urban prosperity and the presence of a large number of creative Professionals; the quality of human capital; the quality of urban transportation networks; the diffusion of ICTs (most noticeable in e-Government) and lastly a high score in multimodal accessibility indicator.

With reference to the six dimensions of smart city, Lazaroiu and Roscia, (2012) had defined a model with corresponding indices in an attempt to assess urban intelligence or how “good” or “bad” a city is in achieving its smartness (Vanolo, 2014), or its projected level of progress (Fei, 2012). Some studies like Duarte et al., (2014) and Glebova, et al., (2014) had addressed issues on ICT and defined corresponding assessment frameworks (connectivity, accessibility and communicability).

In a bid to develop their smart city roadmapping framework, Lee et al., (2013) defined a set of indices that can measure smart city service performance, components, corresponding devices for service access and technology. Indices regarding smart services assessment concern service measurement, service anticipation, space type, infrastructure components and formal types were grouped in sub-categories, while they were calculated with time scale. Conversely, device assessment concerns their importance, performance level (maturity, use and productivity) and anticipation. Lastly, technology was classified in five categories (sensing, processing, network, interface and security) and is being evaluated with regard to its importance, performance level (application availability, future evolution, maturity, substitute existence at national level, most advance nation in this technology) and anticipation.

Another work done by Marsal-Llacuna, et al., (2015) where they conducted study on urban monitoring contribution to smart city measurement. They compared indicators that address the city's sustainability and livability or sustainable and livable city respectively. Corresponding groups of indicators are opposite with the first group measuring urban environment and local economy with long term data and data from big cities, while the second group measuring quality of life with real time conditions with data even from mid-sized cities. Consequently, their study contributed to the ISO Global city Indicators for City Services and Quality of Life, and they suggested a Smart City monitoring synthetic indices, the Smart City real-time monitoring index. Similarly, class is the real-time smart city monitoring where Malek (2010) studied the suitability of the Informative Global Community Development Index (IGC) for monitoring the smart city initiative. IGC refers to a creative and innovative community which develop its own technology. In his work he assumed that the process of developing an intelligent city has to maximize community's interest in terms of ICT, but his findings from Subang Jaya smart city Malaysia did not justify this claim.

The next class, according to Kourtit, et al., (2014) looks at the size and global performance of city and while the work of UN Habitat, (2014) examined the city potential or good urban governance and urban competitiveness by Singhal et al., (2013), all measured the smart city capacity. Earlier, Kourtit, et al., (2012) wanted to measure the innovation potential of smart cities and in this respect, they performed a principal component analysis (PCA) on European cities. Their study identified the most relevant variable with the highest loading factors, in regard to advanced business and socio-cultural attractiveness (ADBA), presence of a broad (public and private) labour force and public facilities and the presence and use of sophisticated e-services of smart cities.

De Marco et al., (2015) proposed several safety measurement indicators, which provide decision makers with a significant tool to develop corresponding policies. Their study developed a three-level index named the Global Safety Indicator (GSI), which was analysed in road safety and later personal safety on a second level. Road safety uses parameters that measure corresponding mobility threat (traffic, accident, construction sites, parking space, and surface safety) and personal threats (noise, distress and rallies and events). In the same vein, Winters (2011) defined an index model as a measure of city population growth. More directly he defined variables and formulae to calculate inhabitant's input and output flows and to measure agglomeration changes within the urban ecosystem. His study showed that in-migration occurs for educational purposes, and it is mainly based on people from the same state, while many of the immigrants select to remain within the smart city, which results to corresponding population growth

The fourth class emphasizes on sustainability – both economic and environmental-(Pires, et al., 2014; Mori and Christodoulou, 2012; ITU, 2015), local government effectiveness (da Cruz and Marque, 2014) and resilience (Desouza and Flanery, 2013). Such a measure is not a simple process and involves alternative values, while the adoption of a synthesized index, a composite index or a single indicator should be avoided. It is appropriate to compare environmental, economic, and social aspect respectively among cities at least, because the aspects are complex complement of trade-off relationship and because a composite index often implies weak measurement (Mori and Christodoulou, 2012). Moreover, the European Initiative on Smart Cities or more specifically the Strategic Energy Technologies Information System (SETIS) focused on smart energy networks, these include: 50% of heat and cooling demand from renewable energy sources (RES); launching at least 20 exemplars by 2015 for "smart grids" coupled with "smart building" equipment and measuring energy consumption with "smarter meters".

The last class which address policy making in the cities, which can also be evaluated with regard to its potential impact (Kii et al., 2014) even with a focus on particular decisions (that is, energy consumption (Gouveia et al., 2016)). Beyond the above scientific studies, several market analyses can be located that evaluate city performance from alternative perspectives. For instance, with regard to city attractiveness for investments, top four factors concern easy access to market, customers and clients (instead of the availability of quality staff); quality of telecommunication; transport links with other cities and internationally; and current local economic climate (Cushman and Wakefield, 2009).

There are many benchmarking processes because of the broadness of the field. In similar vein to the modelling overview, the benchmarking comparisons also show the diversity of dimensions that are taken into account. The benchmark sometimes looks completely at different aspects which hampers comparison. This makes it hard or even impossible to compare the benchmarking outcomes with one another. In one benchmark a city might be doing well, whereas the same city might be performing lower in another benchmark. In general, it appears that scholars do not follow existing modelling when they introduce their benchmarking methods.

3.3 Critical Review of Existing Smart City Benchmarking Models

Arribas-Bel et al. (2013) observed that cities and metropolitan areas in our world are to some extent operating like business firms in an open globalizing world. They may wish to enhance their international image, their socio-economic or cultural profile or their relative position. There have been many attempts to create a ranking system for major cities in our world in order to offer a systemic performance assessment of these cities. Such ranking system has normally two objectives: 1) it provides stakeholders a comparative insight into the strong and weak points – relative to competitors- of the city at hand, and 2) it offers evidence-based information for a tailor-made marketing policy of a given city (Cerreta, Concilio, and Monno, 2010). Such benchmarking exercises provide decision makers with focused handles on how to improve their relative position.

An original comparative study on leading cities of the world and their competitive advantages was undertaken by Grosveld (2002). His critical analysis of the strong and weak points of cities all over the world has been inspired by Porter's seminal book on 'The Competitive Advantages of Nations' (1990). This research aims to map out the key local factors that determine the international competitive position of cities in a globalizing world with the aim to arrive at a global ranking of cities. The data for the statistical review of these cities stem mainly from perceptions of decision-maker and experts in these cities. The perception are subdivided into integral and functional perceptions and are based on survey questionnaires. The absence of stakeholder, NGOs and businesspeople make this finding ungeneralizable

Another recent study on the comparative performance of cities can be found in Caragliu, et al., (2011). The authors aim to analyse urban performance from the perspective of infrastructural, human and social capital. They address in particular smart cities. The statistical analysis of these cities was based on extensive database from the EU Urban Audit data source, which comprises much information on demography, social aspects, economic impacts, training and education, environment, culture and recreation. The authors aim to offer an exploratory underpinning for city rankings on the basis of a broad set of underlying city attribute (e.g., accessibility, public transport, etc.). The authors combined also the city profiles with various functional urban criteria and were able to confirm various positive correlations between urban growth and underlying parameters. A major deficiency was of a taxonomy to categorise the smartness of the smart cities involved in the benchmarking exercise.

An interesting study on the urban world, by mapping the economic power of cities, is the research publication of Mckinsey Global Institute (2011). This research gives a ranking of the economic performance of 600 cities all over the world, based on their contribution to global economic wealth. It goes without saying that major metropolitan areas such as New York, London, Shanghai, Tokyo, Paris or Chicago assume top positions on this rank list. To measure the smartness of a city, economic aspect is just one of the many parameters. Hence this benchmarking process is grossly deficient as issues bordering on living, environment, governance, mobility, environment, infrastructure and services had not been considered.

The Japanese institute for Urban Strategies (2010) would have been the best of the benchmark but it focus on global cities alone has limits the scope of the study and its robustness. The study was based on actual data collection complemented with opinion of stakeholders. It maps out the strength and weakness of many global cities and their potential to attract creative people and excellent companies from around the world amidst keen competition.

Another benchmark is the work of Arribas-Bel, et al., (2013) where they based their work on the foundation laid by the Global Power City Index of the Japanese Institute for Urban Strategies (2010). It provides a comprehensive ranking of leading global cities based on 69 indicators of a city across the multiple dimensions namely: ‘economy’, ‘research and development’, ‘cultural interaction’, ‘livability’, ‘ecology and natural environment’ and ‘accessibility’. The Self-Organizing Maps (SOMs) offered an enhanced visualization of the results of the GPCI and depict the similarities among cities under consideration. The methodology of analysis, the SOM, is dynamic and the factors assessed left out the people that are the core of the smart cities

Table 3. 2 Critique of Existing City Benchmarking studies (Source: Authors Literature Review, 2021)

Author	*Benchmark*	*Aim*	*Methodology*	*Findings*	*Observations*
Grosveld, (2002)	*Comparative study on world cities and their competitive advantages*	*Map out key local factors that determine the international competitive position of cities globally*	*The perception are subdivided into integral and functional perceptions; questionnaire survey Statistical analysis*	*City were ranked accordingly*	*Only decision-makers and experts in these cities were use in the survey. Stakeholders, NGOs, businesspeopl e were excluded*
Caragliu, et al., (2011)	*Comparative performance of smart cities*	*offer an exploratory underpinning for city rankings on the basis of broad-base city attributes*	*Analyse urban performance from the perspective of infrastructural , human and social capital Statistical analysis of European Urban Audit data base*	*Positive correlations Urban growth and the underlying parameters were unravelled*	*The taxonoly of smart city was not developed.*
Mckinsey Global Institute, (2011)	*Mapping the economic power of cities*	*Ranking economic performance of 600 cities in the world base on their contribution to global economic wealth*	*survey*	*Major world cities like New York, London, Shanghai, Tokyo etc. assumed top positions*	*It is discriminatory , Economy alone does not make a city. Administration , mobility, security,*
Japanese Institute for Urban Strategies (2010)	*Global Power City Index (GPCI)*	*Mapping out the strength and weakness and rank cities on their comparative*	*Survey and interviews*	*It maps out the strength and weakness of a city and rank them*	*Its focus on global cities limits the scope of the study and its robustness*

		potential to attract brain and businesses		*according to their socio-economic power to attract brain and investment*	
Arribas-Bel et al., (2012)	*Benchmarking through Self-Organizing Mapping*	*Mapping out the relative disparities in competitive performance among a preselected major global city*	*Survey and Questionnaires*	*The SOM depict the similarities among cities under consideration*	*The methodology of analysis, the SOM, is dynamic and the factors assessed left out the people that are the core of smart cities*
Berrone and Ricart, 92016	*City in Motion Index (CIMI)*	*Its goal is to enable measurement of the future sustainability of the world's main cities as well as the quality of life of their inhabitants.*	*Survey and Questionnaires*	*The smartest is bounded within Europe and America*	*77 `city indicators under 10 dominant categories Major international cities were used. It does not tell us the level of smartness of each city. Biased toward Europe and America*
Debnath et al. (2014)	*Transport cities*	*Benchmarking smart city by the smartness of their mobility*	*Web search and contacting transport Authorities and Agencies*	*London, Seattle and Sydney topped the list*	*This is inadequate to determine the smartness of a city as it is just one of the six dimensions of a smart city*

Giffinger et al. 2007	*Quality of health conditions in European medium-sizes cities*	*Identify best practices of regional development strategies for medium-sized city*	*Case studies*	*Ranking should be of the process of drawing lesson and policy transfer between medium-sized cities*	*Medium-sized city only in Europe were used. This has limited the generalization of the finding from this study*
Sikora-Fernandez, (2018)	*Comprehensive Smart City Index (CSCI)*	*To defined smart cities in Poland in human and technical dimensions*	*It use the six dimensions of smart cities*	*The is need for enlightenment campaign in order to influence the citizen to accept the smart city notion*	*It was localized to Poland cities*

3.4 The Need for City Benchmarking

With the global development in human capital which has enhanced the production of ICT-enhanced tools, applications, and systems, that have been deployed in solving simple and complex social, environmental, economic and sustainability challenges, it is natural for such technology to be adopted in every milieu inhabited by human beings. Hence, smart city adoption has become a global phenomenon (Visvizi and Lytras, 2019).

The rapid development of interest in smart city brought about by issues of urbanization, world trade liberalization, increased labour mobility, increased dynamic of cluster development, decentralization of municipal administrations, increasing awareness of the myriad of complex challenges that the cities face and the reconceptualization of cities as the centre of human interaction and above all, centre of administrative authority (Lu et al., 2021).

In the smart city, the need for investment in the digital and physical urban environment is directed against the limited financial resources of many of the cities and an increasing competition for public and private investments, businesses and the city population (Hatuka and Zur, 2020). This can be made more convincing to the population by benchmarking. Also, the creation of beautiful economic spaces and living areas as well as a reliable ICT and physical infrastructure thus form the major advantage for attracting the skilled tourist, workers, citizen and businesses needed for economic success (Komninos et al., 2021). In addition, cities are increasingly seen as instruments for defining one's personality and as a means for expressing one's lifestyle. Strengthening citizens' identification with their place of residence by developing purposeful marketing strategies can thus be expected to form a major part of city marketing in a modern society (Warnecke, Wittstock and Teuteberg, 2019b)

This combination of financial constraints and the necessity of developing both effective and efficient strategies for dealing with the increasing pressures on urban ecosystems highlights a need for assessing, managing and controlling cities' development strategies with regards to sustainability can only be made possible through benchmarking (Warnecke, Wittstock and Teuteberg, 2019a). While many publications on smart cities have focused on the phenomenon of smart city,(Mura et al., 2018), only a handful had examined the operationalization and outcomes of the smart city. Whereas the methods for assessing and controlling sustainability performance may be drawn from research streams such as sustainability accounting (Sharifi, 2020b) city ranking, and benchmarking have been established as a strategic tool for not only assessing urban development but also positioning cities in a competitive environment and devising targeted marketing strategies.

Of late the benchmarking of cities has been much discussed. Although city benchmarking is a disputed concept (Aleksandrov et al., 2022), it is generally believed that cities play a vital role in economic transformation (Florida, Rodríguez-Pose and Storper, 2021) . Hence, cities are an interesting research object from the point of view of benchmarking. The benchmarking factors of cities have been defined in many studies. Some of the benchmarking factors are cost factors, business factors, labour cost, research and development environment, infrastructure, grants and attitudes, and living environment. Other benchmarking factors suggested by Soroui, (2021), are infrastructure, quality of living environment, institution and development networks, embeddedness in network, companies, human resources and image. The combination of image, human resources and living environment form an interesting combination to review. The competitiveness of cities (Brandão, Breda and Costa, 2019), is heavily dependent on the propensity to attract different kinds of flow in a connected global environment. These include, as an instance, financial, human and technological flow.

The quality of the living environment is a vital factor in benchmarking a city. The power of a place plays a strong role when the creative class chooses where too live and work. The quality of a place has three dimensions which includes what is going on (the vibrancy of life on the street, people partaking in outdoor activities); what there is (the combination of the natural environment and the built environment; and who there are (diverse kind of people, interacting and providing cue that anyone can plug into and make a community.

Many people from diverse background are attracted to the city through branding. Branding is the process of planning, designing and communicating the identity and the name of the product, services or business in order to manage or build the reputation(Melewar et al., 2018). Branding a place, of course, is different from branding products and it is not possible to approach the task with the same method. While cities are influenced by economy, environmental disasters, terrorism and international politics, products are affected by external changes. The goal of place branding is to increase the attractiveness of the city through a combination of factors that can enhance its standing and ranking of the city.

3.5 The Challenges of Smart City Benchmarking

Most of the publication that have emerged from research institutions on smart city benchmarking have identified the strength and weaknesses of the cities studied (Castanho et al., 2021; Saborido and Alba, 2020; Mora, Deakin and Reid, 2019) and are also generally confined to the areas of the author's interest, some particular regions of the world, or to some defined population group, thereby making the result not generalizable (Warnecke, Wittstock and Teuteberg, 2019a). The forgoing benchmarks exclude interactive elements that allow stakeholders to continuously monitor and assess the development and sustainable performance achieved in their city in comparison to other neighbouring cities. Some benchmarking are freely available online for smart cities to benchmark themselves with other cities, but the indicator used in this online benchmarking framework may not be available in the smart city dashboard (Lnenicka et al., 2022).

3.6 Type of Indicators

Indicators can be classified to two types, namely the single indicators and the composite indicators. here are the details of each indicator.

3.6.1 Single indicators

The single indicator consists of statistics related to one phenomenon or a single measurement. For instance, the total number of deaths per annum or the death rate where the total number of dead people is standardized against the total population. Direct measure are the most desirable single indicators, that are unambiguous and well defined, which have strong representativeness as they measure what they claim to measure, and can be captured as a quantitative construct (Kitchin, Lauriault and McArdle, 2015). These indicators are sensitive to change, easy to interpret, neutral and value-free, quick and cost effective to collect, process and update, independent of external influence, objective, traceable over time (Kitchin, Lauriault and McArdle, 2015). Where the phenomenon of attention is intangible or not directly observable, an indirect indicator is used. For instance, the number of people admitted to the hospital as result of motor bike accident can be used to measure the rate of motor bike accident (Perry et al., 2007). In some situations, the high cost of direct measure, leads the officials concerned to opt for surrogate variable from pre-existing data sets like the census figures.

3.6.2 Composite indicators

The composite indicators are produced in-house or collected from third parties like consulting firms, (who has intellectual property rights over their indicators) or a think tank. This is where a new measure is obtained by combining several single measures using a system of weight or statistics (Freudenberg, 2003). Composite indicators accept that no one indicator can reveal the extent or complexities underpinning an issue like area characteristics or deprivation. A good example of composite indicators is well-being which may cover dimension such as income, employment, health and education. Other composite indicators include the environment, economy, globalisation and society (Freudenberg, 2003).

3.7 Benefits of Benchmarking

The benchmarking activities have become expedient due to a lot of factors some of which are listed below:

> First, when the authorities desire to succeed at an international level and prepare to invest, they need to know where they stand in comparison to other cities. Other government-level authorities are also interested in the international position of the most important cities in their country, state or local government. This can play an important role, for example, in determining policy on the quality and timetable for investment in national and regional infrastructure.
>
> Lobbying from associations of businesses, emphasizing the importance of certain actions, can also influence not only the direction of the city authorities' policy but also the attitude of their own members. Their arguments are often supported with some kind of ranking list, in order to demonstrate that there is certain room for improvement.

Individual companies, institutions and people working in an international context (or with an ambition to do so) have a professional need for information on how cities are positioned as a factor in their plan for, for example, establishing a branch of their company, a concert tour, the sale of real estate or determining a schedule of conference.

3.8 Benchmarking procedure

It was also striking that the city 'rankings' were almost entirely based on quantitative data; so much of this, so much of that. Where was the human component, where were the feelings? Of course, you can read each year in Fortune which cities are 'the hottest places on earth' according to a number of senior executives. Life is indeed fast and everything changes, but do these 'top shots' really change their minds so quickly that each year different cities are suddenly 'hot'? Most remarkable, however, was that the publicists themselves decide what the relevant competitive factors for cities are. Without any kind of research, they simply select them in accordance with their own opinions, or at least so it seems from discussions with such colleagues. Of course, each emphasizes slightly different aspects than the other. No wonder, then, that the ranking or typology of cities is different each time. The top three, the 'triad' New York – London – Tokyo, seem to enjoy complete consensus, but after that it becomes rather confused. (Grosveld 2002)

In this way the conviction grew that there was some room for a practitioner newcomer in the heavily populated academic world, room for someone who wanted to examine the international competitive position of cities - preferably by testing the theory in practice, as Porter did. He stated that," The ability to upgrade an economy depends heavily on the position of a nation's firms in that portion of the economy exposed to international competition" (1990, p. 545). For that reason, he focused his research on that part of the economy. In this way the idea was born of first examining the competitive advantages, competitive positions and related rankings through analysis of the literature, existing data and from experience and then to test the findings through research among the 'city-makers.' These are the businesses and institutions that (can) make a substantial contribution to the international competitive profile of a city. Their top executives deal implicitly and explicitly with international competition every day and should therefore know a great deal about the factors that are important in competition, and they will certainly know which cities go the furthest to meet their needs. Their insight, their perception must provide the data on the basis of which a competitiveness model for cities can be designed.

3.8.1 Harmonizing local smart city indicators in Europe

In a bid to create a common indicator that can be compared at across the different states and local level, the European Union is providing support at harmonizing the smart city indicators. This has proven to be an uphill task of generating consensus on general guideline at the European level. The process of harmonization has enhanced the interaction between different actors within different projects.

3.9 Chapter Summary

The chapter is focused on what benchmarking is and it presupposes that one should be able to recognize one's deficiencies and identify other organizations that are excelling in such sphere and be willing to look at them and implement the knowledge gained in their own organization. The same principle as applied to organizations is applicable to smart cities. Existing benchmarking activities have been fraught with many shortcomings such not being able to reach the desired stakeholder when the study is being conducted, the use of indicators that do not capture the entire sphere of the smart city.

The need for benchmarking of smart cities is no more essential than now, with the proliferation of smart cities and businesses. Professional are looking for centre with economic prosperity and global infrastructure that can facilitate the ease of doing business. However, benchmarking also come with some challenges which are not limited to researchers conducting benchmarking on their areas of interest or restricted to some regions of the world. The indicators for benchmarking smart cities are either single or composite indicators. The benefit of smart city benchmarking among other is to see where a particular smart city stands with respect to its contemporaries in the world and this has been useful in attracting investments to the city. The process of city benchmarking in some instances do not follow a scientific system whereby objective indicators were used. Some process go through literature and existing data before conducting a sampling of experts to arrive at their decision.

Chapter 4: Theoretical Framework

4 Chapter introduction

This chapter looks at the theory of benchmarking and goes to define what benchmarking entails leading to the model for benchmarking smart cities. Also, the criteria for benchmarking was discussed and also the classification of benchmarking. This is followed by the different types of benchmarking models. The theories of evaluative practices and dynamic system theory were examined and the implication of these theory on smart city was discussed.

4.1 The Theory of Benchmarking

In 1979, the first comprehensive benchmarking project was conducted by Xerox Corporation based on the fact that the production cost of photocopier machine in the USA was far more exorbitant than in Japan. Xerox was able to gain insight into the process, methods and materials used by the Japanese photocopier manufacturer to make their photocopier competitive and profitable. This method used by Xerox to make Xerox photocopier more competitive and efficient is called benchmarking. This led to the development of a nascent managerial tool called benchmarking and improves Xerox's competitive position. Benchmarking is defined as the search for industry best practices that lead to superior performance (Camp, 1989).

Benchmarking has become a household name in the business environment, and it is widely practiced globally. This has made benchmarking to be subjected to different modification and innovations to its original intent, scope and methodologies as evident from different literature. This has made benchmarking strategies, tactics and activities to be continuously relevant and timely in the contemporary social, economic and environmental affairs. Hence, benchmarking in the contemporary situation focuses on the entire supply chain and its electronic management and the whole gamut of internal operations of firms and organizations. This is particularly the situation with the development of supply chain management and e-commerce.

4.2 Definition of Benchmarking

Rank Xerox proposed a definition of benchmarking, and it says that "it is a continuous systematic process of evaluating companies recognised as industry leaders, to determine business and work processes that represent best practices and establish rational performance goals"(Rolstadas, 2013). In all cases in operational terms benchmarking is usually condensed to the search for industry best practices that lead to superior performance. The term best practices is meant to be the method used in work processes that best meet customer requirement. Benchmarking is about how certain goals are achieved, the process followed, the outcomes and not just about the achievement of the best performance.

The definition of benchmarking varies. Prominent features in the definition include measurement, comparison, identification of best practices, implementation and improvement. In one definition, (Camp, 1989), defined benchmarking as the achievement of exceptional performance through the search for the best industry practices by implementation of these best practices procedures. There are many other definitions of benchmarking, Nandi and Banwet, (2000), forty-nine of these definitions have been found by Spendolini while Maire et al, (2005), noted that the various definition of benchmarking are postulated to express a specific aspect of benchmarking exercise and based on these definitions, they propounded that benchmarking should consist of four stages of development. Some of the definitions that features prominently during this evolution are Vaziri (1992), Maire, (2002) Freytag and Hollensen, (2001), International Benchmarking Clearing House Design Committee (1995), Dervitsiotis (2000), and Bemowski, (1991). A current definition of benchmarking indicates that it is the improvement of an organization performance by identifying, understanding and adapting the outstanding practices of some of the best organization in the world in that perspective. Hence, benchmarking is an activity that looks outwards to find the best performance and outstanding practice and then measures the concrete business operations against those goals (Tokos, Pintarič and Krajnc, 2012).

Also, from the various definition of benchmarking it can be inferred that benchmarking is also a continuous examination of process, strategies, functions, products or services and performance compared with or between best-in-class organizations by obtaining information through appropriate data collection method, with the intention of assessing an organization's current standards and thereby carry out self-improvement by implementing changes to scale or surpass those standards.

The nature of benchmarking shows that it is a major investment that is both time and resource intensive and consequently should be carefully executed (Matook, Lasch and Tamaschke, 2009). Therefore, publications in the past were more directed on organizational prerequisite and conditions for fruitful benchmarking which are as follows:

Centred around employers, customers and continuous improvement (Kanji, 2008).

Willingness to change, willingness to share information, strategic focus and flexibility, management support (Wu et al., 2013).

Procedure understanding and commitment, good communication is needed within the organization (Klein, 2012; Punjaisri and Wilson, 2011).

In the contemporary dispensation, benchmarking is concentrating on improving the benchmarking process and identifying the missing links. This fact is supported by Dattakumar and Jagedeesh, (2003), who noted that benchmarking methods has seen a steady growth and seems to be heading towards maturity level, considering the gamut of literature published in the field. For instance, the limitations of benchmarking in an established organization to a more competitive future one was discussed by Dervitsiotis (2000). Similarly, Ungan (2004), noted that the fact that many organizations are conducting benchmarking, however, many of these establishments are not fully adopting the best practice as it was expected and therefore, he looked at the factors that have impact on the embracing of decision of best practices in manufacturing.

A very important observation that benchmarking of organization usually take place at the output stage, which is the downstream of businesses, was made by Anderson and McAdam, (2004). However, benchmarking should take place at the upstream stage of input, process stage where lead benchmarks of performance are to be recognized. This suggest that benchmarking must grow from being backward looking static measures to more forward-looking dynamic ratios for which a new model called lead benchmarking has been recommended. In the same vein, to be able to assert that a best practice is actually the best; to also be able to know how to assess the best practiced organization; and what is the best technique for determining the best practice organization- this requires a robust capability in data analytics in the benchmarking exercise (Collins et al., 2006).

4.3 Smart City Benchmarking Models

The benchmarking model is an instrument use to measure the level of sophistication, quality and competency of sets s of objects. Benchmarking models have been produced for many fields of life to assess qualitatively the progress of a specific area towards a set goal, with each maturity level representing a discrete stage of development within a desired or typical evolutionary path (Tarhan, Turetken and Reijers, 2016). Each of the benchmarking level is defined by a wide-ranging set of broadly accepted and generalizable criteria. The lowest level denotes the initial stage of development, whereas the uppermost level defines complete maturity with high performance, thus allowing the employment of maturity model as a comparative basis for categorising improvement approaches (Keathley-Herring et al., 2016). Hence, high performance corresponds with high level of maturity.

The New Public Management (NPM) framework is the root of performance management in public sectors in the OECD countries in 80s and 90s (Hammerschmid et al., 2019). As part of this paradigm shift, the public sectors were adopting the management tools from the private sectors with the intention of redefining institutional roles to enhance market and service orientation and also of increasing efficiency and accountability (van Helden and Uddin, 2016). Though the degree to which such methods were applied varied between individual countries and institutions, and some argument on whether NPM even make up a coherent body of thought endured (Warnecke, Wittstock and Teuteberg, 2019b), it is usually depicted by management tools aiming to enhance performance, performance monitoring, such as, customer satisfaction surveys, audits and benchmarking (Kuhlmann and Bogumil, 2018).By virtue of being able to identify the strength and weakness of smart city to define measures for improvement, the concept of benchmarking is certainly appropriate for assessing the performance of smart city (Peterson, 2018).

4.4 Benchmarking Criteria

There is little progress in the past decade in the study of cities, their position in the world and the factors that determine this position (Malecki, 2004). Most of the publications on the ranking of cities are in publication on rankings and typologies of cities and these rankings cannot be made without indicating which factors, elements, criteria, functions and indicators that were used (Van Raan, 2005) .Some of the techniques that have been use in benchmarking include the Integral Approach, Functional approach, Global City, Mixture of Factors, Urban Problem Index and Best City for Business indices.

The Integral Approach is the most comprehensive and has a good concrete overview. It uses sixteen factors and many of these factors could not be substantiated. A good example of this index was the World City Hypothesis (1986 and 1995) by John Friedmann, who stressed that some of the indicators that were used to assess a city are its place in history, cultural facilities, its multicultural nature, integration into the world economy, and its role as a capital city. He made New York as a good example and stated that the power of this index lies in their combination. Friedmann introduce the World City Formation Index due to the deficiency of the World City Hypothesis. The World City Formation Index has the following indicators: multinationals, financial centres, international institutions, business services, industry, transport and communication, hotels, number of inhabitants and professional workforce.

Another extreme classification performed using some functions such as financial institutions, transport, hotel and congress is the Functional Approach. Here in this group are all the reports, researches, indexes and studies that classify cities according to one distinguishing factors like criminality, quality of life and cost of living (Harry, 2002). The third factor called Global City Model developed by Sassen, (2013), suggests that the cities are ranked based on the presence of the headquarter of multinational, financial institutions and related management of corporate services domicile in the city, the idea which Knox, (2011), disagreed with because they are not based any critical research.

The fourth is a combination of publications which do not fall under the initial three but on an agglomeration of factors which are not comprehensive. The mixture have some common factor like the economic function of Sassen, (2013), are normally integrated coupled with their peculiar parameters,(Palomaki, 1991 and Knox, 2011), included international organizations; (Knox, 2011), cultural centrality; Short, (1999), site of global centrality; Lippman-Abu Lughad, (1995), multiculturality; van den Berg, (1991), urban governance; the concern authors have is a justification for the particular emphasis they have chosen, but what remains, is how relevant these selections are in the context of international competition.

Cheshire, (1990) produced the fifth factor in which he used data for immigration, unemployment, gross municipal product and what he calls the 'travel demand index' leaving out the productivity functions that goes with the indices. Many researchers do not like this method. Best City for Business produced by Fortune Magazine and Europe Top City Monitor by Wakefield, or Healy and Baker Real Estate Consulting are the sixth factor. The Best City for Business does not have a reliable method of city assessment while the Europe Top City Monitor utilizes factors that are annually reviewed through consultation of 500 senior executives in Europe, who know what they are talking about (Harry, 2002).

4.5 Classification of Benchmarking

Going through the literature reveals the existence of diverse classification of benchmarking. Fong et al., 1998, suggested the following classification as shown in table 4.1.

Table 4. 1 Classification of Benchmarking. Source: Fong et al., (1998)

Classification	Type	Meaning
Nature of referent other	Internal	Comparing within one organization about the performance of similar business units or process
	Competitor	Comparing with direct competitors, catch up or even surpass their overall performance
	Industry	Comparing with company in the same industry, including non-competitors
	Generic	Comparing with an organization which extends beyond industry boundaries
	Global	Comparing with an organization where its geographical location extends beyond country boundary
Content of Benchmarking	Process	Pertaining to discrete work process and operating system
	Functional	Application of the process benchmarking that compares particular business functions at two or more organization
	Performance	Concerning outcome characteristics, quantifiable in terms price, speed, reliability etc.
	Strategic	Involving assessment of strategic rather operational matters.
Purpose for the relationship	Competitive	Comparison for gaining superiority over others
	Collaborative	Comparison for developing a learning atmosphere and sharing of knowledge

As there are many definitions of benchmarking, this suggests that there would be diverse classification of benchmarking to support these definitions. This is enunciated in the table 4.2 for clarity

Table 4. 2 Overview of the other different classification schemes and types of benchmarking. Source: Fong et al., (1998)

<table>
<tr><td>Authors</td><td>Number of Classifications</td><td>Name of each classification and type</td><td>Remarks</td></tr>
<tr><td rowspan="2">(Maas and Flake, 2001)</td><td rowspan="2">2</td><td>Hooded benchmarking</td><td>This is a benchmarking process which limits the anxiousness of copying and misuse of data by taking care of sensible data and releasing them anonymously</td></tr>
<tr><td>Open benchmarking</td><td>This is a benchmarking process in which the handling of data and information is agreed upon by the partners involved through the use of a code of conduct</td></tr>
<tr><td>(Nandi, 1995)</td><td>12</td><td>According to the organization chosen for benchmarking
• Internal benchmarking
• Competitive benchmarking
• Industry benchmarking
• Best-in-class benchmarking
• Relationship benchmarking</td><td>Relationship benchmarking has not been addressed by many authors, however, internal benchmarking, competitive benchmarking, industry benchmarking and best-in-class benchmarking have been defined by some authors.</td></tr>
</table>

		According to the goals of the benchmarking • Performance/Result benchmarking • Product/Customer satisfaction benchmarking • Strategic benchmarking • Process benchmarking • Diagnostic benchmarking	The benchmark in this category can be classified as sub-classification of the above- mentioned categories. The source of data for each type can be best-in-class industry, joint-venture partners, internal plants or competitor. The definitions given by other authors are similar to the ones given to strategic benchmarking, process benchm-arking, and product benchmarking. Other benchmarking process which were not addressed by other authors like performance bench-marking and diagnostic benchm-marking have been proposed.
Shetty, (1993)	3	Strategic Benchmarking	
		Operational benchmarking	
		Business-management benchmarking	
Lema and Price, (1995)	6	Internal benchmarking	
		External benchmarking • Reverse engineering • Competitive benchmarking • Functional benchmarking • Generic benchmarking	The sub-classification under external benchmarking are some-what non-functional as one of the procedures in benchmarking is looking for a benchmarking partner. In this situation, the firm may select an internal plant or a competitor or a best-in-class company, that may not be a direct competitor.
	5	Internal benchmarking	They noted that Consultant study benchmarking is one of

Singh and Evans, (1993)		Functional benchmarking Competitive benchmarking Generic benchmarking Consultant study benchmarking	the method of conducting benchmarking but that it is not in line with common classification of benchmarking
(Spendolini, 1992)	3	Internal benchmarking Competitive benchmarking Functional benchmarking	It does not consider strategies, performance and practice benchmarking, it is concerned about products, services and processes
(Codling, 1992)	3	Internal benchmarking	The definition of internal and external benchmarking is related as both are comparing with partners from different business units of the same enterprise
		External benchmarking	
		Best practice benchmarking	The definition given by Spendolini, (1992), for functional benchmarking is similar to the meaning given to best-practice benchmarking
(Partovi, 1994)	6	Four types according to benchmarking partners • Benchmarking internal operations • Benchmarking your competitors • Benchmarking against best-in-practice • Strategic benchmarking	

		Two types • Product benchmarking • Process benchmarking	Strategic benchmarking integrates strategic competitive analysis with best-in-class benchmarking
(Malec, 1994)	3	Strategic benchmarking	Here is a different arrangement. For instance, competitive benchmarking seem to look like strategic benchmarking. This classification is deficient with respect to process, performance and internal benchmarking
		Business benchmarking	
		Product benchmarking	
Lema and Price (1995) and (Jackson, Safford and Swart, 1994)	4	Internal benchmarking	These authors agreed on the classification of benchmarking, however, there is no consensus on the meaning they gave to each of them
		Functional Benchmarking	
		Competitive benchmarking	
		Generic benchmarking	
(Karlof and Ostblom, 1993)	3	Internal Benchmarking	
		Functional benchmarking	The meaning of functional benchmarking combines the meaning of generic and functional benchmarking
		External benchmarking	While this contradicts the definition given by Codling, the meaning of external benchmarking overlap with that of competitive and functional benchmarking.

			They disagree with the notion of a competitive benchmarking
(Le Vie, 1999)	6	Internal benchmarking	Based on cooperation, relevance of information and degree of breakthrough, the type of benchmarking has been proposed. The core definitions are not change while the classify-cation are different.
		External competitive benchmarking	
		External industry(compatible) benchmarking	
		External Internal (cross-industry) benchmarking	
		Combined internal and external benchmarking	

It is the contention of Fong et al., (1998), that during the process of selecting a particular benchmarking type, the firms should adopt a contingency approach for the selection of different benchmark. They should look at major factors such as the degree of natural trust, level of interdependence, strategic activities and number of benchmarking partners that guide the choice. For instance, when benchmarking partners are highly interdependent, the process of benchmarking is expected to be highly collaborative or very competitive. Benchmarking is likely to be collaborative when it is initiated by a third-party agent and likely to be competitive when initiated by an individual. These comments are the evidence that suggest that the current classification scheme makes it more difficult for the users to recognise and select a correct benchmarking type. The following categories of benchmarking classifications have been identified. They are functional benchmarking, competitive benchmarking, best-in-class benchmarking, external benchmarking, strategic benchmarking, operational benchmarking, business management benchmarking, consultant study benchmarking, reverse engineering/product benchmarking, process benchmarking, open benchmarking, internal benchmarking, relationship benchmarking, performance benchmarking/result benchmarking, diagnostic benchmarking, hooded benchmarking, etc. With these broad categories of classification of benchmarking, many of the categorization overlap in their meaning with one another. This creates confusion and raises some critical queries in the mind of practitioners such as: are there separate benchmarking process for each category of benchmarking, judging by the magnitude of the different classification and in a benchmarking process why there should be a process in identifying the benchmarking subject?

On the basis of experience and domain knowledge, benchmarking could simply be classified as internal and external benchmarking. The remaining categories like product, process, strategy and functional benchmarking can be subsumed under these two categories. This is because, when we decide to benchmark, we want to choose the subject of benchmarking which can be a process, function, product, performance and strategy. Whatever may be the theme, an appropriate benchmarking partner has to be located. Such partner may be from internal sources or an external firm, which may be another plant or a branch of an organization or it can be a direct rival or a firm from totally different industry. This type of classification for benchmarking may be simple and can lessen the confusion among the practitioners.

4.6 Different types of Benchmarking Models

The transformation in benchmarking has moved from continuous and systematic process of evaluation of the product and services to a continuous process of learning, identification, and implementation of the best practices so as to achieve a competitive advantage, which could be internal, external or even generic. A good benchmarking system should be flexible for modification to meet individual requirements and also provide the basic framework for implementation ((Elmuti and Kathawala, 1997). The model that is eventually decided upon should emphasize logical planning and organization, clear and simple, and creating a protocol of behaviour and outcomes. The function of the benchmarking process model is to describe the stages that should be carried out while performing benchmarking. As the basis of different benchmarking framework is similar, majority of the authors have tailored their methodology or models based on their personal observations and practices (Mackay et al., 2004).

Benchmarking activities could involve many stages that may be up to thirty-three steps while some could just be as little as about three few steps (Bhutta and Huq, 1999b). During the process of designing a new benchmarking wheel, Andersen and Moen, (1999), have identified 60 different existing models proposed and developed by esteem researchers, experts and consultants, and academics in the field of benchmarking. The benchmarking model have been classified by Baba, Yusof Mohd and Azhari, (2006), as consultant-expert models and academic research models. A third category has been developed and this is called the industry-based model.

The Consultant/Expert-based models: Using experience in conducting consultancy services to firms embarking on a benchmarking project, these models are developed from the expert's personal judgement and opinions. By using the client organizations, these models would be adequately validated and tried and therefore the approach used by the expert/consultant is usually more practical in nature. On the other hand, the Academic/Research-based models are developed through the research, experience and knowledge of the academics and researchers using theoretical and conceptual paradigms which may be real or hypothetical while the Organization-based models are developed and propounded by organizations based on their knowledge and experience and therefore tends to differ from the model developed by other organizations in terms of its process, product, scope and market.

The foregoing benchmarking models are, because of the background of their developers, different in the number of phases, steps involved and their application and this has made it a challenge in selecting the requisite benchmarking tool to use in conducting a benchmarking exercise as each of the benchmarking models have been customised to their fields or areas development. This puts the expert in a dilemma of choosing the appropriate benchmarking tools and whether it meets their requirements.

4.7 Theory of Evaluative Practices

The Theory of Evaluative Practices involves the feasible approaches that could be adopted to assess the performance of a system or construct (Shadish et al., 1991). This study aligns with Scriven's (1991) logic of evaluation, which commences by identifying the items to be evaluated and proceed to establish the criteria for the merit of the items. Subsequently, the performance of the items in relation to the criteria of merit must be determined before drawing valid conclusions. In order to accomplish these objectives of the logic of evaluation, a social agenda approach, which favours constructivist evaluation (Guba and Lincoln, 2001) and qualitative methodology, was adopted. According to Bryson et al., (2011), it is vital to consider the stakeholders views and needs in a valid evaluation process. Hence in obtaining an in-depth understanding of the phenomenon, a constructivist evaluation is desirable.

4.8 Dynamic System Theory

Although performance measurement and benchmarking of smart cities have received massive research attention (Giffinger et al. 2007; Moir et al., 2014; Zygiaris 2013; Joss et al. 2015), a key challenge is the non-existence of smartness measurement and benchmarking models that represents the dynamic and complex relationships among interacting political, economic, social, technological, legislative, and environmental factors (Caird, 2018). Besides, Caird and Hallett (2019) highlight that existing models focus more on projects rather than at the city level. The identification of relationships between soft/intangible metrics (whose urban value and outcomes are difficult to evidence) and concrete metrics at a city level even poses a greater challenge. This PhD will therefore adopt Dynamic System Theory (DST) to describe the relationships that exists among various components a smart city as a complex system. DST characterises all possible inputs to a system and represents both predictable and unexpected outcomes (Theken, 2005).

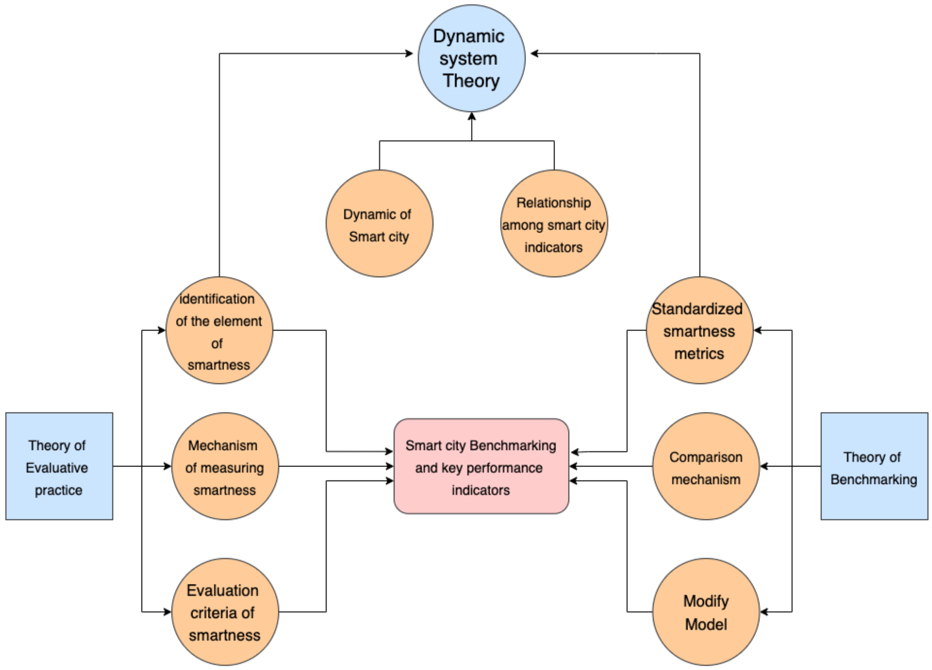

Figure 4. 1 Theoretical Underpinning of this Study (Source: Author Literature review)

4.9 Implication of the Theories on the study

Theories of benchmarking and dynamic system theory both touch on this study, as they both emphasize the importance of setting benchmarks in order to measure and assess the performance and effectiveness of a system. Benchmarking theory is used to compare the performance of an organization against a standard or reference, while dynamic system theory looks at how a system evolves and changes over time. Theory of evaluative practices is also relevant to this study as it focuses on the use of evaluation to identify opportunities for improvement and progress. This includes identifying specific objectives and measuring performance against them, as well as using evaluative practices to assess the impact of changes to the system. This theory is especially relevant to the study as it emphasizes the importance of using evaluative methods to assess the effectiveness of a system and to identify areas for improvement. Generally, all three theories are relevant to this study as they focus on the importance of measuring performance and assessing the effectiveness of the city. They provide a theoretical framework for understanding how to use benchmarking, dynamic system theory, and evaluative practices to measure and assess the performance of the smart city, and how to identify areas for improvement.

4.10 Chapter Summary

The theory of benchmarking emerged as a consequence of Xerox Corporation seeking to improve their process, method and materials of production by drawing insight from a sister company in Japan. Benchmarking is a continuous systematic process of evaluating companies recognised as industry leaders, to determine business and work process that represent best practices and establish rational performance goals. The benchmarking model is an instrument deployed to measure the level of sophistication, quality and competency of sets of objects. It has a range where the lowest level denotes initial stage of development, and the uppermost level defines complete maturity with high performance. The benchmarking criteria like Integral Approach, Functional Approach, Global City, Mixture of Factors, Urban Problem Index and Best City for Business Indices were reviewed.

The different types of benchmarks and their classifications was espoused and the different types of benchmarking models like the industry-based model, the Consultant /Expert-based model and the Academic/Research-based model. The theory of evaluative practices and dynamic system theory and their implication on the study, as they emphasize the importance of setting benchmarks in order to measure and assess the performance and effectiveness of the city.

Chapter 5: Methodology of this Study

5 Chapter Introduction

This chapter looks at the methodology of the study, the research design and the process involved in the research. Also, some of the philosophical alignment of the study like the ontology, ontological assumption, the epistemology and the epistemological underpinning of the study, the research paradigm and the research approach to the study were x-rayed. Also is the section on research choice which included both quantitative and qualitative research approach and the justification for the use of a mixed method research. The research strategy, the way to identify the case, multiple or single case study and the justification for the case strategy adopted were looked into. The strategy adopted in the sampling of the participants which comprise of qualitative sampling and quantitative sampling approaches followed by the data collection method which were also both quantitative and qualitative data collection method were discussed. The validity, which comprise external and internal validity and the ethic approval were also discussed.

5.1 Research methodology

A mixed method approach will be used in this study in conformity with the research goal because it is crucial to use a strategy that drives in-depth comprehension of the phenomenon as well as the generalisation of the findings. Mixed methods approach focuses on methods and techniques that drive genuine solution to a research problem and it gives the researcher the possibility of combining data collection and analyses methods from both qualitative and quantitative techniques (Bryman, 2007; Johnson, et al., 2007). The mixed method though usually very expensive and time consuming, maximise the likelihood of getting a high level of sophistication in the accuracy and quality of the final dataset (Beal, et al., 2013); also, to obtain meaningful and useful information (Soyinka, 2016); and obtain a clearer view of the object of study (Sandoval-Almazan, et al., 2015)

Hence the study anticipates fulfilling two purposes by adopting a mixed method research: (1) to statistically demonstrate findings which have broad applicability and (2) to facilitate a practical representation of real-life experiences of practitioners on issues relating to this research area. This approach was used by Dameri, 2013, to investigate the definition of smart city using the theoretical and empirical methods. The research process is shown in the chart in Figure 1. Table 4 shows the choice of methodology and their justification.

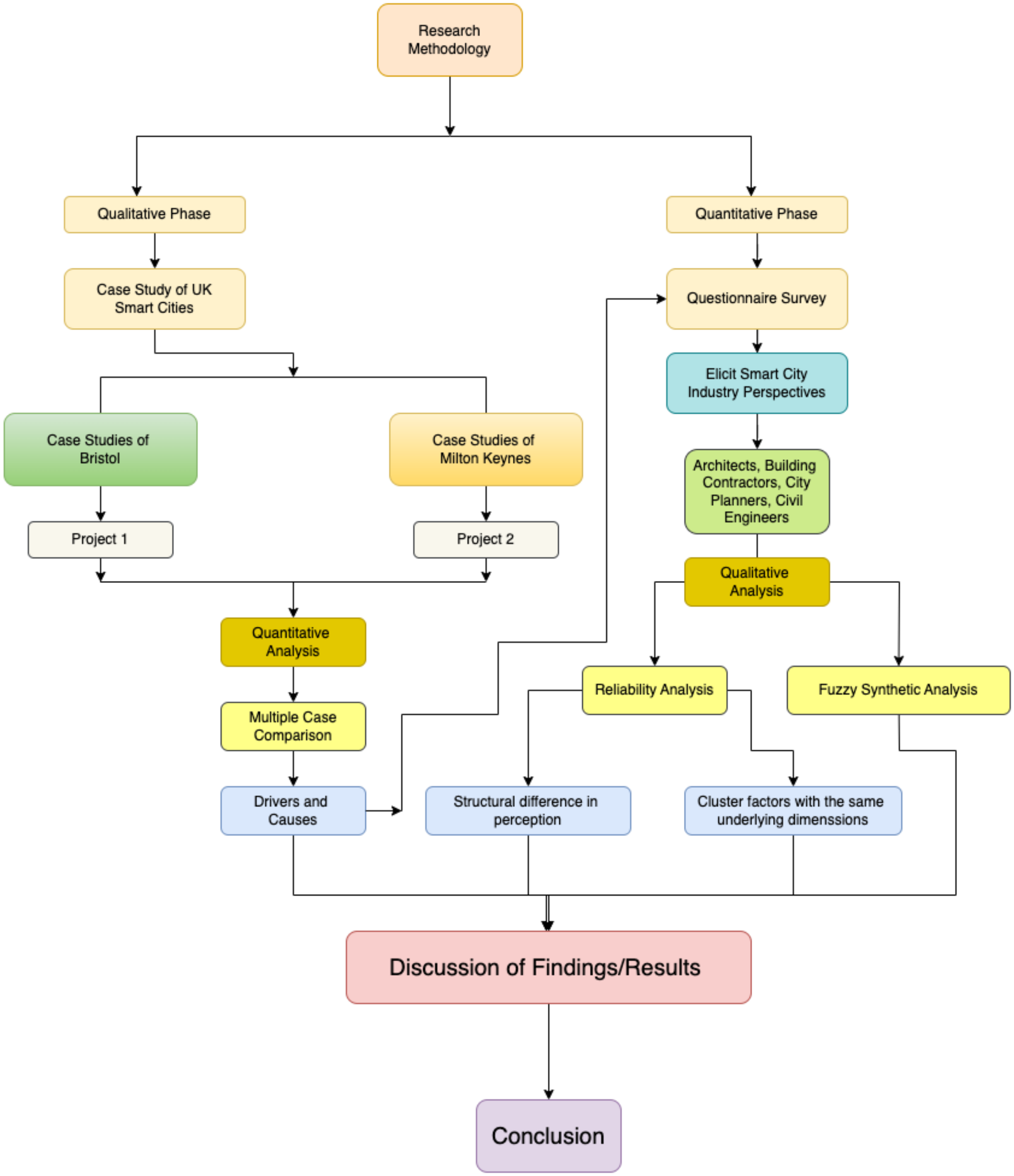

Figure 5. 1 Flow Chart of the Research Methodology for the PhD Study

5.2 Research Design

Overlapping themes and action plans such as conceptual approach, design strategy for data collection and sampling techniques are some of the issues considered in research planning. A good example of research design that have been very amenable is the Saunder's (2011) research onion diagram, in which, the entire research design is taken in hierarchical and chronological order to present a holistic framework for the research process (Mizsey and Fonyo, 1995). This includes the research philosophy, approach, strategy, choice, time horizon, techniques and procedures (Saunder's 2011). Research problems in the current study will be addressed by borrowing ideas from the onion diagram. Though, a more complete approach to the entire process will be introduced. Table 1 below show the stepwise mode for the research.

Table 5. 1 Justification for Choice of Methodology

Area of Choice	**Available Methodology**	**Methodology adopted**	**Justification**
Ontology	Realism (Objective) Idealism (Subjective)	Realism	This is based on the acceptance of value free knowledge for the study
Epistemology	Objectivism Subjectivism Constructionism	Objectivism Constructionism	Knowledge of smart city is existing
Research Paradigm	Positivism Interpretivism Constructionism Post-Positivism Postmodernism Participatory Action Research Critical Realism	Critical Realism	The challenge of sustaining the concept of universality or independent of being in the face of knowledge relativity.
Research Approach/ Reasoning	Deductive Inductive Abductive/ Retroduction	Abductive/ Retroduction	It is borrowing from induction and deduction making triangulation of method very easy in qualitative and quantitative techniques

Methodology	Qualitative Quantitative Mixed Methods	Mixed Methods	The research adopts a mixed method approach, which combines qualitative and quantitative enquiries.
Research Strategy	Narrative Research Phenomenology Ground Theory Ethnography Case Study	Case Study	The method is adopted because the subject of consideration has to be examined to see what they have, lack and needed in order to function optimally
Type of Case Study/Design	Single-Case Design Multiple-Case Design	Multiple-Case Design	This will facilitate comparison in order to bring out the fact
Sampling Strategy for Selecting Case Studies and research participants	Random Sampling Stratified Sampling Maximum Variation cases Paradigmatic Cases Convenience Sampling Purposive Sampling Snowball Sampling	Purposive Sampling, Snowball sampling and Maximum sampling strategies	London and Milton Keynes
Data Collection Methods	Documentations Archival Records Interviews Focus Group interviews Direct Observation Questionnaire Participatory observation	Documentation Archival Records Interviews Survey Questionnaire	Interviews will provide qualitative data. The findings from the qualitative enquiry will be put into a questionnaire survey to further confirm the results from the focus groups.
Data Analysis Methods	Thematic analysis Content analysis Statistical analysis System Dynamics Conservational analysis Cognitive mapping	Thematic analysis Statistical analysis System Dynamics	Thematic analysis will be used to identify popular views amongst experts. Statistical analysis in terms of predictive analytics will be used for the forecast of events. System dynamics will be used to understand how smart cities indicators influence each other and the overall smartness of cities.
Analytical Strategy	Use of theoretical propositions/Research Question/Themes Developing Case Descriptions Use of	Use of Research Questions and theoretical proposition	

	Qualitative and Quantitative Data		
Analytical Technique	Pattern Matching Explanation Building Time-series Analysis Cross-case Analysis	Cross-case Analysis	This is the best way to assess real life situation and projection anticipated

5.3 Research Process

Gerrish and Lacey, (2010) noted that the analytical and systematic actions or step carried out in order to create knowledge is called a research process. It involves, Corbin and Strauss, (1990), the sequential procedures for examining a research problem as well as the techniques of data collection and analysis. For this study, the research process in figure 1 shown above portrays the direction in which the entire study shall be executed.

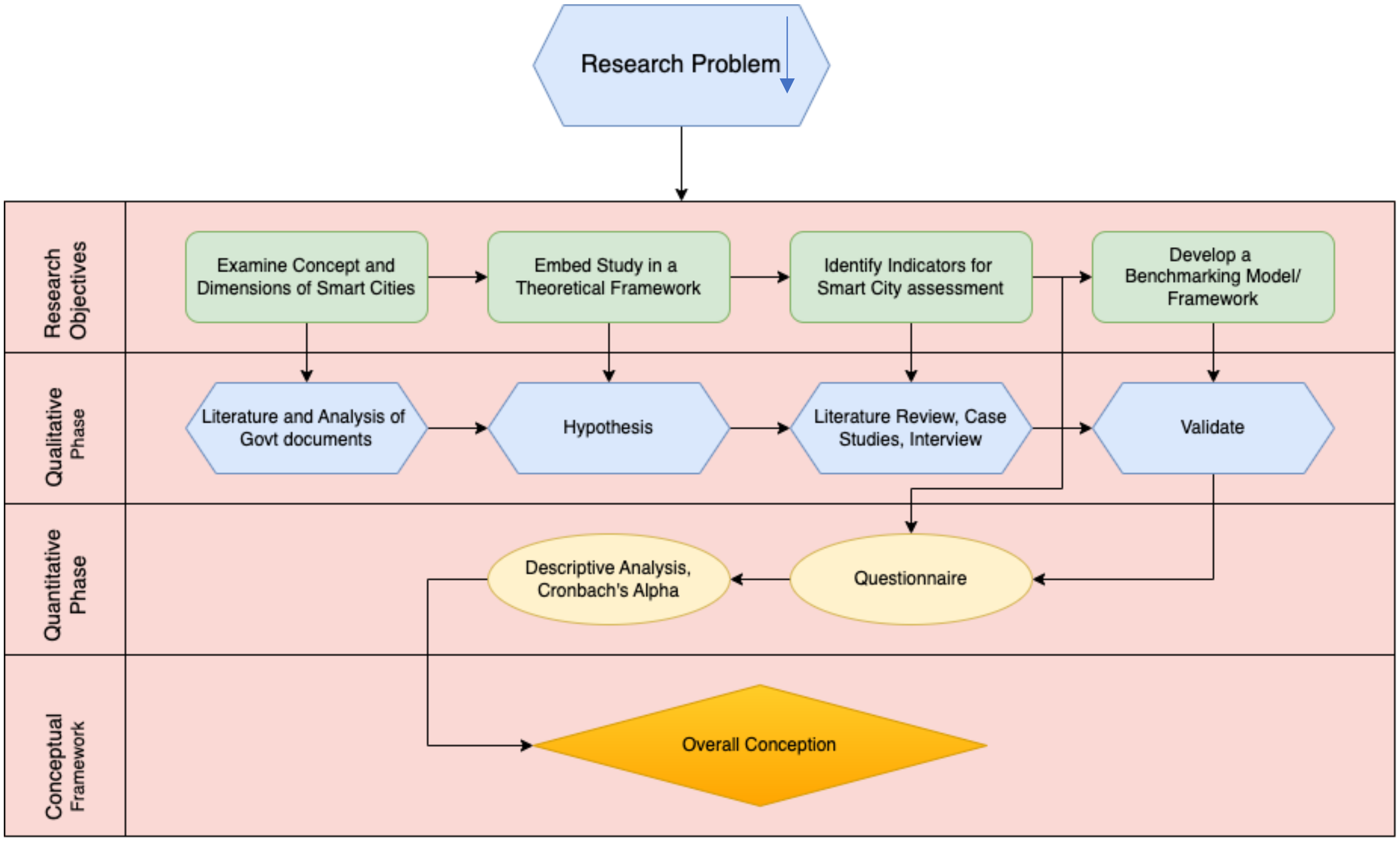

Figure 5. 2 The Research Process for the Study

5.4 Research Philosophy

Crotty, (1998) belief that every study emanates from some idea about the nature of reality and how such reality can be known. Barnett-Page and Thomas, (2009), opined that these belief systems and the means of knowledge attainment often provide justification for our approach to adopted methods, methodology and research. Research philosophy therefore examine the theoretical assumptions underpinning our research using two lenses, namely Ontology and Epistemology (Ji, et al., 2019)

5.5 The Ontology

The study of independent nature and reality of being is called ontology (Klenke, 2016 and Van Gordon, et al., 2018). Ontology looks at what can be known or what is possible for us to know about reality (Klenke, 2016). This reality claim, Rosenberg, (1980), may be classified into Realism and Idealism. The ontological assumption that reality and knowledge exist independently of our perception, interpretations and belief is regarded as realist (objective) ontology (Trigg, 2016). On the other hand, Idealist (subjectivism) ontological assumption describes the philosophical claim that reality exists only as experienced by the subject of the research (Kafatos and Kato, 2017). Every researcher therefore embarks on his research activities on the basis of either of these two ontological assumptions about reality and knowledge claims (Bell, et al.,2018).

5.6 The Ontological assumption underpinning this Research.

In the current research study, a realist ontological assumption based on the acceptance of value free knowledge of reality is adopted. By this philosophical approach, Bhaskar, (1975), argued that truth or knowledge claims (smart city benchmarking parameters) exist as an independent theoretical model. Our action as researchers are therefore that of a causative agent for the observed phenomenon. This study therefore proposes that, the impact of the identification of key performance indicators for benchmarking of smart city can be known from the observation of regular sequence of cause and effects.

5.7 The Epistemology

Goddard, et al., (2019) noted that the word epistemology emerged from two Greek words "episteme" (knowledge) and "logos" (reason). It is explained as the theory of the source, nature and limits of knowledge or social reality (Stehr, 2017). In the views of Ji, et al., (2019) epistemology assesses the way we understand and acquire the knowledge of reality. The question of what comprise valid knowledge is an epistemological question (Blaikie, 2007). As argued by (Brenner and Schmid, 2015), the demarcating line between epistemology and ontology is quite blurred. Often, ontological assumptions usually inform epistemological stance on knowledge claims (Blaikie, 2007). According to Ji, et al., (2019), three major epistemological assumptions about knowledge have been recognised, namely Constructionism, Subjectivism and Objectivism.

5.7.1 Objectivism

The objectivist epistemology holds the belief that truth or knowledge is pre-existing, fixed, available and that only careful scientific research can obtain such scientific knowledge (Holloway, and Galvin, 2016; King, et al., 2018). Therefore, only research carried out with full compliance to scientific laws are regarded as valid knowledge of reality (Weber, 2017). Objectivist epistemology, according to Hiller, (2016), propounded that if a certain "reality" exists at all, them the relationship between the knower and the known must exhibit the freedom. To obtain such knowledge in a credible manner will therefore require a value-free approach that is outside the bias interpretation of the researcher (Yin, 2015; Green, and Thorogood 2018).

5.7.2 Subjectivism

Subjectivist epistemology is rooted in scepticism of the universality of theory or value-free objective reality (Duberley and Johnson 2015) This theoretical assumption holds that the knowledge of reality is only based on the interpretations that individuals and groups ascribe to it (Ji, et al., 2019). Therefore, meaning is imposed on reality via the subjective experience of the individual (Bell, et al.,2018). Subjective epistemology, in the opinion of Blaikie, (2011), is regarded as idiographic and focuses on individual of meaning rather than establishing universal laws.

5.7.3 Constructionism

Ji, et al., (2019), noted that the constructionism is a philosophical assumption that the world is socially constructed, and knowledge of reality is created out of the interplay between the researcher and the external world. According to McLeod and Chaffee, (2017), because some people may have different interpretations of reality, therefore, knowledge of reality is constructed based on individual perceptions through social relations and interaction with reality. Constructionist theoretical assumption, from the standpoint of Blaikie, 2007, presupposes that meaning arising through the collectively shared perceptions of reality (inter-subjectivity) by social actor.

5.7.4 Epistemological stance underpinning the present research work.

Considering the goal, objectives and research questions for this dissertation, a constructivist epistemological approach is adopted. This is in line with realist ontology (Value-free reality) for the study. However, doubt over the choice of epistemology will be cleared when discussing the research paradigm underpinning this study. But more importantly, although the study believes in the constructionism method towards examining benchmarking theory is essential; the subjective interpretations of reality from actors' experiences is not neglected in this study (Bell, et al., 2018). In this regard, the study combines practitioner in the UK public, private, citizen and non-governmental organizations- subjective accounts of benchmarking KPI suitable for evaluating smart cities, with value-free data collection methods to explore wider views of participants.

5.8 Research Paradigm

Klenke, (2016) noted that the research paradigm focuses on the tripartite linkages between ontology, epistemology and methodology. The research paradigm could be seen as that of beliefs, practices and patterns that regulate inquiry within a discipline by providing frames, lenses and processes through which inquiries can be carried out (Merriam and Grenier 2019). The research paradigm also referred to as theoretical perspective, describes an all-embracing and procedural thought process that organizes scientific research (Bulmer, 2017). Paradigms represent the world view of the researcher which informs the approaches, strategies and methods adopted for our research process (Lincoln and Guba 2015). The following are some of the paradigms in social science research-Positivism, Interpretivism, Constructionism, Postmodernism, Critical Realism. Logical Positivism, Radical Structuralism, Post-Positivism etc (Lincoln and Guba 2015; Klenke, 2016)

While the theoretical assumption underpinning this research work emerged from critical realism philosophical paradigm, efforts shall be made to offer brief discussion on few of the major paradigms (Positivism, Interpretivism, Constructionism and Critical Realism) in order to draw adequate comparisons and justification for their adoption (Table 5 highlights the different research paradigms)

Table 5. 2 Research Paradigm (Source: Author's Literature Review)

Paradigm	Critical	Interpretivism	Positivism
Ontology	Objectivist	Subjectivist	Objectivist

Epistemology	Objectivist	Subjectivist	Objectivist
Theory	Particular	Particular	Generalize
Reflexivity	Epistemic	Hyper	Methodological
Role of Researcher	Close to data	Close to data	Distance from data

5.8.1 Interpretivism

In contrast to the positivist's stance on meaning and world reality, interpretivism philosophical assumptions stems from idealist or subjectivist ontological and epistemological background respectively (Hiller, 2016). Interpretivism theoretical assumption challenged the value free proposition of positivism and argued that meaning and social reality only exists on the basis of the interpretations ascribed to it (Kachuyevski, and Samuel 2018). Therefore, knowledge or meaning is relative and does not exist outside of the mind (Blaikie, 2007). Rather, meaning is imposed through subjective interpretations of the individual (Sharp, et al., 2017). As a result, interpretivism focuses on research techniques that demonstrate interactions between the researcher and the participants.

5.8.2 Constructivism

In the opinion of Katsirikou and Lin (2017), constructivist research holds the assumption that there is nothing as objective truth, neither is there such thing as subjective reality. Rather, constructivism argues that knowledge or meaning is only constructed by individual through interactions with the external environment (Blaikie, 2007). In a similar vein, Neuman (2003), social dialogue and interplay defines what reality is under a constructivist philosophical perspective. Therefore, meaning is made out of the relationship between the knower and the known (Blaikie, 2007).

5.8.3 Positivism

The positivist research philosophical assumption is objectivism (Antwi and Hamza 2015). The positivist philosophical perspective lays claim to value-free proposition, which is, that knowledge exist independently of the mind (Burrell and Morgan 2017). This suggestion sees a separation of the knower (researcher) from the knowledge attained (Johnson and Onwuegbuzie, 2015). In the view of Guba and Lincoln (2015), positivist studies assume that scientific knowledge can only be acquired through statistics, facts, numerical data, standardized questions, random sampling etc. Hence, any dilution of research with the subjective interpretations of the researcher's feelings will create bias as well as weaken the generalization of research findings (Katsirikou and Lin 2017). Positivist paradigm rejects the idea that meaning is either socially constructed or imposed on reality (Blaikie, and Priest 2019). This research philosophy is very common in natural and some social science research (Hughes and Sharrock 2016).

5.8.4 Critical Realism and Justification for its adoption in this study

The theoretical assumption underpinning this study, as previously stated, is Critical Realism. Critical realism emerged due to the challenges of sustaining the concept of universality or independent of being, in the face of knowledge relativity (Bhashkar, 1975; Archer, et al., 2013). In the views of Schoonenboom, (2019), the critical realism paradigm says that the relationship between independent reality (quantitative) and the perceptions that we make of it (qualitative) is the primary focus of research.

This therefore allows objective reality to find a common ground with socially interpreted reality (Ormston, et al., 2014). Critical Realism combines ontological realism (objectivism) with epistemological relativism (subjectivism) as well as an emancipatory axiology (Archer, et al., 2013; Günbayi and Sorm 2018). Although, critical realism agrees with the positivist's assertion of value free proposition, it argues that such knowledge is socially constructed (Denzin and Lincoln, 2008: pp 17)

Within the context of this study, the adoption of critical realism paradigm was based on three essential considerations which include:

1. Methodological Pluralism-the adoption of critical realism is also based on method pluralism. Method pluralism rest on the proposition that research method and methodology in a study is influenced by the identified research questions (Midgley, et al., 2017; Downward and Mearman, 2006). This idea, as further substantiated by Schoonenboom, (2019), allows combination of different research methods or methodology. As such, this study will triangulate qualitative data collection methods
2. This study seeks to investigate theoretical construct from benchmarking. "Benchmarking is considered a socially constructed theory regarding the notion of self-evaluation and self-improvement through the systematic and collaborative comparison of practices and performance with similar organization in order to identify strength and weaknesses, to learn to adapt and to set new targets to improve performance (Blackstock, et al., 2012). Being an abstract concept, objective testing of theoretical assumptions is necessary for obtaining generalizable findings (Archer, et al., 2013). However, since benchmarking here is treated as an abstract mechanism (Baharlouei, et al., 2013) independent reality is only understood via human interactions (subjective assumptions) with the phenomenon (Scott, 2005). Critical Realism therefore enables objective reality to be combined with subjective reality (Scott, 2005). Also, the motive of this study, which focuses on exploring benchmarking

instrument through the views of UK public and private sector experts on identification of Key Performance Indicators (KPI), is squarely in line with this research.

3. Triangulation – Critical Realism paradigm encourages triangulation of data, methods, theory and investigators in a research activity Ji, et al., (2019). Therefore, it allows the researcher to extract ideas and insights from various data sources and employ suitable methods to generate diverse viewpoints (Gioia, et al., 2013). Triangulation enhances internal rigour in research and helps to cross validate findings (Creswell, 2013). Through triangulation, Scott, (2005), qualitative outcomes can be validated through quantitative analysis of findings and vice versa. This study will thus rely on extracting qualitative data as inputs for quantitative analysis.

With quantitative methods of data collection and analysis respectively, this approach is common in inter-disciplinary research where data and findings may emerge from disciplines having different ontological believes (Schoonenboom, 2019). Critical realism thus allows such interface of standpoints and methodology to hold in a single study.

Based on the preceding expositions, it is enough to say that critical realism is the appropriate philosophical paradigm for this research work. It encourages mixed method triangulation which this dissertation heavily relies upon, in terms of using quantitative techniques to analyse quantitative outcomes.

5.9 Research Approach

The approach to this research is Abduction, instead of deduction (theory testing) or induction (theory generation). Abduction, also regarded as retroduction in some studies, derives ideas from existing known structures namely deduction and induction (Kennedy and Thornburg, 2018; Moscoso, 2019; Kroll and Koskela, 2019; Koskela, et al., 2018). Retroduction makes triangulation of method very easy particularly for quantitative and qualitative techniques (Kennedy and Thornburg, 2018), thereby preventing epistemological weaknesses inherent in inductive and deductive approaches in order to extend the frontier of knowledge. This is fact buttressed by Oliver (2011) who noted that the major tool in critical realism is the abductive inference.

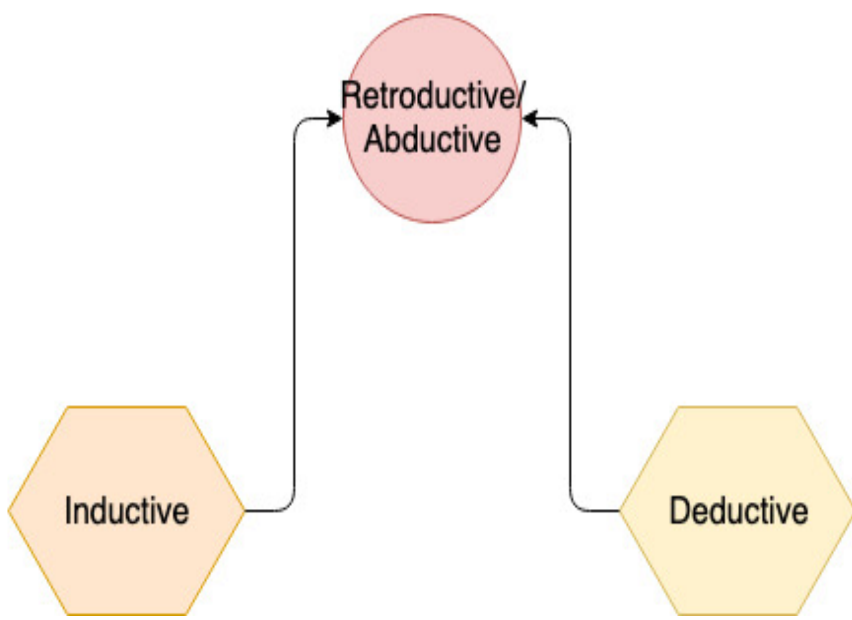

Figure 5. 3 Retroduction/Abduction taking a cue from both Deductive and Inductive

5.10 Research Choice/Method of Enquiry

The objectives of a study are reflected in the research choice undertaken by the researcher (Turner, et al., 2017). In many studies on social enquiry, Blaikie (2007), research choice has been broadly classified into two categories namely, quantitative and qualitative. Conversations on these two methods have been used to define:

I. Types of data collected.
II. Methods of data collection,
III. Inquiry in which certain methods were applied.
IV. Paradigm, theoretical standpoints and strategies of enquiry (Blaikie, 2007)

While some studies are regarded as qualitative based on certain choices of data collection, analysis or research strategy (Bell, et al., 2018; Palinkas, et al., 2015), others are classified as quantitative (Bell, et al., 2018). However, more recent literature has embraced a combination of different methods, also known as mixed methodology (Blaikie, 2007). This study therefore explores both qualitative and quantitative strategies to provide a basis for its research choice (mixed methodology)

5.10.1 Quantitative Research

Quantitative research is an approach of objective testing of theoretical assumptions (Brannen, 2017; Antwi and Hamza, 2015). Quantitative research places emphasis on facts that directly or indirectly emerge from observed regularity in social phenomena (Crotty, 1998). This type of research is mostly well-detailed, uses more of randomized experiments and structured data collection methods, that is, sample surveys, multivariate statistical analysis, frequency etc (Bryman, 1992; Blaikie, 2007). The assumption underlying quantitative research is that of value-free relationship between the researcher and the research participant (Lincoln and Guba 2015) Quantitative research is more common in the field of natural sciences and usually emerges from positivist's theoretical background.

5.10.2 Qualitative Research

Qualitative research involves subjective analysis and exploration of social phenomena, within their natural environment (Kruth, 2015). Qualitative research lays emphasis on theory generation and descriptions that examines social actors (Crotty,1998). Consequently, efforts are centred on understanding the patterns or meaning that individuals or group attribute to social phenomena (Creswell 2013). According to, Denzin and Lincoln, (2008), researchers in the field employ interpretive approaches such as unstructured or semi-structured techniques, participants' observations, focus group discussions among other.

5.10.3 Justification Mixed Method Research in this study

As a means to examining the benchmarking of cities, this research is adopting the exploratory sequential mix methodology approach. With this strategy, initial exploration of the construct from benchmarking through qualitative approaches was followed with a quantitative approach research. According to Creswell and Zhang, (2009), sequential mixed method is suitable where a phenomenon is yet to be conceptualized, adequately explored in the literature or is being examined in a context whose research question are unknown. The mixed method approach known as “multiple operationism”, which allows the combination of various methodologies in single study (Blaikie, 2007). In the opinion of Denzin and Lincoln (2008), integrating quantitative and qualitative methods and data in a single study is essential towards increasing richness and rigour in social enquiry. Consequently, mixed method supplements the non-overlapping disadvantage of either method (qualitative and quantitative), with strength of the other (Johnson and Onwuegbuzie 2004; Creswell, 2014).

Though, this is not oblivious of a number of opposing arguments against mixed methodology approach to research (Tashakkori and Creswell 2007; Tashakkori and Creswell 2008; O'Cathain, et al., 2007; Onwuegbuzie and Leech 2005; Goodman, 2008). According to Onwuegbuzie and Leech (2005), several of these arguments have focused on the feasibility of a mix method in a single study. Scheiner, (2019); Birks, (2019) Archibald, (2016) and Shabani, et al., (2015) have debated that triangulation in mixed research is hindered by the notion of incommensurability of different ontological and epistemological assumptions that underpins different methods. O’Cathain, et al., (2007) also doubted the practicality of gaining any unique insight through a mixture of methods in research. In addition, mixed methodology faces the challenge of validity of research findings due to the weakness associated with integration of different methods (Onwuegbuzie and Johnson, 2006). Despite the opposing views, mixed method approach continues to become more popular by gathering magnificent following and proponents (Morse, 2003; Brannen, 2005) and it is thus adopted for this study.

The adoption of mixed methodology approach in this study therefore aims to address the objectives of this study which are:

- To examine the concept and various components and dimensions of smart cities.
- To identify a comprehensive list of smart indicators relevant for measuring the smartness of a city.
- To examine the concept benchmarking especially within the concept of smart city benchmarking.
- Develop a robust smart city benchmarking framework for measuring the smartness of cities by integrating various smart city dimensions and indicators.
- Evaluate the developed smart city benchmarking framework using real-life test-cases of two smart cities in the UK, namely Bristol & Milton Keynes.

Looking at the detailed objectives, it is evident that the first objective of the study shall adopt interpretive approach (literature review, documents from government and non-governmental organizations). The second objective is also adopting the interpretive approach of literature review. The third objective is also to be addressed using interpretive approach of literature review and interviews. The fourth of objective shall adopt the constructionist approach method of evaluation and fifth objective shall adopt the objectivist approach.

5.11 Research Strategy

The research strategy is the general plan of how the researcher will try to answer the research questions. In the same light, Bryman (2008), described the research strategy as a general guidance on the conduct of research. In the contribution of (Wedawatta and Amaratunga, 2011), a research strategy gives the global direction of the research including the process through which the research is done. The appropriate research strategy, according to Saunder et al, (2009), has to be chosen based on research questions and objectives, the extent of existing knowledge on the subject area to be investigated, the quantity of time and available resources, and the philosophical bases of the researcher. Contrary to the foregoing, (Yin, 2018) recommended that three conditions are necessary for a research strategy. These are: the research question, the extent of control a researcher has over actual behavioural events, and the extent of focus on contemporary or historical event. Some of these strategies overlap and one has to choose the most beneficial to one's study. The common research strategies are case study, action research, experiment, grounded theory, archival research, cross sectional studies, longitudinal studies, ethnography and participatory enquiry (Easterby-Smith et al., 2008; Collis and Hussey, 2009; Saunders et al., 2009). Amongst these diverse strategies, this research has adopted the case study research strategy as the appropriate strategy for the study.

5.11.1 Identifying the Cases

In designing a case study research, Yin, (2012) noted that the "case" to study is usually the first step. The case is a social object or unit whose character and context must be carefully studied within a bounded system (Blaikie, 2000). The cases being studied in this current project are Bristol and Milton Keynes. Bristol, according to Wood, et al., (2017), came first of smart cities in the UK and Milton Keynes was unique for having been selected for the multi-million pounds innovative Smart City Project leas by the Open University (Park, et al., 2018)

5.11.2 Multiple or single case study

There has been ample criticism of single case study design in the literature (Vaus, 1991; Stake, 1995; Flyvbjerg, 2006; Campbell and Stanley, 1966). The lack of comparison was criticised by Vaus, (1991), whilst the drawing of a scientific inference from one single case study was doubted by Campbell and Stanley, (1966). The above claims were debunked by Noor, (2008) and Yin, (2012) and they argued that generalization is possible in case studies, since multiple cases and sources of evidence could generate research findings that can be replicated in similar context.

Going by the views expressed by Yin, (2012) and Creswell, (2012), the study shall also be adopting the multiple case study approach. Hence, two case studies of smart cities project shall be evaluated. This will, Baxter and Jack, (2008), allow a variety of view to be explored and consequently reinforcing and boosting the research finding.

5.11.3 Justification for the Case Study Strategy adoption in the Study

The research strategy for this study is "Case Study". Case study has a long history in clinical medicine, social anthropology and currently in sociology, political science, and management etc. Longhofer, et al., (2017). In the opinion of Yin, (2014) the case study research, contemporary phenomenon (the case) is investigated in its real-world context, particularly when the boundaries between the phenomenon and the contest may not be clearly conspicuous while Creswell, (2007) feels that case study methodology involves investigating a research problem through one or numerous cases in a confined system. Some researchers like Blaxter, et al., (1996), and Blaikie, (2000) have argued that case study strategy allows investigation of the complexity and particular nature of a phenomenon. Hence, Yin, (2014) noted that investigation in case studies frequently take different approaches such as descriptive, explanatory, and exploratory techniques depending on the research questions of the study.

In this benchmarking research, exploratory case study strategy shall be adopted. This implies that opinion of UK experts in smart city both in the public and private sectors shall be explored to identify suitable benchmarking mechanism for evaluating smart city projects

5.12 Sampling Strategy

In order to make generalization about a larger population, sampling, which, involves the selection of units or cases from a much larger population so as to observe the smaller group is carried out (Lohr, 2019; Cooper, et al.,2019; Grove, 2019; Raju, and Prabhu, 2019). By sampling, representatives among parts of a population can be guaranteed (Johnson and Bhattacharyya, 2019).

In the current research work, quantitative and qualitative sampling strategies shall play a prominent role in addressing the research questions. According to Schildcrout, et al., 2019, quantitative sampling method are usually randomised and based on probability of chance. Qualitative sampling method, on the other hand, according to Kristensen, et al., (2019), are non-probabilistic in nature. The difference between quantitative and qualitative sampling approaches centre on the size of the sample population as it affects margin of error and confidence level (Kristensen, et al., 2019). Qualitative research focuses on the depth of knowledge and context of a social phenomenon, (Blaikie, 2000), while from the quantitative angle, the larger the sample size, the smaller the sampling error and the higher the confidence level, hence the generalizability of its findings (Little, and Rubin 2019; Cooper, et al.,2019; Combs, et al., 2019)

5.12.1 Qualitative Sampling Strategy

Two sampling strategies shall be used at the qualitative stage of the study. One of them is the Maximum Variation Sampling Method which shall be used for selecting the two case studies of smart cities in the UK. In the opinion of Lohr, (2019), maximum variation sampling which, is also known as maximum diversity sampling is a type of purposive sampling. This sampling method is very useful when investigating small sample population and when a random or quota sampling methods would be useless (Grove, 2019; Zack, et al.,2019). For there to be heterogeneity, the maximum variation sampling focuses on selecting samples from a population that is completely different from one another (Morse and Clark 2019; Johnson and Bhattacharyya, 2019). by this method, multiple perspectives are explored, which allowed the capture of essential and variable features of a phenomenon (Kumar, 2019; Johnson, and Christensen, 2019; Uher, 2019). The following studies: Kumar, 2019; Memarian, et al., 2007; Fink 2019; Liston-Heyes, and Juillet, 2019; Cellini and Turner, 2019; Zou, et al., 2019).

In consonance with the foregoing, this study chose two different smart cities-Bristol and Milton Keynes.

These cases were chosen based on the following important facts:

- The two case studies represent the cutting-edge in smart cities in the UK.

- In the study conducted by Wood, et al., 2017, Bristol was the foremost smart city in the UK
- Milton Keynes also has a unique advantage of being selected for the multi-million pounds innovative Smart City project lead by the Open University (Park, et al., 018), which has projected the city as a beacon of good practices for smart cities initiatives
- Milton Keynes was the first to introduce the "Redway", a fully dedicated non-road path for cyclists, pedestrian and electric buses (Park, et al., 018).

The second stage of the qualitative study involves thirty interviews with experts in public and private sectors. A purposive sampling method was used to select information-rich participants for the study. The purposive sampling is also known as judgemental sampling as it is a technique through which the research participants were selected based on careful consideration of the criteria in mind (Kristensen, et al., 2019). In the context of the current study, the purposive sampling technique was used because of the following identified reasons:

Interview participants

- Policy formulators and city administrators and the regulatory authorities.
- Experts in public and private sector with experience in smart city conception planning and implementation.
- Experts in public and private sector with experience in smart city administration.

- Internet of things service providers.
- Utility service providers like energy and water.
- The end-users of smart city.

5.12.2 Quantitative Sampling Approach

In order to assess the applicability or generalizability of the qualitative findings from this study, a survey to large sample of population via questionnaires was done. This was done by sampling the experts in architecture, planning, engineering and administration domicile in the Bristol City Council, the Milton Keynes Council and other experts in the private and academic environment all of whom were selected through a snowball sampling method. The snowball sampling is also known as network, chain referral or reputational sampling (Kogan, et al., 2019; Blaikie, 2000). It involves identifying your sample population by building on network of contacts to access other likely participants (Kumar, 2019). Hence, the research capitalized and built on referral from existing contacts in the UK public and private sectors to recruit respondents to the study's questionnaire.

5.13 Data collection Method

Quantitative and qualitative data collection method, which represent the main data collection method, was adopted for this study. Each is further explained below for lucidness and clarity.

5.13.1 Quantitative data collection method

The second phase of the study involved quantitative data collection through questionnaire survey to public and private sector experts. The main objective behind the survey was to confirm wider applicability of the benchmarking indicators through the qualitative study.

5.13.2 Qualitative data collection method

The first phase of the study involves a two-way qualitative data collection strategy comprising of literature review and case study investigation. The study explore construct in smart city benchmarking, through extensive literature review, towards identifying benchmarking indicators relevant for evaluating the smart cities. Nevertheless, confirming the applicability of the identified benchmarking indicators and associated measures within real life contexts was deemed necessary for the study. In this regard, multiple case studies of two smart cities project in the UK were explored through documentary analysis and interviews.

5.14 Validity

DeLanda, (2019), noted that validity is explained as measuring of the extent to which a measurement or concept is well established and conforms accurately to social reality. Research validity measures the correctness of a research design and the method adopted for arriving at a scientific conclusion (Kumar, 2019). In the purview of this study, the research design shows a careful sequence of procedure for both the qualitative and quantitative sections of the study and this is further explained below.

5.14.1 External Validity/Transferability

External validity often referred to as “Generalizability” in quantitative research or “Transferability” in qualitative studies, examines whether results generated from scientific research, when replicated or repeated under similar condition will lead to the same result (Kumar, 2019; Bracht and Glass 1968; Calder, et al., 1982). Within the context of this study, external validity of finding is enhanced with the adoption of triangulation of methods and data sources. This in conformity with Lincoln and Guba, (1994) who argued that triangulation enriches qualitative research and improves transferability. Also, the adoption of multiple case studies at the qualitative level of the study is expected to increase the transferability of findings (Vaus, 1991; Yan and Cantor, 2019). Additionally, since the study shall be employing questionnaires, whose internal consistency will be confirmed, generalizability will be maximized, whilst significantly diminishing bias in the findings (Mazzarella, 2019).

5.14.2 Internal Validity/Credibility

Qualitative Study: In this study the research problem was explored using case study interviews and documentary evidence which were combined with theoretical data from literature review. This would make multiple sources of data and collection methods helped facilitate better insight into the phenomenon (Tracy, 2019). This perspective aligns with studies such as Kumar, (2019), Lincoln and Guba, (1994), Creswell, (2007), who argued that relying on multiple sources of data and method enrich the validity of qualitative research via triangulation. In addition, twenty-five interviews shall be conducted with individual end-users and experienced public and private sector experts from Bristol and Milton Keynes City Councils. This showed sufficient sample size for a qualitative study based on the recommendation of Moustakas, (1994), Willig, (2019), Spiers, and Riley, (2019).

Quantitative Study: Here, data from qualitative study were used to develop the structured questionnaire. 95% confidence level with 5% margin of error shall be adopted for the study. The questionnaire shall also be pilot tested in Bristol City Council. Reliability test shall also be carried out on the questionnaire data to ensure internal consistency of the measurement scale and reliability of measures.

5.15 Negotiation of Access

In PhD research, it was a nightmare sometime to get a negotiated access to sources of data. Hence, with full cognizance of the nature of the research participants (experts in public and private sectors and individuals end users) and specialized nature of the research topic, a purposive and snowball sampling approaches was used to gain access to interview participants and questionnaire respondents for the qualitative and quantitative studies. Consequently, a gate keeper was engaged within the various public, private sector experts. This network of referral was judiciously harnessed in this study.

5.16Approval by the Ethic committee of the University

The protection of research participants data are of utmost consideration in this study (Gruschka et al., 2019). As this study is only exploring the perception of expert in public and private service and also some individual from the general public, ethical concern is not worrisome as the participants do not fall under vulnerable citizens as classified by the Ethics Committee and Guidance Document of the University of the West of England. The study is not seeking sensitive documents and the privacy and anonymity of participants shall be ensured whilst informed consent guideline of the University was strictly complied with. The University ethical guidelines was adhered to in obtaining consents and permission from participants using the Consent Form and Participant Information Sheet which was signed by the participants intimating them with what the study is about and their right to participate or withdraw at any time they are no longer convince of their participation.

Chapter 6: Case Studies

6 Chapter Introduction

This chapter is the case study section, where Bristol city, its vision, philosophy and the re-engineering of Bristol smart city agenda were discussed. The execution and the challenges encountered were also highlighted. Milton Keynes the second smart city case study was also studied. This includes MK: Smart, dimension of Milton Keynes smart city, the Open University, the smart city agenda, data hub, citizen participation, transportation, and education. Finally, education and its impact was also highlighted.

6.1 Bristol City

Bristol is at the confluence of the Rivers Avon and Frome and located at about 190km west of London. The Avon, which is to the west of Bristol, flows into the estuary of the rivers Severn, which itself emptied into Bristol Channel of the Atlantic Ocean, about eight miles to the northwest (Kenneth Pletcher., 2023). Bristol has a population of about 380,615 in 2001 and which jumped to 428,234 in 2011 (World Population Review, 2023). It covers about 110 square kilometres (Kenneth Pletcher., 2023).

Bristol city is one of the foremost smart cities in the United Kingdom, Figure 6.1, with a diverse religion, about 45 religious' bodies, people from 187 countries around the world with about 91 spoken languages. Unfortunately, a high level of deprivation is evident in some parts of Bristol city. Bristol city in association with adjacent cities and localities is one of the economic hubs in the United Kingdom. It is also one of the international networks enabling connections, trade, and shared learning (Kenneth Pletcher., 2023)

Bristol, Figure 6.2, is an education centre with schools such as Bristol Grammar School, Colston's School and Clifton College, founded in the residential vicinity of Clifton. the University of Bristol founded in 1876 and the University of the West of England and some other colleges. It also houses Cathedral School, and Queen Elizabeth's Hospital and some prominent institutions like the Ministry of Defence (Kenneth Pletcher., 2023)

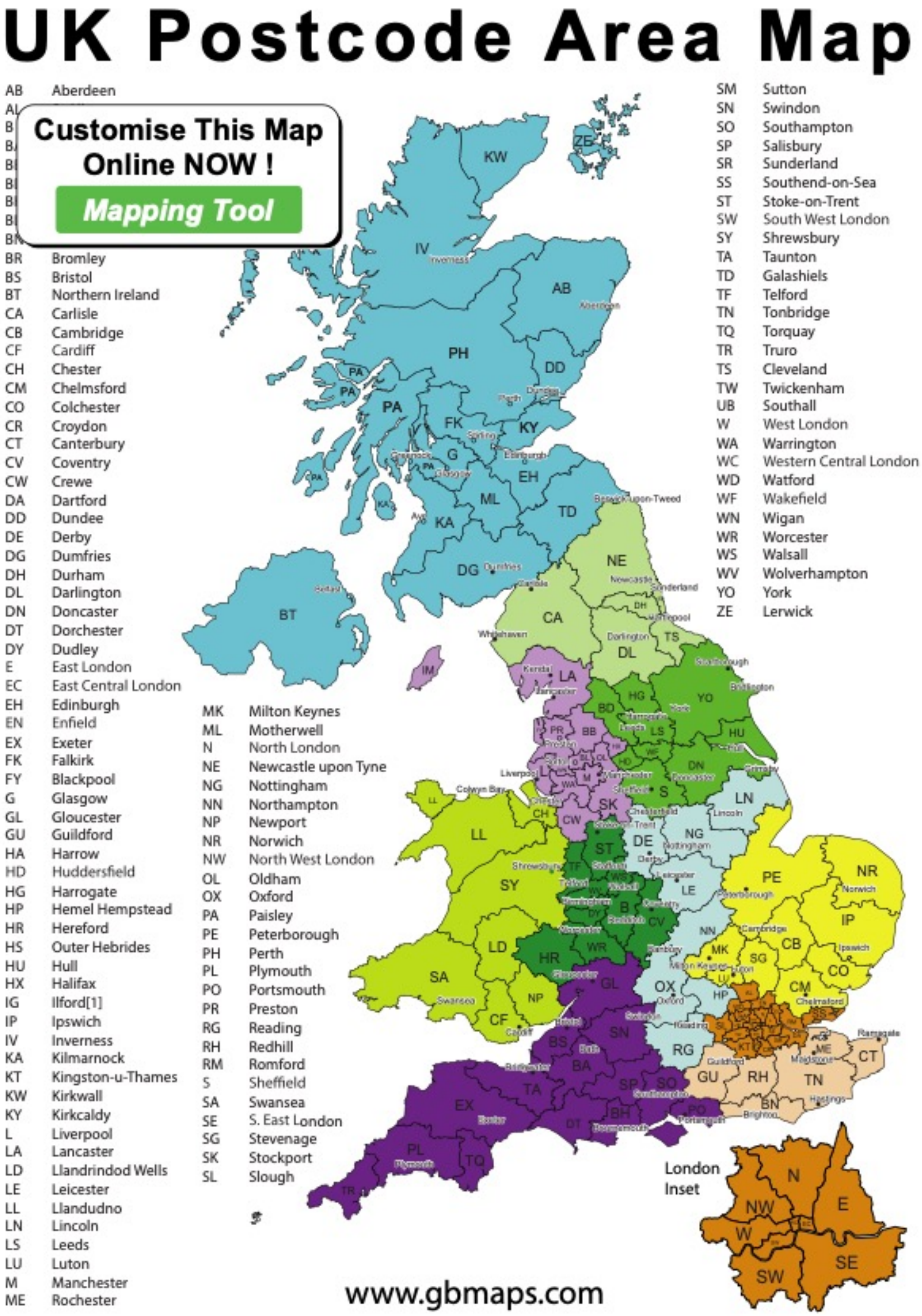

Figure 6. 1 Map of the United Kingdom (Source:GBMAPS.COM, 2022)

6.1.1 Vision of Bristol city

In 2019, the Bristol city council proposed a new vision which was facilitated by being digitally well-connected and data driven. The vision of the Bristol city is a place with vibrant culture, and good access to opportunities, services and amenities in order to make the city liveable, sustainable and prosperous by the year 2050. This is called the Bristol's One City Plan which has as one of its objectives as the bringing together of the people around common causes, shared values and an understanding of the challenges which need to be tackled in producing a fair, healthy and sustainable city. This vision is annually reassessed in order to strengthen the focus of this city and reduce the issue of disjointed and uncoordinated policy (Lockwood, 2020).

The 30-year Bristol city vision was planned around six dimensions, namely, connectivity, health and well-being, homes and communities, economy, environment, and learning and skills (Lockwood, 2020). Each of these dimensions is further divided into three goals or sub-themes to help sequence activity, provoke action and act as a challenge to the city to progress toward its long-term vision. Table 6.1 shows these Bristol One City Theme (Lockwood, 2020).

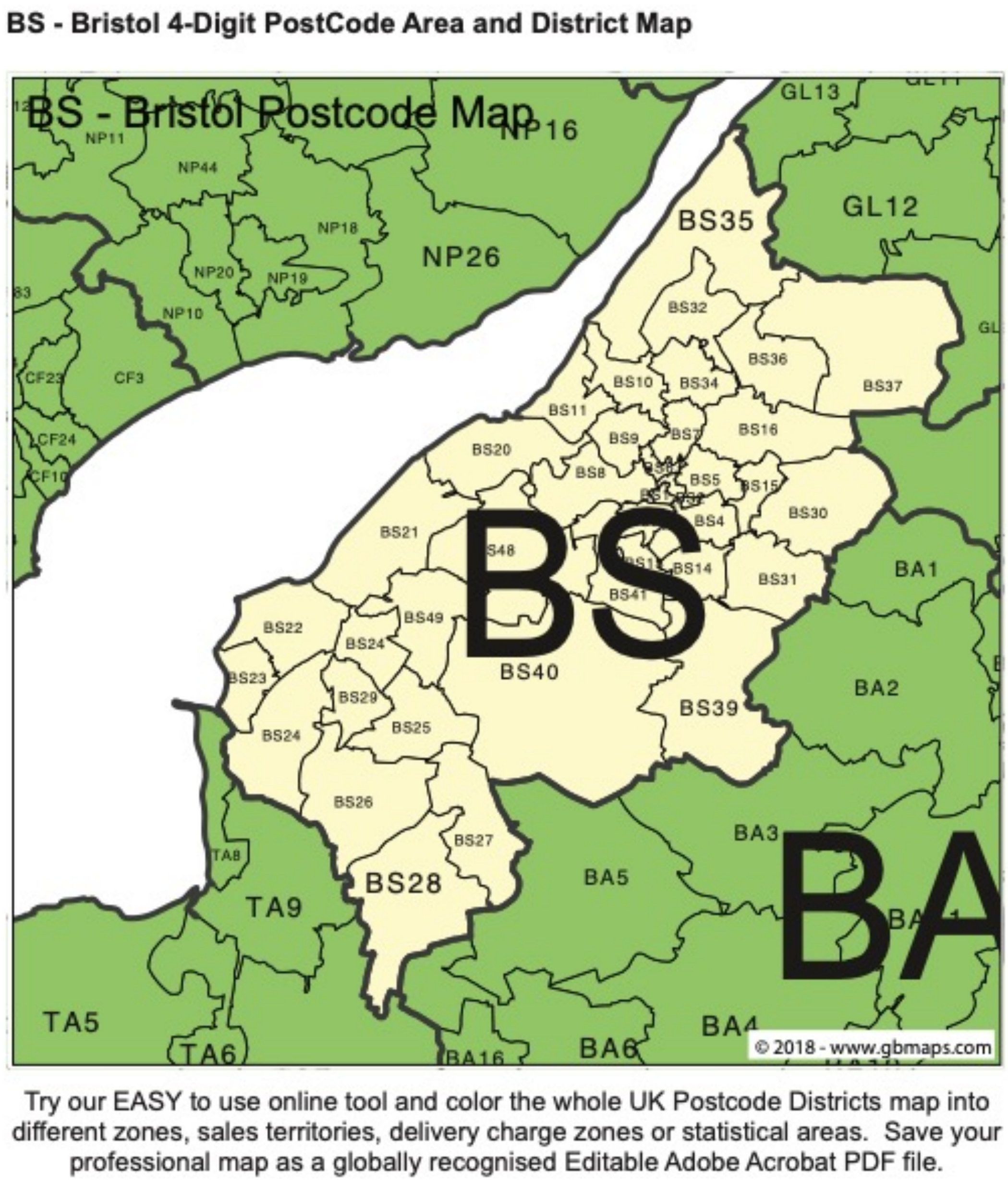

Figure 6. 2 Map of Bristol Smart City. Source: (GBMAPS.COM, 2022)(GBMAPS.COM, 2022)

Table 6. 1 Bristol One City Themes (Source: Lockwood, 2020)

One city Thematic board	Sub-theme	2050 vision statements
Connectivity	Healthy, active, sustainable transport	By 2050 everyone will be well connected with digital services and transport that is efficient, sustainable and inclusive, supporting vibrant local neighbourhood and a thriving city centre
	Well-connected city	
	World class communication infrastructure	
Economy	Tackling economic exclusion	By 2050 everyone in Bristol will contribute to a sustainable inclusive and growing economy from which all will benefit
	Economic growth and productivity	
	Neighbourhood and employer integration	
Environment	Carbon neutrality	by 2050 Bristol will be a sustainable city with low impact on our planet and a healthy environment for all
	Healthy, ethical sustainable food	
	Healthy natural environment	
Health and well-being	Mental health	By 2050 everyone in Bristol will have opportunity to live a life in which they are mentally and physically healthy
	Health inequality	
	Adverse childhood experience	
Home and Communities	Affordable, secure, warm, home	By 2050 everyone in Bristol will have a home that meets their needs within a thriving and safe community
	Safe city for all	
	Connected inclusive neighbourhoods	
Learning and skills	School engagement and attendance	In 2050 everyone in Bristol will have the best start in life, giving the support and skill they need to thrive and prosper in adulthood
	Improved support for children	
	Post 16 and lifelong learning	

In order for the city to progress towards toward her long-term visions, and also help to sequence the activities of the city boards, the dimensions and their sub-dimensions are reviewed annually. As part of that review cycle, these goals are refreshed and three are chosen as priorities for the City Office to focus on (Lockwood, 2020). The three new themes agreed upon in January 2020 are:

1. Connectivity- Mass transit of the people is encouraged through improved funding of overground and underground transit by both the public, private and commercial sectors of the city economy.
2. Environment- To promote a legacy programme on the environment and ensure that Bristol achieve the gold standard in the Sustainable Food City award.
3. Home and Community- This target the reduction in the number of families in temporary accommodation by massive investment on housing.

The purpose of this vision is to align the Bristol City vision into the global Sustainable Development Goals so as to evolve a Bristol City with Net-Zero emissions by 2030. For these efforts to yield result, community participation is promoted through place-based leadership, community involvement and co-production which is coordinated by the City Mayor's Office. The place-based action is designed to harmonize a range of voluntary, private, public and sector partners in order to generate a wholesome and fool proof proposal for the development of the city (Michalec, Hayes and Longhurst, 2019).

6.1.2 Philosophy of Bristol

The One City Plan is to have a city that is socially liveable to work and connect with one-another, sustainable and prosperous, attractive to both business and people due to the easy access to jobs, amenities and services and the presence of vibrant diverse culture (Lockwood, 2020).

The innovation in the city of Bristol is reflected in its creativity, placing the people at the centre of all its activities and approaching complex challenges in a simple and easy manner. The street of Bristol is the lab of experiment since the digital journey in the early 2010s. Having recognised that the city of Bristol is on a social and technological journey, the One City Approach and the Bristol City Council's smart city agenda have been on the principle of placing people at the centre of its focus (Michalec, Hayes and Longhurst, 2019)

As most smart cities are framed base on their infrastructure, however, the smart city principle of the Bristol City Council is framed using technology to elicit the smartness of the people who are involved in the modelling of the future directions of the city (Lockwood, 2020)

6.1.3 Re-Engineering the Bristol's smart city agenda

The importance of innovation and technology was emphatic in the One City Plan where it was the backbone of the vision of the One City Plan through the use of digital connectivity by helping the city planner transform both the city and the Council. To further consolidate on this vision, the Bristol smart city council launched the Connecting Bristol in 2019 (Lockwood, 2020)

The support of the Bristol's smart city mission is the thrust of the Connecting Bristol mantra where its goal is to create a well-connected city with world-class infrastructure that is digitally enabled with an inclusive public service. In consonance with the six dimension of the Bristol City Council, top priorities for the following five years that supported the foundational delivery of the Bristol Smart city vision and priorities were highlighted as shown in Figure 6.3 (Lockwood, 2020).

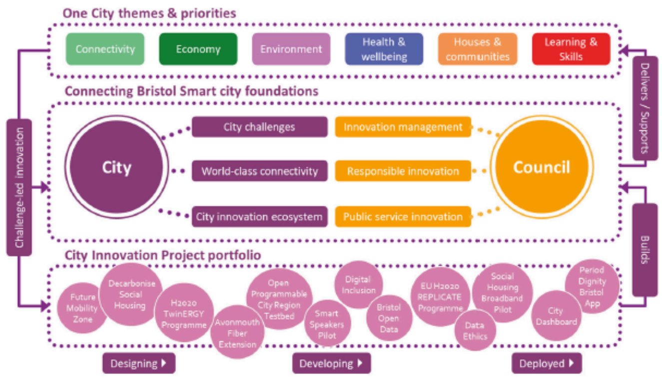

Figure 6. 3 Overview of the Connecting Bristol Strategy showing the six themes, their links to the six One city Plan theme and a selection of smart city projects in the pipeline (Source: Lockwood, 2020)

The six dimensions of the Bristol City Council can be divided into themes. The first three are city-focused while the second three are council-focused. They are both to produce specific capabilities in order to be able to achieve net zero carbon emissions and better digital infrastructure in the smart city (Lockwood, 2020).

The objectives of the city-focused themes are the problems affecting the Bristol city, improving telecommunication infrastructure and supporting the city-led initiatives while the council-focused themes are aimed at improving the council ability to manage innovation process, digitise public services and entrench responsible innovation practices that ensures that any technology used is citizen-centred, ethical and aligned with the value of the city plan. These objectives are shown in the table 6.2 (Lockwood, 2020).

Table 6. 2 Connecting Bristol smart city themes, focus areas and projects. (Source: Lockwood, 2020)

Smart city Themes	Focus	Project Examples
City challenges	Mobilise projects that support the one city plan's annual priorities	H2020 REPLICATE programme
		H2020 TwinERGY programme
		Period dignity app
		Computer reuse scheme
		One city dashboard
World-class connectivity	Drive the roll-out of digital infrastructure across the city	Social housing broadband pilot
		Avonmouth fibre extension
		Open data platform
		Open programmable city region and Bristol is open testbed
City-wide innovation ecosystem	Foster an inclusive, city-led approach to digital innovation	Bristol and Bath community data
		hackathon
		Our data initiative
Responsible innovation	Promote citizen-centred, ethical, trusted use of data and technology	Digital inclusion programme
		Data ethics training
		Data ethics and governance
Innovation management	Improve innovation outcomes and reduce impact of limited resources	Horizon scanning
		Innovation ambition matrix
Public service innovation	Exploit new technologies to deliver transform public services	Smart speakers' pilot
		Community team digital engagement pilot

The foregoing process is not a template for smart city implementation but an outline of how the Bristol Council Authority intends to achieve their smart Bristol based on real-world opportunities and problem solving rather than focus completely on technology.

In relation to the One City ethos, the Connecting Bristol strategy emphasize that cities are chaotic, emergent, social places in which people converge to live, work and socialise. By stressing that the role of technology should be to complement human capacity and not to whittle it down, thereby encouraging the efficiency of the citizen through their capacity (Lockwood, 2020).

In Bristol, the goal is a sustainable, vibrant and inclusive city using technology as an enabler for catalysing change but not making technology an end in itself for achieving the goal and also to help the people shape their future and make the city vision a reality. A smart city is therefore achieving liveable and better outcomes for the people using digital tools rather than the application of data and technology to increase efficiency, optimise costs and enhance conveniences (Lockwood, 2020).

Consequently, Connecting Bristol is a strategic departure from technology demonstrators and the prevalent, market-driven technology-push smart city model. A challenge-led approach aims to ensure that smart city projects are grounded by specific challenges aligned with the city vision and corporate vision. The high point should be identifying the challenges of the city rather than a technology solution. The emphasis should be to couch complex social and economic challenges in a manner that can easily be solve using the latest technology (Lockwood, 2020).

The ability to connect people is paramount especially with the Covid-19 pandemic situation. Hence the smart city is being programmed to support economic recovery, in addition to the ability of the Bristol Council to innovate with limited resources has become more vital in order for the Council to achieve its enunciated missions (Lockwood, 2020).

6.1.4 Execution

The interim implementation is centred on expanding digital infrastructure through the city, focusing digital exclusion and improving the Council's capability to use smart technologies. With the current funding challenges, the Council needs to innovate well with limited resources. This will require specific investment with the ability to guide promising ideas through the innovative lifecycle, across the dangerous periods and scaling into new services and solutions (Lockwood, 2020).

A sequential approach has been employed in which prospective projects or grant funding opportunities are scored against criteria like impact, match with strategic objectives, social value and level of funding, to create a simple go/no-go stage-gate process. This enable an extensive possibility to be refined into a little number of projects that have resources assigned. These handpicked initiatives form the pipeline of projects delivering the Connecting Bristol strategy. To further refine the smart city initiatives that is prioritised and resourced, a portfolio approach is chosen. All initiatives in the pipeline (planned, in progress and completed) have been mapped onto a modified Innovation Ambition Matrix to provide a holistic view of anticipated impact and risk, Figure 6.4 (Lockwood, 2020).

Fundamentally, an ambition matrix is used to define commercial innovation ambition trading off growth with tolerance for risk on the basis of a product newness versus a target market that is well-known or unfamiliar. In a public sector paradigm, market is substituted by challenge, enabling innovation to be categorised as either 'inventing the new' or 'improving the old'(Lockwood, 2020). This instrument therefore provides a way to align innovation investments with the organization's appetite for risk, justify longer-term investments and offset the risks associated with more transformational initiatives (Lockwood, 2020).

Bristol innovation portfolio is majorly directed on improving current services that address known challenges (Lockwood, 2020). This represents a mid-level of risk and a focus on immediate solutions. Major city problems, such as the need to decarbonise, are being tackled through a small handful of long-term research and development programmes like REPLICATE and TwinERGY, both directed on using new technologies to support sustainable community energy use. These more state-of-the arts transformational projects are purposefully limited numerically. These projects are risky and offer the greatest opportunity to transform the city. Few numbers of these projects reduce the exposure of the Council to risk, whilst still creating opportunities for transformational change (Lockwood, 2020).

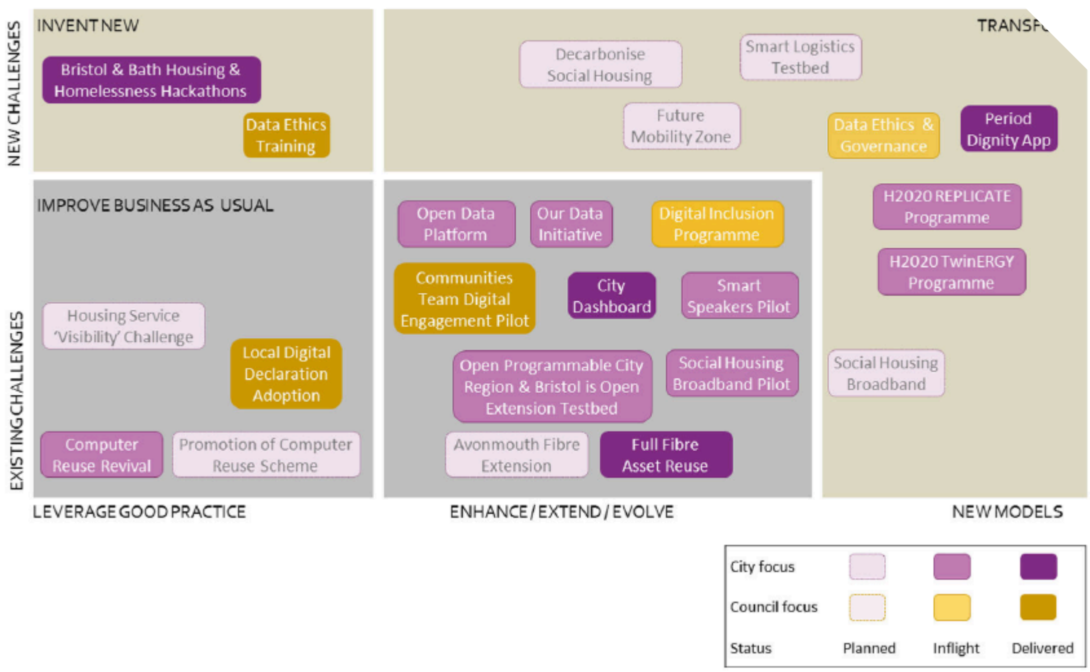

Figure 6. 4 Smart city project on to an Innovation Ambition Matrix to show the balance of projects focused on improving existing services versus transformational projects developing new services in response to emerging challenges (Lockwood, 2020).

REPLICATE (Renaissance in Places with Innovative Citizenship and Technology) is one of Bristol's flagship smart city projects initiated in 2016 (Lockwood, 2020). It is an EU-funded 5-year project to explore how new technologies could ease fuel poverty, increase sustainable travel and tackle inequalities. This seven-million-euro programme working in partnership with local organisations and the Ashley, Easton and Lawrence Hill Neighbourhood Partnership area was led by Bristol City Council. This area is growing rapidly, and it is the largest district in Bristol with a resident population of 50,600 and has the highest percentage of black or minority ethnic resident of 44% (Lockwood, 2020). The areas are perceived to be blighted by noise and pollution from traffic due to mass influx of new households to the area (Lockwood, 2020).

In the past four years, the programme team and the community collaborated on projects bearing on smart mobility, digital inclusion, digital infrastructure, intelligent data and smart energy (Lockwood, 2020). With the intent for energy efficiency, the smart energy project had prompted many homes to instal smart appliances, upgrade their boiler, insulate their loft, and instal solar PV systems to reduce their carbon footprint and save money on energy. In addition, thirteen social houses are provided with district heat network in order to lower the carbon footprint and have cheaper heating systems (Lockwood, 2020).

Community co-design and engagement are the other benefits derivable from the REPLICATE programme apart from technological innovation. Community co-design and engagement have produced the Bristol Approach which was a participatory framework that support access to technology, knowledge and resources needed to solve community challenges (Lockwood, 2020).

The goal of REPLICATE is to create pathway from pilot to implementation and ultimately to scale-up city-wide of successful programme and mainstream them into council services and city business model. This will afford the city to share knowledge with other cities that have successfully mainstream similar programmes in their domain (Lockwood, 2020).

6.1.5 Challenges ahead

Digitization has become a house name in Bristol, and this has brought about greater use and reliance on digital infrastructure. However, digitization is not without its own challenges like the risks associated with increasing use of data and artificial intelligence, poor transparency, erosion of privacy and lack of meaningful consent from people to collect, use and share their data. These challenges could be the bases of lack of public confidence in the digitization process (Lockwood, 2020).

Bristol needs to overcome the challenges of digital-divide and digital exclusion by being well-connected and data-enabled. Responsible innovation ensures that the goal of digital-inclusion is achieved through ethical, societal and regulatory avenue that can be sustainable through the confidence and trust of the citizen and ensuring that the future of Bristol smart city is pivoted on technology and data that are handle so as to protect the privacy, safety and trust of the people (Lockwood, 2020).

6.2 Milton Keynes

Milton Keynes has been developed as a new town since 1967 and it contains several pre-existing towns. It has a thriving urban centre and a unique grid road structure surrounding some 100 individual neighbourhoods (Blanco Pastor, Canniffe and Rosa Jiménez, 2023). It is a unitary authority with its southern part being mainly urban, while the north remains largely rural. Since 1967, its population has grown from 60000 to about 249000 in the 2011 and it has attracted many people, offices, and industries to become an area of remarkable growth and development (Cook and Valdez, 2021). It contains some cities like Bletchley, Wolverton and Newport Pagnell which are built-up industrial cities along the main railway routes from London to the Midlands and the north. Milton Keynes attractiveness to commerce and industry were influenced by its location (Cook and Valdez, 2023).

Milton Keynes has some permanent theatres, music venues, and an open art and an international Festival, during which multi-arts programs are staged in unusual places and public spaces (Shipman and Vogel, 2022). Milton Keynes is bisected by M1 motorway and prides itself as centre of technology, logistics, advanced manufacturing, finances and education such as the Open University whose student receive their lecture online (Kukulska-Hulme *et al.*, 2020). It provides accommodation to the winner of the Formular One championship, the Red Bull manufacturer's

Racing team. The historic site of British code breaking activities during the second world war was in Bletchley Park (Cheetham, 2022).

Figure 6. 5 Map of Milton Keynes. Source: (GBMAPS.COM, 2022)(GBMAPS.COM, 2022).

6.2.1 MK: Smart

MK: Smart is a large collaborative initiative, spearheaded by the Open University and partly funded by the Higher Education Funding Council of England. It is an innovative solution being developed to support the growth of Milton Keynes which has a Central Data Hub that support the collection and management of data relating to all aspects of life, environment and the economy, acquired through satellite technology and other sensors. These data are instrumental in the efficient management, organisation and monitoring of transport, energy, water and the environment (Cook and Valdez, 2023).

In addition to this technological innovation, is the community engagement activities where the citizens are actively in the innovation and decision-making process through the MK: Smart Citizen Lab. This citizen lab project involves the engagement of citizen in finding solution to local challenges like policies, community issues using Citizen Scientists, Citizinvestor, and Commonplace (Cook and Valdez, 2021).

6.2.2 Dimension of Milton Keynes Smart City

The Milton Keynes smart city agenda can broadly be split into seven dimensions. They are Smart Data; Smart Transport; Smart Energy; Smart Water, Smart Enterprise; Smart Citizens and Smart Education.

6.2.3 Open University

The Open University is located in Buckinghamshire where it has its headquarters and commenced operation in January 1971 (Bayley, 2022). The aim is to extend academic opportunities to everyone seeking it and hence it has no academic prerequisites for enrolment. Courses are centrally organized and coordinated online using media like television and correspondence, study group and seminars held at centres distributed throughout Great Britain (Kukulska-Hulme *et al.*, 2020)

6.3 Smart City Agenda

The smart city agenda of Milton Keynes is targeted at sustainability of the social, environmental and economy of Milton Keynes using available social and infrastructural capital. In order to surmount these challenges, MK has had to embark on some collaborative projects in association with The Open University, Milton Keynes Council, the University of Cambridge and funding was provided by the Higher Education Funding Council for Education. The project includes the Data Hub, Citizen participation, Transport and Education (Cook and Valdez, 2021) .

6.3.1 Data Hub

The basis of MK Data Hub is the collection, integration and application of huge amount of data from a variety of City's data sources like data from key infrastructure network linked to energy, water and transport; data crowdsourced from social media and mobile applications; data from sensor on weather and pollution; data from local and national open data sources. These data sources have been of immense assistance to Apps developers (Cook and Valdez, 2021) .

6.3.2 Citizen Participation

This engagement process has encouraged the citizen to participate in the installation of solar PV panels on their rooftops and the cost-benefits of each installation. Through the citizen participation, there is effort to develop apps to assist in flood management, detect tree diseases and plan for extreme weather mitigation (Willamson, 2022).

6.3.3 Transport

The idea here is to encourage the citizen to use public transport so as to reduce congestion and carbon footprints. This has been achieved using Cloud Enabled Mobility to connect users with travel information and other cloud-based services like booking and billing systems.

Apps have been developed that provide real-time information about parking space availability and an app called MotionMap which is expected to provide real-time data on the movement of vehicle and people within the city is also developed to monitor bus timetables, estimate the rate of congestion and crowd density of pedestrians (Cook and Valdez, 2021).

6.3.4 Education

This involves raising awareness of school pupils, secondary and tertiary education students, corporate bodies and the wider community on what is meant by smart city. The following initiative have been adopted: a free massive open online course on smart cities; education on data management for primary and secondary pupils (Cook and Valdez, 2021).

6.4 Educations and Impact

The data hub has 497 datasets, 27 data owner and 11 data licenses. The MK Data Hub provides data and technical infrastructure to MK Smart project (Okai, 2019). These data provide an important resource for the Urban Data School that is used to teach data literacy to both primary and secondary school pupils. MK Smart also has a programme to develop smart city solution for academics, businesses and student as well as the development of a short postgraduate certificate in New Enterprise Creation. Through this programme 60 small and medium-sizes enterprise have been engaged with over 400 business connections consolidated (Cook and Valdez, 2021).

With the introduction of extra 200 sensor into the parking space, the success recorded in the smart parking has been very encouraging to the Milton Keynes smart council and this has made parking a pleasurable experience for drivers (Cook and Valdez, 2021).

6.5 The alignment of the case studies with the eight themes of smart city

Smart Governance

The Bristol city vision which is focused on being digitally well-connected and data driven aligns with the smart governance where data and technology are used to improve the efficiency and effectiveness of city management. So also, is the Bristol One City Plan, which is a strategic framework aimed at addressing various city challenges through coordinated efforts. On the other hand the collaboration and sharing of knowledge between the Open University, the University of Cambridge and the Milton Keynes Council is a partnership fostered in smart governance.

Smart Mobility

Bristol has a focus on connectivity, including efficient and sustainable transport while Milton Keynes is focused on the use of technology to encourage public transport usage, reduce congestion and monitor transportation through apps like MotionApp.

Smart Economy

Bristol as an economic hub, has a vision of economic growth and productivity while Milton Keynes has a vision of attracting businesses and industries and involvement in innovative projects like MK: Smart.

Smart Economy

Education plays a mojor role in developing a skilled workforce commencing from the primary to the tertiary level in Bristol agenda and the Milton Keynes Smart Citizen Lab and the participation of the citizens in decision-making processes toward influencing their city’s future.

Smart Infrastructure

Here Milton Keynes has the Central Data Hub, harnessing data from different sources and the use of sensors technologies for monitoring energy, water and the environment while Bristol intend to procure digital infrastructure to improve her services.

Smart Services

In this aspect, Bristol is focused on using technology to transform the city and improve services in the city while Milton Keynes has developed apps for real-time information on parking availability and addressing local challenges like flood management and tree diseases.

Smart Environment

Bristol has introduced carbon neutrality and a healthy environment, while Milton Keynes a focused on monitoring weather and pollution using sensors the installation of solar panels to reduce carbon footprint.

Smart living

Both Bristol and Milton Keynes align with this theme in that the quality of life of their citizens if of utmost value by using sensor to monitor their environment in order to have a more pleasant, safe, healthy and good quality of life.

On the whole the alignment with the eight themes is actively pursued by both Bristol and Milton Keynes, in working towards their goal of maintaining the smartness.

Chapter 7: Qualitative Study

7 Introduction

The qualitative study began with two-prong strategy comprising of extant theoretical literature review and case study exploration. While the literature review provided a comprehensive background for the study and ensured the identification of valuable theoretical data, the case studies provided empirical context for investigating the smart city paradigm.

7.1 Sample and Sampling Techniques

The aim of this research is to develop a sturdy benchmarking framework or scale that is capable of accurately measuring the smartness of cities across selected dimensions. Owing to this ambition, the target population for the qualitative study were stakeholders with adequate experience of at least five years in the Town Planning Authorities, end-users, City Councils, and professional who have links with smart cities, who may be Architects, Builders, Engineers, Estate Agents, Administrators, Civil/Structural engineers, Contractors, Project Managers, and experts in academics.

Due to the scarcity of people with adequate knowledge and experience in smart city, as this field of smart city is still burgeoning, a non-probabilistic purposive sampling technique (Campbell et al., 2020) was adopted. Purposive sampling technique is suitable for qualitative research, as it matches the aim and objectives of the research and thereby enhancing the rigour of the investigation and reliability of the data and results (Campbell et al., 2020). It enables the researcher to freely select information-loaded participants in order to have a broad understanding of the phenomenon that is being researched upon and as observed by Creswell, (1998), that it ensures the logical applicability of the finding to other cases. Another reason is the objective of formulating a benchmarking framework which the experts will be able to provide adequate information about.

The means of reaching out to the research participants was internet search, personal contacts and referrals from these personal contacts.

7.2 Interviews

An interview involves two or more participants holding a meeting face-to-face, through the internet or over the phone (Yin, 2018). Interview can uncover ideas and deliver insight that no other method can provide (Jeschke et al., 2021). Due to the availability of expert and experienced participants for the study, the interview was identified as the most appropriate method for primary data collection and also due to the prevalence of COVID-19 which, had restricted close contact between individuals. The interviewees exhibited a profound and complex knowledge of smart city. This intensity of knowledge allowed interviewees to offer more pertinent and representative answers to the open questions. The participants were very explicit when an open question was asked so as to meet the goal of revealing existing knowledge to be studies (Rosenthal, 2016).Thus a minimum of five interviewee and a maximum of twenty-five is required for conducting interview in which a phenomenon is being investigated (Griffiths and Walsh, 2018). In line with this requirement, this study interviewed only twenty-five participants who met the criteria set out for this study. Table 7.1 shows the characteristics of the interviewee.

A wealth of unstructured data was generated through interviews (Pantano, Dennis and Alamanos, 2022). The analysis of data approach can offer the objective criteria of the selection grouping of the data, tackling any weakness or over-stressing of answers obtained, using interviews as the primary method of data collection.

Table 7. 1Characteristics of the interview Participants

Profession	Participant	Years of
Project	2	5-10
Contractors	2	16-20
Architects	3	16-20
Administrators	4	5-10
Software	2	5-10
Civil	3	11-15
Academics	2	16-20
End-users	2	11-15
Town Planning	3	16-20
Estate Agent	2	11-15
Total	25	

7.3 Limitations of Interview

There are risks of bias and validity in the process of conducting interviews (FitzPatrick, 2019) . Particularly in the face-to-face, there is a risk of unconscious bias being shown by the interviewer and responded to by the interviewee. in

7.4 Interview Approach

A crucial element of any social research is in conducting a pilot study (Doody and Doody, 2015). As such, the efficacy of the interview was tested by first conducting a pilot list of questions which were reviewed before the pilot was completed with some selected experts on smart city. After the pilot study, the researcher was able to justify the clarity of both the Consent Form, the Participant Information Sheet. The questions were also reviewed and adjusted, resulting in the final question in Appendix II.

Face-to-face interviews were done between July 2021 and January 2022. Each interview used the semi-structured interview approach. First, consent was obtained to record the interview. The recording provided an exact record of discussion to clarify details during analysis, in which case a written record is more likely to miss essential data. Secondly, during the interview, one was able to seek clarifications on areas of doubt or ambiguity to ensure that the data collected was accurate and valid. Thirdly, the interview enabled the research to achieve high response rate after proper schedule of interview times to reduce the cases of postponement, which may elongate the research time.

7.5 Process of Interview

Each participant got a copy of the research questions and a date for the interview. They were given the participant information sheet and the consent form and notified that the interview will be recorded and transcribed. A period of 25-45 minutes was earmarked for each interview. However, this time was never fully exhausted, but it was designed to give a big room for the flexibility of the interview. Both the researcher and interviewees had a copy of the interview questions, nevertheless, the process did not always follow the laydown sequence of the questions as this could have impeded the richness of the responses and reduced the opportunity for new thoughts to be recognized and deliberated. Fortunately, each interview covered the content of all the questions. Each participant was able to discuss free because of the questions were semi-structured. Though the researcher and most of the participant were not familiar, this nevertheless, does not hamper the discussion and the atmosphere of cordiality. There were no expression of anxiety or concern during or after the completion of the interview. Many are happy to have participate in the interview, given the discussion and the contemporariness of the research. Some of the key questions asked were describe how a city is benchmarked. what are the factors to be considered in benchmarking a smart city? What is your opinion about benchmarking of smart city? What are the challenges of generating benchmarking indicators? How can the challenges of benchmarking indicators be surmounted?

The interview was recorded as MP3 files, stored in the OneDrive and later transcribed. To ensure accuracy of the content transcribed, the researcher listened to the MP3 audio while review the transcripts. On completion of the transcript editing, it was sent to the participant to confirm if the transcript represents their opinion. The chance to clarify correct comments follows the principles of interview transcript review (ITR) (Mankki, 2022). The ITR is a technique employed to enhance the rigour of interview-based qualitative research. It achieve this by furnishing participants with a copy of the transcript, which they review, and this verification of accuracy seeks to increase the reliability of the interview process (Rowlands, 2021). Though, previous research indicates the process adds little to the level of transcript accuracy and present a risk of data removal or selective editing, it was observed that the additional effort of carrying out a thorough review resulted in making some few changes (Dean et al., 2021). ITR affords the interviewees with the last chance to ensure that the thought put out are accurate and adequate (Pettigrew, Fritschi and Norman, 2018). This process of ITR also reinforces the relationship between the researcher and the participants through the transparency and willingness to share the data to promote inclusion and engender inclusion towards the research project by the participants.

One of the shortcomings of using the ITR approach is that it prolong the time of the research (Ghafar, Miptah and O'Caoimh, 2019) and this can be surmounted by adequate and effective planning. Another challenge is that of data leakage whereby the wrong transcript is sent to the wrong participant(Zou et al., 2018). This was overcome in this research by being extremely careful and also critically checking message to ensure that the messages are sent to the email address of the right participants that it was meant for.

7.6 Data Analysis

During qualitative data analysis, it was pertinent to first read and explore the data so as to ensure proper acquaintance with them (Braun, Clarke and Weate, 2016). This was subsequently followed by coding of the data, which was done by labelling and segmenting the text data. From a group of similar codes, themes were also generated, and these themes were thoroughly reviewed prior to connecting interrelated themes with one another (Jimoh et al., 2019). In compliance with this process, the recorded interview was converted into written scripts, which were then analysed for the indicators of benchmarking. Nvivo was used to carry out the thematic analysis (see figure 7.1).

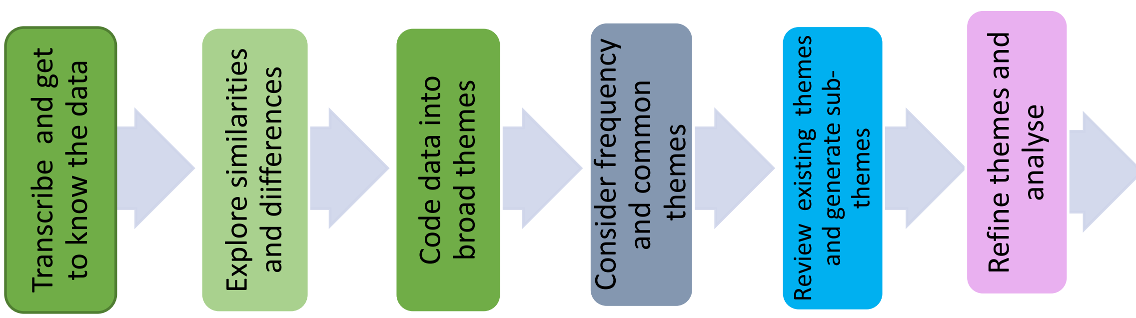

Figure 7. 1 The Data Analysis Process

Each of the participants were given a list of indicators that they updated, eliminated, amended, or confirmed based on their experience of benchmarking of smart cities prior to the interview. This was to facilitate the process of the interview and reduce the time.

7.6.1 Coding Scheme and Categorization

In order to identify common themes in the process of benchmarking of smart cities, a thematic analysis approach was used for the research. The thematic analysis is the identification of underlying themes or patterns in a qualitative material, document or data set (Kiger and Varpio, 2020). Thematic analysis, being a content-driven technique, allows exhaustive comparison of all segments of qualitative data to identify relationships and structures among frequently recurring themes (Mackieson, Shlonsky and Connolly, 2019). Usually, the frequency of specific themes or codes within a data can be collated by the researcher and simultaneously permit the analysis of their meaning within a specific context (Hermann et al., 2022). As the analysis of qualitative interview is a lengthy process, usually because huge amount of data were generated during the process, a cautious approach was exercised by the researcher towards the data as this affects the quality of the interview as well as the validity and reliability of the whole research (Shufutinsky, 2020; Roller, 2019).

At the end of the interviews, the researcher reviewed each interview with a view to familiarise himself with the narratives, and to facilitate understanding of the thoughts, opinions and experiences that have been expressed by the participants. The interviews were then transcribed by listening to the audio recording and subsequent checking the transcript for transcription accuracy. To enhance familiarity with the data, the transcripts were read and also re-read as a first step in thematic analysis (Trainor and Bundon, 2021). This was followed by generation of initial codes with the researcher highlighting meaningful parts of the data. The codes generated from literature review were confirmed by the respondent. These are the smart economy, smart environment, smart living, smart people, smart mobility, smart governance, smart services and smart infrastructure.

Step four comprised of reviewing the themes, where themes were developed, refined, or discarded, prior to the next step, step five, where themes were named and defined. This comprised the themes under each of the codes generated and confirmed by the interviewees in order to produce a comprehensive list of indicators for the benchmarking of smart cities in Table 7.2.

Table 7. 2 Indicators of Smart City Benchmarking Confirmed through Qualitative Study

S/N	***Dimensions***	***Notations***	***Indicators***	***Interviews***	***Documents/ Literature***
1	*Smart Environment*	*SEn1*	*Intelligence distribution networks*		✓
		SEn2	*Green planning and management of the city for sustainability*	✓	✓
		SEn3	*Efficient waste management systems*	✓	✓
		SEn4	*Leveraging smart meter for energy conservation in the city*	✓	✓
		SEn5	*Reliability of energy supply system to the citizens*	✓	✓
		SEn6	*Ensuring sustainability of materials from the natural environment*	✓	✓
		SEn7	*Good Air Quality in the environment*	✓	✓
		SEn8	*Clean sources and distribution networks for water supply*	✓	
		SEn9	*Ensuring contamination-free land*	✓	✓
		SEn10	*Preservation of the heritage assets*	✓	✓
		SEn11	*Preservation of the unique natural resources, ecological system, and biodiversity*	✓	✓
		SEn12	*Ensuring a cohesive healthy community*		✓
		SEn13	*Minimisation of exposure to health hazards*	✓	✓
		SEn14	*Remote health monitoring and intervention*	✓	✓
		SEn15	*Efficient and effective management of natural resource*	✓	✓
		SEn16	*Provision of abundant public open space with smart resource management*		✓
		SEn17	*Create a recreational opportunity for the people*	✓	
		SEn18	*Reduction of pollutant emissions in the environment*	✓	✓
		SEn19	*Ensuring environmental aesthetics for the city*		✓

		SEn20	*Collaboration between government and people to monitor and manage environment policies*	✓	✓
		SEn21	*Improvement in air quality, water, forest, soil conditions*	✓	✓
		SEn22	*Minimizing of Health hazards (e.g., by pollution, accidents, noxious substances in food)*	✓	✓
2	*Smart Economy*	SE1	*People with Innovative Spirit*		✓
		SE2	*Entrepreneurship capacity in the citizens*	✓	✓
		SE3	*Good Economic image and trademarks*	✓	✓
		SE4	*Highly Productive people in the city*	✓	✓
		SE5	*Flexibility of the labour market*	✓	✓
		SE6	*International embeddedness of the labour market*	✓	✓
		SE7	*Ability to transform ideas into valuable process, products and services*	✓	✓
		SE8	*Economic make-up of the people*	✓	✓
		SE9	*Competitive skill of the people*	✓	✓
		SE10	*Management efficiency of the smart city system*	✓	✓
		SE11	*Ease of Digital business licensing and permitting*	✓	
		SE12	*Open and transparent economic activities*	✓	✓
3	*Smart Mobility*	SM1	*Good Urban planning*		✓
		SM2	*Use of ICT in transportation logistics*	✓	✓
		SM3	*high speed mobility*	✓	✓
		SM4	*Real-time public transit information*	✓	✓
		SM5	*Digital public transit payment*	✓	✓
		SM6	*Autonomous vehicles*	✓	✓
		SM7	*Predictive maintenance of transportation infrastructure*	✓	✓

		SM8	*Intelligent traffic signals*	✓	✓
		SM9	*Smart parking*	✓	✓
		SM10	*E-hailing (private and pooled)*		✓
		SM11	*(Inter-)national accessibility of the transport services*		✓
		SM12	*Availability of ICT-infrastructure*	✓	✓
		SM13	*Availability of car-sharing, ride sharing, new biking systems*	✓	✓
		SM14	*Electromobility (including low carbon)*	✓	✓
		SM15	*Traffic intelligence*	✓	✓
		SM16	*use of smartphones for facilitating mobility demand and ticketing.*	✓	✓
		SM17	*Availability of pedestrian and bicycle path*	✓	✓
		SM18	*Teleworking of the workers*	✓	✓
		SM19	*enhancement of regional and international integration*	✓	✓
		SM20	*Availability of clean non-motorised transit*	✓	✓
		SM21	*collective mode of transportation through the extensive use of ICT*	✓	✓
4	*Smart People*	*SP1*	*Diversity in the people's Age*	✓	✓
		SP2	*Level of educational qualification of citizens*	✓	✓
		SP3	*Affinity to lifelong learning ambition of the people*		✓
		SP4	*Social and ethnic plurality in the community*	✓	✓
		SP5	*Attraction of high human capital into the system*	✓	✓
		SP6	*Creativity amongst the people*	✓	✓
		SP7	*Social innovation of the people*	✓	✓
		SP8	*Competitiveness spirit of the city inhabitants*	✓	✓
		SP9	*Tolerance and engagement of the people*	✓	✓

		SP10	*Imaginative people*	✓	✓
		SP11	*Versatility of the people*		✓
		SP12	*Engagement in public life and decision-making*	✓	✓
		SP13	*Level of skill of the people*	✓	✓
		SP14	*Open mindedness of the people*	✓	✓
		SP15	*Employment rate for graduate*	✓	✓
		SP16	*Cosmopolitanism/open-mindedness*	✓	
		SP17	*Participation in public life without discrimination*	✓	✓
5	*Smart Living*	*SL1*	*Availability of Cultural facilities to the people*		✓
		SL2	*Availability of world-class health facilities to the people*	✓	✓
		SL3	*Telemedicine availability to the citizens*	✓	✓
		SL4	*Individual safety in the community*	✓	✓
		SL5	*High quality Housing availability*	✓	✓
		SL6	*Education facilities for the citizens*	✓	✓
		SL7	*Enrolment of young people in general education and vocational training*	✓	✓
		SL8	*High level of Employment and low level of unemployment*	✓	✓
		SL9	*Enhanced attraction to Tourist*	✓	✓
		SL10	*Promoting Social cohesion amongst the people*	✓	✓
		SL11	*Remote patient monitoring for the vulnerable*	✓	✓
		SL12	*Lifestyle wearables by the vulnerable*	✓	✓
		SL13	*Infectious disease surveillance*	✓	✓
		SL14	*Availability of world-class education*	✓	✓
		SL15	*Promoting art and culture and natural heritage*	✓	✓

		SL16	*Place of security for women, children and the vulnerable*	✓	✓
6	*Smart Government*	*SG1*	*Participation of the citizens government's decision-making*	✓	✓
		SG2	*Availability of public and social services for the citizens*		✓
		SG3	*Transparency in governance activities*	✓	✓
		SG4	*Transparency in decision-making process.*	✓	✓
		SG5	*Citizen's participation in implementing, monitoring and evaluating government's initiatives*	✓	✓
		SG6	*Multi-stakeholder participation in decision making*		✓
		SG7	*Availability of Political strategies and perspectives*	✓	✓
		SG8	*Sustainable social behaviour of the people*	✓	✓
		SG9	*Achieving smart, sustainable and inclusive growth*	✓	✓
		SG10	*public value creation, vision and strategy formulation*	✓	✓
		SG11	*Social inclusiveness of the citizens*	✓	✓
		SG12	*Clarity of environmental protection policy*	✓	✓
		SG13	*Availability of e-Services for public engagement*	✓	✓
		SG14	*Availability of E-government for transactions with government*	✓	✓
7	*Smart Infrastructure*	*SI1*	*Availability of Good Road networks*	✓	✓
		SI2	*Availability of Utilities services*	✓	✓
		SI3	*Enabling environment for human capital development, competition and innovation*	✓	✓
		SI4	*Power generating systems availability*	✓	✓
		SI5	*Availability of institutions for capacity buildings*	✓	✓
		SI6	*Application of ICT in all aspects of life like mobility, education healthcare and others*	✓	✓
		SI7	*Preponderance of Computer literate personnel*	✓	✓

		SI8	*Prevalence of 5g internet network*	✓	✓
		SI9	*Availability of Web 4.0*	✓	✓
		SI10	*Availability of IoT and embedded devices*	✓	✓
		SI11	*Availability of Cloud computing and Wi-Fi Services*	✓	✓
8	*Smart Services*	*SS1*	*Provision of efficient Emergency services for the citizens*	✓	✓
		SS2	*Efficient Services for the community*	✓	✓
		SS3	*Efficient Municipal waste disposal*	✓	✓
		SS4	*Waste recycling for resource re-use*	✓	✓
		SS5	*Predictive policing to reduce crime*	✓	✓
		SS6	*Real-time crime mapping to monitor criminal activities*	✓	✓
		SS7	*Digital tracking and payment for waste disposal to ensure successful waste disposal*	✓	✓
		SS8	*Gunshot detection in order to apprehend criminals*	✓	✓
		SSS9	*Smart surveillance of the city in order to pre-empt crime and pollution*	✓	✓
		SS10	*Body-worn cameras to reduce police brutality*	✓	✓
		SS11	*Disaster early-warning systems in order to save lives in emergencies*	✓	✓

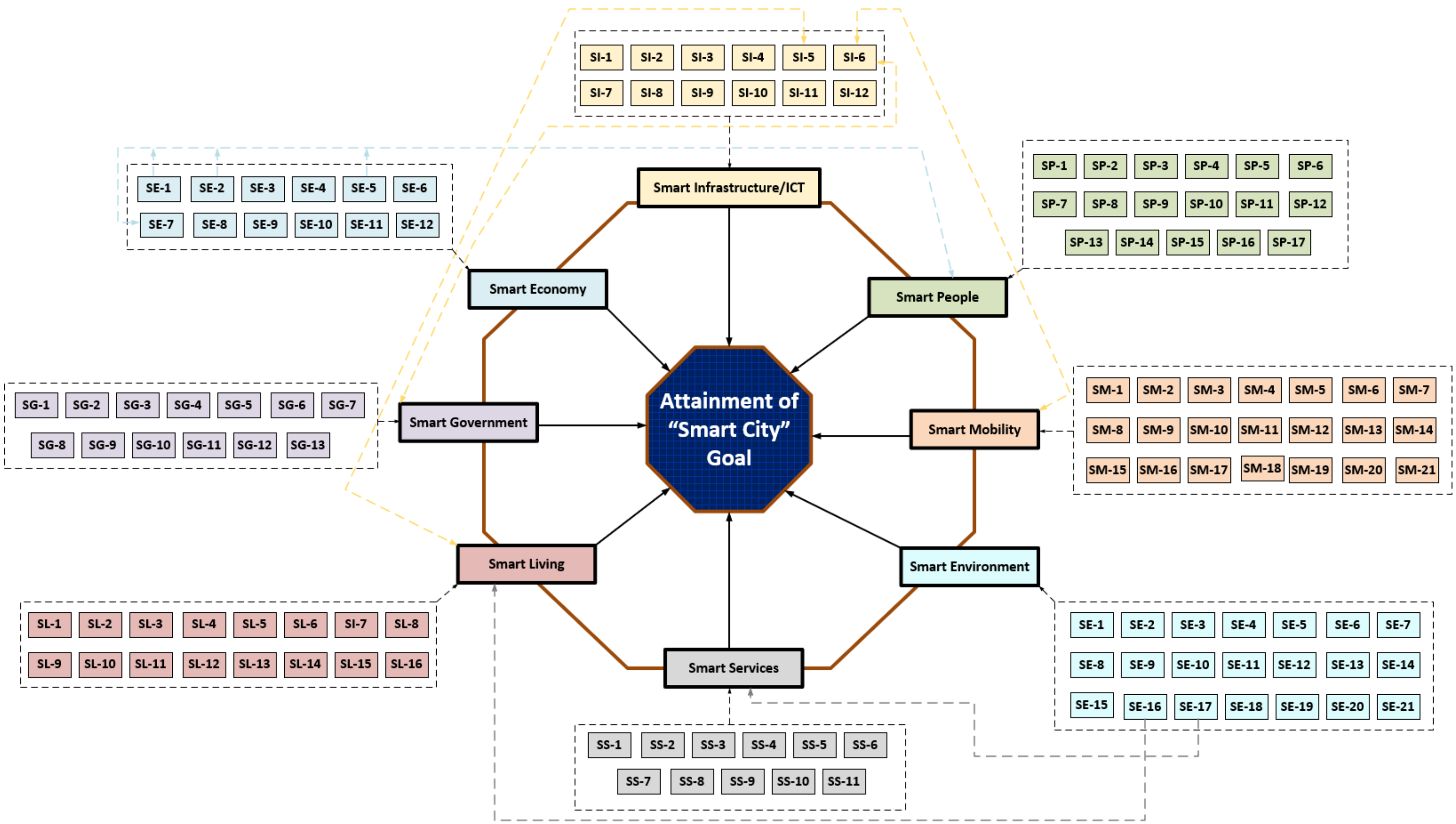

Figure 7. 2 Conceptual Framework for Smart City Dimensions and their Smartness Indicators. Source: Author's literature review

7.7 Qualitative Research Outcomes and Conceptual Frameworks Development

The qualitative research outcomes are combined with earlier literature review findings presented in chapter 3. Since the research is on developing a robust benchmarking framework for benchmarking smart cities, the findings are presented here.

7.8 Chapter Summary

The chapter began with an overview of the nature of the qualitative study followed by the sampling technique which was both purposive and snowball sampling combine so as to be able to reach the desired participant in the study and harnessed the relevant information. Once the participant have been identified, interviews were conducted following the University ethical guidelines and the interviewees supplied the pertinent answers to the semi-structured question posed by the researcher. During the interview session, information about indicators for the benchmarking of smart cities were elicited from the interviewees which confirmed most of the indicators extracted from extant literature, all of which were recorded and later turned into a transcript for the thematic analysis carried out using Nvivo and the subsequent development of a conceptual framework for smart city dimension shown in Figure 7.2

Chapter 8: Quantitative Study

8 Chapter Overview

As earlier noted in the methodology chapter and some part of this study, this research involves both qualitative and quantitative phases. Chapter 7 was the presentation of the qualitative phase while this chapter presents the quantitative data collection procedures and the accompanying findings. Population sample, sample strategy, questionnaire development and piloting, final survey distribution and statistical analysis, wider applicability of identified factors influencing benchmarking practices were examined. In addition, views of experts from different background were compared. The subjective importance of identified measures was also examined across the eight broad categories of indicators.

8.1 Population and Sampling Techniques

Following the research guidelines and strategy, it was important to confirm the broader applicability and generalizability of the study's finding through a large survey of sample. The major reason for this was to achieve two vital goals for the research: to confirm the validity of the eight constructs generated from the qualitative study, and to explore expert's view regarding factors identified from literature contributing to benchmarking of smart cities. looking at the special nature of the research, choosing information-rich participant was of utmost value. In this respect, a purposive sampling technique was initially used for the study. This enabled the study to identify survey respondents based on pre-determined, vital and specific criteria (Ji et al., 2019). In this instance, these criteria are included:

1) Choosing private sector experts with experience and participation in smart city projects
2) Picking public sector employees with vast knowledge and involvement in smart city projects
3) Selecting private sector experts with knowledge in smart city management

4) Selecting public sector employees with knowledge of smart city administration

Based on the bullet points, the questionnaire survey was targeted at suitable public and private sectors participants with varying experience in UK smart city. Though the UK public sector workforce is currently estimated at 5.70 million as at September 2021 according to the UK's office of National Statistics (ONS) (Office of National Statistics, 2022), however, the nature of this research requires only employees with broad experience in smart city administration and management to be sampled. Coincidentally, open database for accessing UK's public-sector employees could not be found.

Based on this above information, the study chose another sampling method to achieve its objective. Hence a snowball sampling method was finally selected to execute the survey. First, initial contacts were established with some existing contact within the private and public sectors using known gate keepers.

8.2 Questionnaire Design and Formulation

The main goal of this survey was to streamline and validate the indicators retrieved from literature review and those obtained from interview with expert in the field of smart cities. Toward this end, the questionnaire for this study was developed from qualitative data identified through literature review, semi-structured interview and other documentary evidence. Firstly, six dimensions were identified from literature and these were supplemented with two other dimensions (smart infrastructure and smart services) smart city dimensions were identified for smart city benchmarking. These eight benchmarking dimensions were used to form eight sections of questions in the questionnaire. In addition, 124 indicators that are regarded as contributing to each of the eight dimensions of smart city benchmarking were identified. These 124 indicators constitute the independent variables predicting the dependent variables (dimensions of smart city). These data was then integrated into an important section of the questionnaire.

8.2.1 Section of the Questionnaire

In producing questionnaire for this study, eleven major sections were created. The first section introduced the research to the respondents and highlighted the research aim and objectives. The contribution of the questionnaire survey to the study was highlighted. The first section focuses on the demographics of the respondents. The next captures information about the concept and dimensions of smart cities and how they felt smart cities could be made smarter. The remaining sections comprised of the eight broad dimensions of smart city identified from literature which are smart governance, smart environment, smart economy, smart mobility, smart infrastructure, smart people, smart living, and smart services. Under each category, the respective benchmarking mechanism were situated along with their measures. A total of one hundred and twenty-four (124) questions were used to elicit participant's views on factors that could be used to benchmark smart cities.

8.2.2 Scale of Measurement

The Likert scale is a very useful and reliable tool for measuring self-efficacy and attitude (Wu and Leung, 2017). For this study, the Likert measurement was adopted. As a psychometric measurement tool (Stamatakis et al., 2017), Likert scale permits the indirect measurement of latent values and different facets of multidimensional constructs (Hauck et al., 2016). Often, the Likert scale requires individual to respond to series of questions (usually multiple item questions) on a continuum scale of whether they "Not Important" or "Very Important"(Dykema et al., 2022).

In order to minimise a response bias and errors, the Likert scale offers both positive and negative responses(Kreitchmann et al., 2019). Although the rating scale range in category from three, four, five, six and seven(Han, 2017), the most common of them is the 5-point scale (Chyung et al., 2007). Therefore, in this study, a five-point Likert scale was adopted in which 1= "not important", 2= "Slightly important", 3= "undecided", 4= "important" and 5= "very important". Respondents were later asked to indicate the extent to which they regard the factor as "not important" to "very important" for the benchmarking of smart cities. this established a basis for arriving at the average rank of all the participants' rating across the variable, thereby exhibiting the importance of each variable.

8.2.3 Pilot Study and its Evaluation Techniques

Pilot-testing was done on the questionnaire for variation, meaning, content and construct validity (Mallah et al., 2021; Wells et al., 2018). This was to allow the researchers to assess what the respondents construe and understand the questions, and to see if adequate alternative responses have been provided for the answers (Boateng et al., 2018). Prior to pre-testing, pre-coding that allowed for easy processing of questionnaire data and help to prevent time loss during analysis and filling was done (Bryman, 2008).

There have been different opinion on the number of participants for the pilot study (Justice et al., 2019; Tyler et al., 2017; Newbutt et al., 2016). While (Chatzitheochari et al., 2018), suggested ten (10) respondents, (Chamorro-Petronacci et al., 2020), recommended the size of between ten and thirty (10-30) respondents. A total of ten (10) respondents may be suitable for effectively pre-testing a research instrument was the argument muted by (Chamorro-Petronacci et al., 2020), in another related study. In line with these precursors, this study identified ten (10) respondents for pilot-testing of the designed questionnaire.

From the UK public, private and academics sectors, using the researcher's existing network, ten (10) respondents were selected. The participant for the pilot study comprised of two (2) private sector experts, three (3) public sector experts and five (5) academics from the department of Business and Management. Each of the participant selected in the pilot study have an average of six (6) years' experience in in consulting capacity on smart city in the UK. The respondents in the pilot study were able to assess the lucidity of the questions, appropriateness of the measurement scale and logic of the measurement variables in relation to the constructs being measured. Many feedbacks like shortening of the sentences and rewording of the questions were suggested. The feedbacks were immediately incorporated and used to develop the final questionnaire. After the pilot study, the total number of questions on the questionnaire came to one hundred and thirty (130).

8.3 Data Collection

After the pilot test, and the questionnaire further refined based on feedbacks from the experts, the questionnaire survey commenced with the administration to two hundred (200) respondents through face-to-face and emails channels. It is pertinent to note that the adoption of a snowball sampling method in the study necessitated that some of the respondents be met face-to-face to fill the questionnaire. (Day et al., 2021), (Bartolic et al., 2021), (Liu et al., 2019) have noted that face-to-face survey is much preferred due to its flexibility, representative, personal interaction and quick-response opportunities. The face-to-face distribution allowed the respondent to quickly fill and return the questionnaire promptly. Therefore, many trips were undertaken to different government, industry and trade-led symposia and one-to-one meeting were attended in order to access some of the two hundred (200) respondents. Many of the respondents were also contacted by email after telephone conversation intimating them with the purpose of the questionnaire. This ensure wider participation by different professionals. Several reminder emails and few additional follow-up trips were made to some of the respondents to stimulate their responses. This phase of this study lasted for about eleven months commencing from February 2021 to January 2022. At the end of the data collection exercise, a total of two hundred (200) respondents have been reached for the study.

8.4 Statistical Analysis Technique

In order to understand the underlying patterns across the responses given by the different respondents and also to ensure that the data collected were amenable to fuzzy synthetic evaluation (FSE), a befitting statistical analysis appropriate for the data was chosen. For this to be feasible, different analysis was done for the purpose of cleansing, description and validation of the data using the IBM SPSS software. Through Cronbach's Alpha test, reliability of both the measurement instrument and the different factors were intensely examined. Test for multicollinearity among factors was used to test for the missing data. To unravel the significance ranking of each observed variable in the questionnaire, descriptive statistical analysis was also conducted. The top ranked variable in the questionnaire was identified by their mean ranking.

8.5 Response Rate

Out of the two hundred questionnaires distributed, one hundred and fifty-six were returned, amounting to a response rate of 78.0%. Seven of the questionnaires were incomplete and therefore rejected. This left us with a total one hundred and forty-nine usable response, which constitute 74.5% of the distributed questionnaires.

As shown in Table 8.1, 11.4% of the respondents are Project Manager/Administrators, 4.7% are Contractors, 11.4% are Architects, 6.0% are Estate Agents, 12.8% are respectively Software Engineers and Town Planning Authorities, 13.4% are Civil Engineers, 10.1% are Academics, 7.4% are End-users while the remaining 10.1% comprised of others which include students, business people and some workers. Their experiences varies from five to twenty years of interaction with smart cities.

Table 8. 1 Showing the response rate to the questionnaire of the survey

11.4	Participant	Percentage (%)	Years of Experience
Project Manager/ Administrators	17	11.4	5-10
Contractors	7	4.7	16-20

Architects	17	11.4	16-20
Estate Agent	19	6.0	5-10
Software Engineer	19	12.8	5-10
Civil Engineers	20	13.4	11-15
Academics	15	10.1	16-20
Town Planning Authorities	19	12.8	16-20
End-users	11	7.4	5-10
Others	15	10.1	11-15
Total	149	100	

8.6 Preliminary Data Analysis and Screening

Data cleansing and screening were executed in preparing data for additional statistical analysis. This comprised of identification of outliers, unengaged respondents, missing value analysis and checking for multi-collinearity. The check for outlier was done using Mahalanobis distance (D) statistics following the guidance from (Atkinson, Riani and Cerioli, 2010).

8.6.1 Missing Value Analysis

In order to address concern due to incomplete data, the missing values analysis was executed as they affect the precision of statistical computation (Mattei and Freiisen, 2019). As a way of avoiding complexities in assumptions and theories guiding statistical analysis, missing value provide a methodical approach for treating incomplete data. Three key functions that were performed by missing value analysis include: identification and description of the patterns of missing values, estimation of means and other descriptive statistics, and finally, replacement of missing values with estimated values (Chin et al., 2020).

There are three types of missing value, they are: Missing Completely at Random (MCAR); Missing at Random (MAR); and Not Missing At Random (NMAR). A value is said to be MCAR if the probability of having a missing value for a particular variable is related neither to the missing variable nor other observed variables in the array of data. The MCAR is statistically beneficial in that the analysis remain unbiased by the replacement of the missing value with an overall average for the variable (Jenghara et al., 2018). Also, the systematic nature of missing value where the missing value could be explained by other variable in the dataset is referred to as Missing Value at Random (MAR). In this situation, the missing value could be determined by identifying the variable that could predict the value of the missing data. The third scenario, the Not Missing at Random (NMAR), is when the missing value is not at random, and hence, it could be predicted by another observed variable in the array of data (Ispirova, Eftimov and Seljak, 2020). NMAR is very problematic and therefore, the solution to addressing it is either by modelling or to delete the dataset with the missing value (Ispirova, Eftimov and Seljak, 2020).

In the process of dealing with missing value, certain investigators may decide to implement an ad-hoc technique of substituting the missing value or abandon the survey with missing items using listwise, pairwise or case deletion technique (Rachel, Stefano and Liz, 2018). In the present study, as most of the missing data are missing completely at random and they are insignificant, about three in number, because they are less than 5-10 percent of the data. The missing data have been removed using the listwise deletion method recommended by (Berchtold, 2019) because they have insignificant missing value while responses that have missing value between 1 and 3 cases are not more than five from the 149 responses. After adjudging these missing data as MCAR using the Expectation Maximization in the SPSS missing value analysis, and having established that the Chi-square was statistically insignificant, the missing value were replacing with their mean or median. This is founded on the theoretical context that a mean is a sensible estimate of an observation that is randomly chosen from a normal distribution; mean replacement technique was used for the missing value. This is especially suitable when less than 10 percent of data for a particular respondent are missing (Jadhav, Pramod and Ramanathan, 2019). Hence, the mean value of a variable is used to substitute missing data for the variable. The tactic ensures that the incomplete dataset is usable, without affecting the overall mean of each variable on the dataset. According to (Rachel, Stefano and Liz, 2018), this ensures that the data analysis remained unbiased with the substation of the missing value.

8.6.2 Reliability analysis

The Cronbach's Alpha is a tool for estimating the internal consistency and reliability of the questionnaire instrument. It is not a measure of homogeneity and unidimensionality (Joseph and Daniel, 2007). The Cronbach's Alpha is one of the common tests of reliability that determine average correlation or internal consistency of objects in a research instrument (Figueiredo et al., 2022). This is essential as it is important to know the Cronbach's Alpha coefficient, particularly when using the Liker scale in a questionnaire. The range of Cronbach's Alpha coefficient is between 0.00-1.00. 0.00 represents lack of consistency while a value of 1.00 means a perfect consistency. However, a value of 0.70 represent an acceptable consistency, 0.8, suggests a good internal consistency, while a value of 0.9 represents an excellent consistency of the scale measurement (de Diego-Cordero et al., 2022). In addition to the overall Cronbach's Alpha for different categories of variable for Smart Infrastructure, smart Economy, smart People, Smart Mobility, Smart Living, smart Governance, Smart Environment, and Smart Service, Cronbach's Alpha if item deleted were also estimated for each category of the variable. In this scenario, any variable with Cronbach's Alpha above the overall value means that such a variable is not a good construct and should be deleted from the list of variables. The outcome of the Cronbach's Alpha for each category of variables are shown on the Reliability Statistics tables in Tables 8.1,8.4, 8.7, 8.10, 8.13, 8.16, 8.19, and 8.22. Furthermore, the global Cronbach's Alpha for the respective construct of Smart Infrastructure, smart Economy, smart People, Smart Mobility, Smart Living, Smart Governance, smart Environment, and Smart Service are respectively 0.842, 0.859, 0.813, 0.844, 0.851, 0.890, 0.840, 0.805.

To appreciate the variables that are germane and contributing to each construct, the 'Cronbach's Alpha if item deleted' was executed on the variables. If the Cronbach's alpha of such variable is greater than the construct Cronbach's Alpha, this implies that such variables are not contributing meaningfully to the construct and therefore must be deleted. As for Smart Infrastructure, smart Economy, smart People, Smart Mobility, Smart Living, Smart Governance, smart Environment, and Smart Service whose 'Cronbach's Alpha if item deleted' were respectively shown on Tables 8.3, 8.6, 8.9, 8.12, 8.15, 8.18, 8.21, and 8.24, are less than the main Cronbach's Alpha of their respective construct and hence no deletion of the variables was required.

Table 8. 2 Reliability Statistics of Smart Infrastructure

Cronbach's Alpha	**Cronbach's Alpha Bases on Standardized Items**	**N of Items**
0.842	0.841	11

Table 8. 3 Item Statistics of Smart Infrastructure (SI)

Notation	Variables	Mean	Std. Deviation	N	Mean Ranking
SI1	Availability of Good Road networks	4.11	0.889	149	6
SI2	Availability of Utilities services	4.19	0.803	149	2
SI3	Enabling environment for human capital development, competition and innovation	4.13	0.819	149	5
SI4	Power generating systems availability	4.2	0.788	149	1
SI5	Availability of institutions for capacity buildings	4.05	0.845	149	11
SI6	Application of ICT in all aspects of life like mobility, education healthcare and others	4.1	0.891	149	7
SI7	Preponderance of Computer literate personnel	4.07	0.839	149	10
SI8	Prevalence of 5g internet network	4.09	0.857	149	8
SI9	Availability of Web 4.0	4.09	0.805	149	8
SI10	Availability of IoT and embedded devices	4.17	0.873	149	3
SI11	Availability of Cloud computing and Wi-Fi Services	4.15	0.849	149	4

Table 8. 4 Smart Infrastructure (SI) of Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SI1	41.26	15.745	0.315	0.145	0.716
SI2	41.17	16.118	0.31	0.197	0.718
SI3	41.23	16.154	0.294	0.122	0.720
SI4	41.17	16.343	0.282	0.12	0.723
SI5	41.32	16.19	0.273	0.1	0.724
SI6	41.27	15.36	0.373	0.227	0.704
SI7	41.3	15.953	0.314	0.206	0.717
SI8	41.28	16.336	0.244	0.167	0.730
SI9	41.28	16.744	0.208	0.155	0.736
SI10	41.2	15.635	0.342	0.198	0.711
SI11	41.22	16.079	0.288	0.104	0.722

Table 8. 5 Reliability Statistic for Smart Economy

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.859	0.861	12

Table 8. 6 Smart Economy Item statistics

Notation	Variables	Mean	Std. Deviation	N	Mean Ranking
SE1	People with Innovative Spirit	4.06	0.818	148	6
SE2	Entrepreneurship capacity in the citizens	3.99	0.869	148	10
SE3	Good Economic image and trademarks	3.97	0.888	148	11
SE4	Highly Productive people in the city	3.92	0.837	148	12
SE5	Flexibility of the labour market	4.09	0.872	148	2
SE6	International embeddedness of the labour market	4.01	0.8	148	9
SE7	Ability to transform ideas into valuable process, products and services	4.07	0.846	148	3
SE8	Economic make-up of the people	4.03	0.786	148	7
SE9	Competitive skill of the people	4.07	0.842	148	3
SE10	Management efficiency of the smart city system	4.02	0.853	148	8
SE11	Ease of Digital business licensing and permission	4.07	0.874	148	3
SE12	Open and transparent economic activities	4.14	0.854	148	1

Table 8. 7 Smart Economy (SE) Item-total statistics

Notation	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SE1	44.39	14.757	0.345	0.227	0.711
SE2	44.46	15.719	0.163	0.117	0.753
SE3	44.48	15.299	0.217	0.135	0.740
SE4	44.53	15.679	0.183	0.119	0.747
SE5	44.36	15.417	0.207	0.209	0.742
SE6	44.44	15.2	0.282	0.138	0.726
SE7	44.39	15.354	0.23	0.166	0.737
SE8	44.42	15.483	0.242	0.123	0.734
SE9	44.38	15.325	0.237	0.17	0.735
SE10	44.43	15.594	0.189	0.074	0.746
SE11	44.38	15.284	0.227	0.128	0.738
SE12	44.32	15.429	0.214	0.121	0.740

Table 8. 8 Reliability statistics for Smart People

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.713	0.712	17

Table 8. 9 Item Statistics for Smart People

Notation	Variables	Mean	Std. Deviation	N	Mean Ranking
SP1	Diversity in the people's Age distribution	3.97	0.844	148	14
SP2	Level of educational qualification of citizens	3.84	0.833	148	17
SP3	Affinity to lifelong learning ambition of the people	3.86	0.83	148	15
SP4	Social and ethnic plurality in the community	4.02	0.853	148	12
SP5	Attraction of high human capital into the system	4.05	0.759	148	9
SP6	Creativity amongst the people	4.16	0.865	148	1
SP7	Social innovation of the people	4.07	0.826	148	7
SP8	Competitiveness spirit of the city inhabitants	4.03	0.786	148	10
SP9	Tolerance and engagement of the people	4.02	0.845	148	12
SP10	Imaginative people	4.14	0.862	148	2
SP11	Versatility of the people	4.11	0.821	148	4
SP12	Engagement in public life and decision-making	4.11	0.796	148	4
SP13	Level of skill of the people	4.12	0.848	148	3
SP14	Open mindedness of the people	4.11	0.826	148	4
SP15	High employment rate for graduates	4.03	0.836	148	10
SP16	Cosmopolitanism/open-mindedness of people	3.85	0.82	148	16
SP17	Participation in public life without discrimination	4.07	0.858	148	7

Table 8. 10 Item-Total Statistics for Smart People

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SP1	64.61	26.306	0.077	0.098	0.720
SP2	64.74	25.757	0.146	0.102	0.710
SP3	64.72	24.626	0.288	0.11	0.789
SP4	64.56	25.296	0.194	0.133	0.703
SP5	64.53	25.339	0.232	0.178	0.797
SP6	64.42	24.531	0.281	0.223	0.790
SP7	64.51	24.701	0.281	0.152	0.790
SP8	64.55	25.95	0.14	0.082	0.710
SP9	64.56	25.391	0.186	0.091	0.704
SP10	64.45	24.739	0.257	0.124	0.793
SP11	64.47	25.325	0.204	0.161	0.701
SP12	64.47	25.734	0.164	0.105	0.707
SP13	64.46	24.849	0.25	0.129	0.794
SP14	64.47	24.06	0.363	0.195	0.777
SP15	64.55	25.215	0.211	0.128	0.700
SP16	64.73	25.192	0.222	0.134	0.799
SP17	64.51	24.02	0.349	0.216	0.779

Table 8. 11 Reliability Statistics for Smart Mobility

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.844	0.843	21

Table 8. 12 Item Statistics for Smart Mobility

Notation	Variables	Mean	Std. Deviation	N	Mean Ranking
SM1	Good Urban planning	4.13	0.903	149	5
SM2	Use of ICT in transportation logistics	4.12	0.869	149	6
SM3	Availability of High-speed mobility	4.07	0.831	149	12
SM4	Availability of Real-time public transit information	3.98	0.809	149	20
SM5	Availability of Digital public transit payment	4.17	0.792	149	2
SM6	Existence of Autonomous vehicles in city transport architecture	4.14	0.822	149	4
SM7	Predictive maintenance of transportation infrastructure	4.07	0.867	149	12
SM8	Intelligent traffic signals	3.97	0.865	149	21
SM9	Smart parking	4.11	0.843	149	9
SM10	E-hailing (private and pooled)	4.04	0.804	149	16
SM11	(Inter-)national accessibility of the transport services	4.26	0.775	149	1
SM12	Availability of ICT-infrastructure	4.01	0.881	149	18
SM13	Availability of car-sharing, ride sharing, new biking systems	4.12	0.744	149	6
SM14	Electromobility (including low carbon)	4.05	0.817	149	15
SM15	Traffic intelligence	4.09	0.833	149	11
SM16	use of smartphones for facilitating mobility demand and ticketing	4.17	0.857	149	2
SM17	Availability of pedestrian and bicycle path	4.12	0.829	149	6

SM18	Teleworking of the workers	3.99	0.775	149	19
SM19	Enhancement of regional and international integration	4.04	0.829	149	16
SM20	Availability of clean non-motorised transit	4.07	0.878	149	12
SM21	collective mode of transportation through the extensive use of ICT	4.1	0.836	149	10

Table 8. 13 Item-Total Statistic of Smart Mobility

Notation	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SM1	81.70	44.428	0.395	0.287	0.727
SM2	81.70	45.277	0.339	0.285	0.732
SM3	81.75	45.864	0.306	0.145	0.735
SM4	81.85	45.577	0.344	0.308	0.732
SM5	81.66	45.443	0.368	0.25	0.730
SM6	81.68	47.326	0.176	0.141	0.744
SM7	81.76	45.049	0.36	0.246	0.730
SM8	81.86	44.879	0.377	0.293	0.729
SM9	81.71	45.788	0.307	0.271	0.734
SM10	81.79	47.481	0.169	0.131	0.744
SM11	81.56	46.464	0.278	0.188	0.737
SM12	81.82	44.906	0.365	0.245	0.730
SM13	81.70	47.561	0.184	0.216	0.743
SM14	81.78	46.255	0.277	0.141	0.737
SM15	81.73	44.725	0.411	0.337	0.727
SM16	81.66	45.646	0.312	0.158	0.734
SM17	81.70	46.791	0.222	0.116	0.741
SM18	81.83	46.749	0.250	0.256	0.739
SM19	81.79	46.224	0.274	0.259	0.737
SM20	81.75	46.31	0.244	0.146	0.739
SM21	81.72	45.741	0.314	0.293	0.734

Table 8. 14 Reliability Statistics of Smart Living

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.851	0.848	16

Table 8. 15 Item Statistics of Smart Living

Notation	Variables	Mean	Std. Deviation	N	Mean Ranking
SL1	Availability of Cultural facilities to the people	3.95	0.769	149	16
SL2	Availability of world-class health facilities to the people	4.11	0.79	149	6
SL3	Telemedicine availability to the citizens	4.11	0.831	149	6
SL4	Individual safety in the community	4.14	0.885	149	3
SL5	High quality Housing availability	4.1	0.836	149	10
SL6	Excellent education facilities for the citizens	4.03	0.877	149	14
SL7	Enrolment of young people in general education and vocational training	4.19	0.803	149	1
SL8	High level of Employment	4.11	0.831	149	6
SL9	Enhanced attraction to Tourists	4.04	0.845	149	13

SL10	Promoting Social cohesion amongst the people	4.15	0.825	149	2
SL11	Remote patient monitoring for the vulnerable	4.11	0.839	149	6
SL12	Lifestyle wearables by the vulnerable	4.05	0.76	149	12
SL13	Infectious disease surveillance	4.07	0.819	149	11
SL14	Availability of world-class education	4.13	0.833	149	4
SL15	Promoting art and culture and natural heritage	3.97	0.838	149	15
SL16	Improved security for women, children and the vulnerable	4.12	0.838	149	5

Table 8. 16 Item-Total Statistics for Smart Living

Notation	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SL1	61.42	26.719	0.094	0.133	0.756
SL2	61.26	25.397	0.256	0.154	0.736
SL3	61.26	25.465	0.227	0.092	0.740
SL4	61.23	24.623	0.302	0.203	0.729
SL5	61.27	24.698	0.32	0.180	0.727
SL6	61.34	23.713	0.419	0.302	0.712
SL7	61.17	25.240	0.270	0.185	0.734
SL8	61.26	25.235	0.255	0.215	0.736
SL9	61.33	25.601	0.204	0.127	0.743
SL10	61.22	25.322	0.248	0.188	0.737
SL11	61.26	24.789	0.307	0.152	0.729

SL12	61.32	25.596	0.245	0.193	0.738
SL13	61.30	25.361	0.246	0.173	0.738
SL14	61.24	24.576	0.338	0.222	0.725
SL15	61.40	26.579	0.09	0.069	0.759
SL16	61.25	24.850	0.300	0.170	0.730

Table 8. 17 Reliability Statistics of Smart Governance

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.890	0.889	14

Table 8. 18 Item Statistics for Smart Governance

Notation	Variables	Mean	Std. Deviation	N	Mean Ranking
SG1	Participation of the citizens in government's decision-making	4.1	0.803	149	5
SG2	Availability of public and social services for the citizens	4.15	0.828	149	3
SG3	Transparency in governance activities	4.17	0.828	149	1
SG4	Transparency in decision-making process.	4.16	0.87	149	2
SG5	Citizen's participation in implementing, monitoring and evaluating	4.01	0.834	149	12

	government's initiatives				
SG6	Multi-stakeholder participation in decision making	4	0.805	149	13
SG7	Availability of Political strategies and perspectives	3.99	0.83	149	14
SG8	Sustainable social behaviour of the people	4.02	0.842	149	11
SG9	Achieving smart, sustainable and inclusive growth	4.06	0.84	149	9
SG10	Public value creation, vision and strategy formulation	4.05	0.865	149	10
SG11	Social inclusiveness of the citizens	4.07	0.806	149	8
SG12	Clarity of environmental protection policy	4.08	0.889	149	7
SG13	Availability of e-Services for public engagement	4.1	0.844	149	5
SG14	Availability of E-government for transactions with government	4.12	0.821	149	4

Table 8. 19 Item-Total Statistics of Smart Governance

Notation	**Scale Mean if Item Deleted**	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Squared Multiple Correlation**	**Cronbach's Alpha if Item Deleted**

SG1	52.99	24.54	0.26	0.123	0.779
SG2	52.93	24.198	0.291	0.146	0.775
SG3	52.91	23.621	0.366	0.228	0.765
SG4	52.93	23.515	0.353	0.224	0.767
SG5	53.08	23.912	0.325	0.139	0.771
SG6	53.09	24.202	0.304	0.144	0.774
SG7	53.1	23.753	0.348	0.206	0.768
SG8	53.07	23.874	0.325	0.212	0.771
SG9	53.03	24.067	0.301	0.111	0.774
SG10	53.04	24.174	0.274	0.158	0.778
SG11	53.01	24.73	0.234	0.194	0.783
SG12	53.01	23.628	0.328	0.218	0.770
SG13	52.99	24.23	0.278	0.17	0.777
SG14	52.97	24.425	0.266	0.139	0.779

Table 8. 20 Reliability Statistics for Smart Environment

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.840	0.839	22

Table 8. 21 Item Statistics of Smart Environment

Notation	Variables	Mean	Std. Deviation	N	Mean Ranking
SEn1	Intelligence distribution networks	4.07	0.831	139	12
SEn2	Green planning and management of the city for sustainability	3.95	0.792	139	19
SEn3	Efficient waste management systems	4.16	0.773	139	2
SEn4	Leveraging smart meter for energy conservation in the city	4.14	0.767	139	3
SEn5	Reliability of energy supply system to the citizens	4.12	0.79	139	5
SEn6	Ensuring sustainability of materials from the natural environment	3.97	0.842	139	18
SEn7	Good Air Quality in the environment	4.04	0.824	139	17
SEn8	Clean sources and distribution networks for water supply	4.06	0.858	139	14
SEn9	Ensuring contamination-free land	3.94	0.791	139	20
SEn10	Preservation of the heritage assets	3.9	0.819	139	22
SEn11	Preservation of the unique natural resources, ecological system, and biodiversity	4.09	0.85	139	8
SEn12	Ensuring a cohesive healthy community	4.09	0.816	139	8
SEn13	Minimisation of exposure to health hazards	4.12	0.808	139	5
SEn14	Remote health monitoring and intervention	4.1	0.801	139	7
SEn15	efficient and effective management of natural resource	3.94	0.818	139	20
SEn16	Provision of abundant public open space with smart resource management	4.06	0.773	139	14
SEn17	Create a recreational opportunity for the people	4.07	0.777	139	12
SEn18	Reduction of pollutant emissions in the environment	4.05	0.871	139	16
SEn19	Ensuring environmental aesthetics for the city	4.08	0.826	139	11
SEn20	Collaboration between government and people to monitor and manage environment policies	4.13	0.797	139	4
SEn21	Improvement in air quality, water, forest and soil conditions	4.09	0.838	139	8
SEn22	Minimising of Health hazards arising from exposure to harmful materials (e.g., by pollution, accidents, noxious substances in food)	4.17	0.831	139	1

Table 8. 22 Item-Total Statistics Smart Environment

Notation	Scale Mean if Item Deleted	Scale Variable if item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SEn1	85.260	27.512	0.215	0.157	0.720
SEn2	85.380	27.267	0.264	0.254	0.713
SEn3	85.170	28.390	0.132	0.181	0.733
SEn4	85.190	28.385	0.135	0.108	0.733
SEn5	85.220	28.446	0.120	0.131	0.735
SEn6	85.360	27.913	0.164	0.239	0.729
SEn7	85.290	27.293	0.244	0.208	0.716
SEn8	85.270	28.113	0.135	0.185	0.733
SEn9	85.400	28.487	0.114	0.217	0.736
SEn10	85.430	28.044	0.157	0.140	0.730
SEn11	85.240	28.081	0.141	0.116	0.732
SEn12	85.240	27.429	0.232	0.217	0.718
SEn13	85.220	27.866	0.183	0.168	0.726
SEn14	85.230	27.816	0.192	0.241	0.724
SEn15	85.400	28.400	0.116	0.135	0.736
SEn16	85.270	27.487	0.246	0.174	0.716
SEn17	85.260	29.831	-0.042	0.203	0.758
SEn18	85.280	27.971	0.146	0.115	0.731
SEn19	85.250	27.798	0.183	0.176	0.725
SEn20	85.200	28.292	0.136	0.155	0.733
SEn21	85.240	27.969	0.159	0.119	0.729
SEn22	85.170	27.342	0.236	0.208	0.717

Table 8. 23 Reliability Statistics of Smart Services

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.705	0.704	11

Table 8. 24 Item Statistics for Smart Services

Notation	Variables	Mean	Std. Deviation	N	Mean Ranking
SS1	Provision of efficient Emergency services for the citizens	3.99	0.845	148	8
SS2	Rapid response to public services enquiries by citizens	4.07	0.805	148	3
SS3	Efficient Municipal waste disposal	3.99	0.825	148	8
SS4	Availability of Waste recycling for resource re-use	4.22	0.807	148	1
SS5	Predictive policing to reduce crime	3.95	0.875	148	11
SS6	Real-time crime mapping to monitor criminal activities	4.18	0.833	148	2
SS7	Digital tracking and payment for waste disposal to ensure successful waste disposal	4.05	0.781	148	5
SS8	Gunshot detection in order to apprehend criminals	4.02	0.829	148	7
SSS9	Smart surveillance of the city in order to pre-empt crime and pollution	4.04	0.848	148	6
SS10	Body-worn cameras to reduce police brutality	4.07	0.834	148	3
SS11	Disaster early-warning systems in order to save lives in emergencies	3.96	0.872	148	10

Table 8. 25 Item-Total Statistics for Smart Services

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SS1	40.56	13.704	0.401	0.21	0.751
SS2	40.49	14.428	0.303	0.124	0.774
SS3	40.57	14.478	0.282	0.16	0.778
SS4	40.33	14.658	0.262	0.159	0.782
SS5	40.6	14.432	0.26	0.181	0.783
SS6	40.37	14.589	0.259	0.11	0.783
SS7	40.5	14.646	0.28	0.127	0.779
SS8	40.53	15.149	0.17	0.1	0.702
SSS9	40.51	14.945	0.193	0.135	0.798
SS10	40.48	15.204	0.158	0.126	0.705
SS11	40.59	13.753	0.374	0.163	0.756

8.7 Descriptive Statistics

The descriptive statistics provide both numerical and graphical summary format of the data collected in the study. Items displayed in the numerical analysis includes mean, frequency distribution, standard deviation, range, variance and correlation, while the graphical analysis is the depiction of data using charts, figures (like stem and leaf display) and graphs. Descriptive statistics offers prospect for comparing and ranking between and within groups. In the current study, descriptive statistics was undertaken to generate the means, standard deviation, variance and correlation for the different variables that constitute the respective construct of Smart Infrastructure, smart Economy, smart People, Smart Mobility, Smart Living, Smart Governance, smart Environment, and Smart Service. The topped ranked variables was determine using the mean, because parametric test is considered to be appropriate with large sample size and normally distributed data (Kyriazos, 2018).

As a measure of central tendency, the mean testing is usually employed by statisticians when there is need to determine the means and relative significance of a set of statistical variables (Omoya, Burton and Baroud, 2022). In order to underline the critical Smart Infrastructure, smart Economy, smart People, Smart Mobility, Smart Living, Smart Governance, smart Environment, and Smart Service variables a mean ranking and standard deviation within the constructs were conducted as shown in Tables 8.2, 8.5, 8.8, 8.11, 8.14, 8.17, 8.20, and 8.23.

8.7.1 Descriptive statistics for Smart Infrastructure

The descriptive statistics was carried out to determine the main smart infrastructure variable to be considered in benchmarking smart city. The mean and standard deviation was found using SPSS. This variable were ranked across the smart infrastructure construct within the variables and based on the mean ranking, the top ranked variables are:

1) Power generating systems availability.
2) Availability of utility services
3) Availability of IoT and embedded devices
4) Availability of cloud computing and Wi-Fi services
5) Enabling environment for human capital development, competition and innovation
6) Availability of good road networks
7) Application of ICT in all aspects of life like mobility, education, healthcare and others
8) Prevalence of 5g internet network
9) Availability of Web 4.0

10) Preponderance of computer literate personnel
11) Availability of institutions for capacity building

Table 8.2 shows the eleven variables for smart infrastructure with their mean, standard deviation and mean ranking while the Cronbach's Alpha for the group under smart infrastructure are shown on Table 8.3. All the eleven variables under smart infrastructure have exhibited very good internal consistency with Cronbach's alpha in a range of 0.704 to 0.736. This suggests that the variable under smart infrastructure are contributing meaningfully to the construct.

8.7.2 Descriptive statistics for Smart Economy

In order to identify the major variable that are important for benchmarking of the smart city, descriptive statistics was carried out on constructs of smart economy. Based on the descriptive mean testing, the key variables for smart economy in their order of importance, following the mean ranking, are as follows:

1. Open and transparent economic activities
2. Flexibility of the labour market
4. Ability to transform ideas into valuable process, products and services.
4. Competitive skill of the people
4. Ease of digital business licensing and permission
6. People with innovative spirit
7. Economic make-up of the people
8. Management efficiency of the smart city system
9. International embeddedness of the market
10. Entrepreneurship capacity in the citizens
11. Good economic image and trademarks
12. Highly productive people in the city

Three variables on numbers 3, 4, and 5 shared equal rating of 3 on the mean ranking and therefor, ranked 4. The variables showed good validity with a Cronbach's alpha ranging from 0.711 to 0.753.

8.7.3 Descriptive statistics for Smart People

Another major construct in the benchmarking of smart cities is smart people. It may be described as the most important construct because everything about smart city emanates and revolve around the smart people. Based on descriptive mean testing, the major variables for smart people in their order of importance are as follows using the mean ranking:

1. Creativity amongst the people
2. Imaginative people
3. Level of skill of the people
5. Versatility of the people
5. Engaging in public life and decision-making
5. Open mindedness of the people
7 Participation in public life without discrimination
7 Social innovation of the people
9 Attraction of high human capacity into the system
10 Competitiveness spirit of the city inhabitants
10 High employment rate for graduates
12 Social and ethnic plurality in the community
12 Tolerance and engagement of the people
14. Diversity in the people's age distribution
15. Affinity to lifelong learning ambition of the people
16. Cosmopolitanism/open-mindedness of people
17. Level of educational qualification of the citizens

Some of the variables were sharing the same ranking. These include variables ranked 4, 5, and 6, sharing the 4th rank, ranked 4, variable ranked 7 and 8 sharing the 7th rank, ranked 7; variable ranked 10 and 11 sharing the 10th rank, ranked 10 and variable ranked 12 and 13 sharing the 12th ranking, ranked 12. The variable showed a good validity with a Cronbach's alpha ranging from 0.700 to 0.799.

8.7.4 Descriptive statistics for Smart Mobility

As a means of establishing the smart mobility as a key construct for benchmarking of smart city, descriptive statistics was carried out on the variables constituting smart mobility. The mean, mean ranking and standard deviation was found using SPSS. The variables of smart mobility were ranked in the following order using the mean ranking:

1. (Inter-)national accessibility of the transport services
2 Availability of digital transit payments
2 Use of smartphone for facilitating mobility demand and ticketing
4. Existence of autonomous vehicles in city transport architecture
5. Good urban planning
6. Use of ICT in transportation logistics
6. Availability of car-sharing, ride sharing, new biking systems
6. Availability of pedestrian and bicycle path
9. Smart parking
10. Collective mode of transportation through the extensive use of ICT
11. Traffic intelligence
11. Availability of high-speed mobility
11. Predictive maintenance of transport infrastructure
14. Availability of clean non-motorised transit
15 Electromobility (including low carbon)
15 E-hailing (private and pooled)

17. Enhancement of regional and international integration
18. Availability of ICT-infrastructure
19. Teleworking of the workers
20. Availability of real-time public transit information
21. Intelligence traffic signals

Table 8.11 shows all the twenty-one variables of the smart mobility construct with mean, standard deviation and mean ranking. Following the mean ranking, it was found that variables ranked 2 and 3 ranked equally i.e., 2; variables ranked 6, 7, and 8 ranked equally, i.e. 6; variable ranked 11, 12 and 13 also ranked equally, i.e. 11 and variable ranked 15 and 16 ranked equally on rank 15. The Cronbach's alpha of the construct, shown on Table 8.12, ranged from 0.727 to 0.744 suggesting a good internal consistency and reliability of the constructs.

8.7.5 Descriptive statistics for Smart Living

One other vital element for benchmarking smart city is smart living. It is a key factor in the benchmarking of smart city. From the mean ranking the order of importance of the variables are as follows:

1. Enrolment of young people in general education and vocational training
2. Promoting social cohesion amongst the people
3. Individual safety in the community
4. Availability of world-class education
5. Improved security for women, children and the vulnerable
6 Availability of world-class health facility to the people
6 Telemedicine availability to the citizens
6 High level of employment
6 Remote patient monitoring for the vulnerable

10. High quality housing availability
11. Infectious disease surveillance
12. Lifestyle wearable by the vulnerable
13. Enhanced attraction of Tourists
14. Excellent education facilities for the citizen
15. Promoting art and culture and natural heritage
16. Availability of cultural facilities to the people.

Four of the variables on numbers 6,7,8, and 9 are tied on rank 6. The variables showed good validity with Cronbach's alpha ranging from 0.712 to 0.759

8.7.6 Descriptive statistics for Smart Governance

The descriptive statistics of smart governance in the benchmarking of smart cities is shown on Table 8.17 which shows the mean ranking. The order of the mean ranking from the highest to the lowest is as follows:

1. Transparency in governance activities
2. Transparency in decision making process
3. Availability of public and social services for the citizens
4. Availability of E-government for transaction with government
5 Participation of the citizens in government's decision-making
5 Availability of e-services for public engagement
7. Clarity of the environmental protection policy
8. Social inclusiveness of the citizens
9. Achieving smart, sustainable and inclusive growth
10. Public value creation, vision and strategy formulation
11. Sustainable social behaviour of the people

12. Citizen’s participation in implementing, monitoring and evaluating government’s initiatives.
13. Multi-stakeholder participation in decision making
14. Availability of political strategies and perspective

Two of the variable of smart governance construct ranked 5 and 6 tied on rank 5. The variables showed good validity with Cronbach’s alpha ranging from 0.765 to 0.783.

8.7.7 Descriptive statistics for Smart Environment

Another construct used for the benchmarking of smart cities is smart environment. Table 8.20 shows the standard deviation, mean and mean ranking. The order of the mean ranking from the highest to the lowest is as follows:

1. Minimising of health hazards arising from exposure to harmful materials (e.g., by pollution, accidents, noxious substances in food)
2. Efficient waste management systems
3. Leveraging smart meter for energy conservation in the city
4. Collaboration between government and people to monitor and manage environmental policies

5 Reliability of energy supply system to the citizens

5 Minimisation of exposure to health hazards

7. Remote health monitoring and intervention
9. Preservation of the unique natural resources, ecological system, and biodiversity
9. Ensuring a cohesive healthy community
9. Improvement in air quality, water, forest and soil conditions
11. Ensuring environmental aesthetics for the city
12. Intelligence distribution networks
12. Create a recreational opportunity for the people

14. Clean sources and distribution networks for water supply
14. Provision of abundant public open space with smart resource management
16. Reduction of pollutant emission in the environment
17. Good air quality in the environment
18. Ensuring sustainability of materials from the natural environment
19. Green planning and management of the city for sustainability
20. Ensuring contamination-free land
21. Efficient and effective management of natural resources
22. Preservation of the heritage assets

The variables on rank 5 and 6 are tied on rank 5; the variable on rank 8, 9 and 10 are also tied on rank 9 while rank 12 and 13 were also tied on rank 12 and the rank 14 and 15 were tied on rank 14. The variables showed good validity with a Cronbach's alpha ranging from 0.713 to 0.736.

8.7.8 Descriptive statistics for Smart Services

Smart services are also one of the constructs in the benchmarking of smart cities. The descriptive statistics was conducted on the construct and the standard deviation, mean and mean ranking were determined. Using the mean ranking, the variables are in the following order:

1. Availability of waste recycling for resource re-use
2. Real-time crime mapping to monitor criminal activities
3. Rapid response to public service enquiries by citizens
3. Body-worn cameras to reduce police brutality
5. Digital tracking and payment for waste disposal to ensure successful waste disposal
6. Smart surveillance of the city to pre-empt crime and pollution
7. Gunshot detection in order to apprehend criminals
8. Provision of efficient emergency services for the citizens
8. Efficient municipal waste disposal

10. Disaster early-warning systems in order to save lives in emergencies
11. Predictive policing to reduce crime

The variable sharing ranks are rank 3 and 4, which are tied on rank 3; and ranks 8 and 9 which are tied on rank 8. The variables showed good validity with a Cronbach's alpha of ranging from 0.702 to 0.798

8.8 Chapter summary

This chapter confirmed the wider relevance of the findings at the qualitative stage by exploring the quantitative phase of the study. Findings identified through the literature and semi-structured interviews were used to develop the questionnaire survey which was pilot-tested and later distributed to the interviewees for collection of the data. Although the interviewees were basically recruited through a purposive and Snowball sampling approaches by relying on current network of contacts of the researchers in the UK's planning authorities and some end-users, a total of 200 respondents were sampled with a return rate of 78.0% and 74.5% usable questionnaire responses (149 responses) were returned. These returned questionnaires were subjected to Missing Value Analysis, Reliability Analysis, Mean Ranking and Standard deviation. The study identified top-ranked variables for the benchmarking of smart cities.

Chapter 9: The use of Fuzzy Synthetic Evaluation

9 Introduction

Before now, the development of smart city model had been done by Networked Society Index using geometrical aggregation and min-max normalization model and Cities in Motion Index using the Indicators of Simple Weighting factor, Participatory Method and the DP2 Technique. The Networked Society Index developed by Ericsson and Sweco in 2016 did their ranking on 41 cities (Pozdniakova, 2017). The Networked Society index is a hierarchical index where the sub-index possess different weights. Ericsson and Sweco used geometrical aggregation and a "Min-Max" normalization model to arrive at the Networked Society Index. Through this method of aggregation and min-max normalization technique, it was easy to summarise data, reduce complexity and create insight and better data visualization (Leprince et al., 2021). However, the aggregation model have some shortcomings like the loss of details when the original data is being aggregated (Zhang et al., 2021). In cases where fine-grained information is important, aggregation may oversimplify the data, thereby producing a misleading summary (Luo et al., 2021). Some aggregation methods, such as the mean or sum, can be sensitive to outliers, producing a misleading summary while the outliers can unreasonably influence the aggregate value (Hosseinzadeh et al., 2023). Also, there is loss of variability when data are aggregated into means and sum (Nayak & Hasija, 2021a).

The Cities in Motion Index combined three methods which are the Indicators of Simple Weighting factor, Participatory Method and the DP2 Technique. The indicators of simple weighting factors has a weakness of not allowing for assigning different weight to the indicators or dimensions (Lan et al., 2022) and the real weight assigned to each indicator may not be equal because if the number of indicators in each sub-dimension is different, the weight of each individual indicator in the synthetic indicator will also differ (Sehnbruch et al., 2020). The participatory method has a challenge of the reliability of the weighting factors, given the subjectivity of the individual scores (Nayak & Hasija, 2021b), because it has been shown that it is difficult to assign score to a system of more than ten indicators at the same time without some inconsistencies (Nayak & Hasija, 2021b). The DP2 Technique is a methodology based on distance (Jiang et al., 2023; Strand & Craw, 2022): it implies the difference between one given value of an indicator and another value used as a reference or target. When using this method, the value of the synthetic indicator is affected by the order in which the indicators are introduced (Ribeiro-Navarrete et al., 2021). There is need to develop a comprehensive, reliable, and objective approach to quantifying the success of smart cities projects implemented in any part of the world. This is very important because, through the success index of smart city projects, the relative success of smart city projects can be compared by practitioners in an objective manner. Above all, the abstract concept of smart city success would be eradicated, and this will enable a realistic and reliable success evaluation of smart cities projects based on benchmarking purposes (Akomea-Frimpong, Jin and Osei-Kyei, 2021). In furtherance of the research to develop an excellent practice framework for smart cities implementation, a reliable and practical success evaluation model for the smart city project is developed using the fuzzy synthetic evaluation method. Hence, practitioners in the field of smart city can use the success index equation to evaluate smart city projects success and to compare the success stages of different smart city projects. Therefore, this would improve the implementation practices of smart city in the global arena.

9.1 Fuzzy Synthetic Evaluation Method

The fuzzy synthetic evaluation (FSE), an application of the fuzzy set theory, aims to provide a synthetic evaluation of an object relative to an objective in a fuzzy decision circumstance with multiple criteria (Wu, Chu and Xu, 2021). Issues relating to ambiguous, subjective and imprecise judgements can be adequatly resolved using the fuzzy set theory (Lin et al., 2021). The fuzzy theory can quantify the linguistic facet of available data and preferences for individual or group decision-making while also allowing mathematical operators to be applied to the fuzzy domain (Fei, Feng and Wang, 2021). Complex evaluation with multi-attributes and multi-levels can be efficiently managed and handled with FSE (Fei, Feng and Wang, 2021).

FSE has been successfully deployed in diverse research field such as human resource management (Gurmu, 2021), huge construction projects (Liu et al., 2022), health risk assessment (Zhao, Hwang and Gao, 2016), risk evaluation in public-private-partnership projects (Xu et al., 2010), and knowledge management (Nichita, Marcel and Georgiana, 2013). Challenges of ambiguity, subjectivity and poor precision in judgement of problems can be addressed using the fuzzy set theory (Guiffrida and Nagi, 1998). Through the FSE, human decision-making, which is based on subjective judgment, is objectified by the FSE. Hence it is used in this study to formulate a smart city success index equation. FSE is considered appropriate compared to the normal weighted method because it can objectify and manipulate the subjective judgement that is inherent in human cognitive processes.

The procedure adopted in executing the FSE model is detailed as follows:

Establish a basic set of criteria. $\prod = \{f_1+f_2+f_3 \ldots f_n\}$; where n is the number of constructs

Label the set of grade alternative as $L = \{L_1, L_2, L_3, \ldots L_n\}$. The set of grade categories are the scale measurement. Hence, the 5-point Likert scale is the set of grade alternatives. e.g., L_1= not important, L_2= slightly important, L_3= undecided, L_4= important, L_5= very important

Set the weights for each criterion for factor component. The weighting (W) is determined from the survey using the following equation:

$$W_i = \frac{M_i}{\sum_{i=1}^{5} M_i} 0 \leq W_i \leq 1, \qquad \sum W_i = 1. \qquad (1)$$

Where W = weighting; M = mean score of a particular criterion or factor component; and

$\sum W_i$ = summation of mean ratings.

Apply a fuzzy evaluation matrix for each factor component. The matrix is expressed as

$R_i = (r_{ij})_{m \times n}$, where r_{ij} is the degree to which alternative L_j satisfies the criterion f_j.

Reach final FSE results for the evaluation by considering the weighting vector and the fuzzy evaluation matrix using the following equation:

$$D = W_I^O \; R_i \qquad (2)$$

where D = final FSE evaluation matrix, and O = fuzzy composition operator.

The final FSE evaluation matrix is normalized and a PSI for a particular factor component was calculated using the following equation:

$$\text{PSI} = \sum_{i=I}^{5} D \; X \; L \qquad (3)$$

9.2 Analysis of Data using FSE

Four major steps are involved in the data analysis, they are: selecting the constructs; identifying the critical variables for the constructs; generating PSI for each critical variable for benchmarking smart city; and developing a PSI model for benchmarking of smart cities.

9.3 Selecting the constructs

Table 9.1 shows the mean score analysis and ranking of variable in the construct for benchmarking smart city. The mean ranges from 4.05 to 4.20 for smart infrastructure; 3.92 to 4.14 for smart economy; 3.84 to 4.16 for smart people; 3.97 to 4.26 for smart mobility; 3.95 to 4.19 for smart living; 3.99 to 4.17 for smart governance; 3.90 to 4.17 for smart environment; 3.95 to 4.22 for smart services. Hence, in selecting the critical variable, only variables with normalized value equal to or greater than 0.50 are considered. This normalization criteria were used because it allows the most significant criteria to be selected and used for the model development. Above all, it makes it realisable to satisfy the factor-to-sample ratio recommended for factor analysis technique. In some earlier studies this selection mechanism had also been used to determine the most significant factors (Mazumder et al., 2022)(Mazumder et al., 2022).

As shown on the table 9.1 (column 3) 70 critical benchmarking criteria emerged. These include six variables from smart infrastructure: Power generating systems availability; Availability of utility services; Availability of IoT and embedded devices; Availability of cloud computing and Wi-Fi services; and Enabling environment for human capital development, competition and innovation.

Seven variables from smart economy which are: Open and transparent economic activities; Flexibility of the labour market; Ability to transform ideas into valuable process, products and services; Competitive skill of the people; Ease of digital business licensing and permission; People with innovative spirit; and Economic make-up of the people.

Thirteen variables from smart people which include: Creativity amongst the people; Imaginative people; Level of skill of the people; Versatility of the people; Engaging in public life and decision-making; Open mindedness of the people; Participation in public life without discrimination; Social innovation of the people; Attraction of high human capacity into the system; Competitiveness spirit of the city inhabitants; High employment rate for graduates; Social and ethnic plurality in the community; and Tolerance and engagement of the people.

Eight of the critical variables were from smart mobility and they include: (Inter-)national accessibility of the transport services; Availability of digital transit payments; Use of smartphone for facilitating mobility demand and ticketing; Existence of autonomous vehicles in city transport architecture; Good urban planning; Use of ICT in transportation logistics; Availability of car-sharing, ride sharing, new biking systems; and Availability of pedestrian and bicycle path.

Eleven of the critical variables in smart living are: Enrolment of young people in general education and vocational training; Promoting social cohesion amongst the people; Individual safety in the community; Availability of world-class education; Improved security for women, children and the vulnerable; Availability of world-class health facility to the people; Telemedicine availability to the citizens; High level of employment; Remote patient monitoring for the vulnerable; High quality housing availability; and Infectious disease surveillance.

Seven of the critical variables for smart governance are: Transparency in governance activities; Transparency in decision making process; Availability of public and social services for the citizens; Availability of E-government for transaction with government; Participation of the citizens in government's decision-making; Availability of e-services for public engagement; and Clarity of the environmental protection policy.

Seventeen of the critical variable in smart environment are: Minimising of health hazards arising from exposure to harmful materials (e.g. by pollution, accidents, noxious substances in food); Efficient waste management systems; Leveraging smart meter for energy conservation in the city; Collaboration between government and people to monitor and manage environmental policies; Reliability of energy supply system to the citizens; Minimisation of exposure to health hazards; Remote health monitoring and intervention; Preservation of the unique natural resources, ecological system, and biodiversity; Ensuring a cohesive healthy community; Improvement in air quality, water, forest and soil conditions; Ensuring environmental aesthetics for the city; Intelligence distribution networks; Create a recreational opportunity for the people; Clean sources and distribution networks for water supply; Provision of abundant public open space with smart resource management; Reduction of pollutant emission in the environment; and Good air quality in the environment.

The remaining critical variable are from smart services, and they are: Availability of waste recycling for resource re-use and Real-time crime mapping to monitor criminal activities. These critical variables are used in the next stage of the analysis which is the identification of critical success criteria groupings (CSCGs) for benchmarking of smart cities

Table 9. 1 Showing the Normalization, weighting and total mean

variables	**MIS**	**Normalization**	Weighting (Mean)/ (Total Mean)	Total Mean	Total Weighting= (Total Mean)/(Overall Mean)
		Smart Infrastructure			
SI4	4.20	1.000	0.20153551		
SI2	4.19	0.933	0.20105566		
SI10	4.17	0.800	0.20009597		
SI11	4.15	0.667	0.19913628		
SI3	4.13	0.533	0.19817658		
Total Mean	20.84	3.933		20.84	0.07238625
		Smart Economy			
SE12	4.14	1.000	0.14511041		
SE5	4.09	0.988	0.14335787		
SE7	4.07	0.983	0.14265685		
SE9	4.07	0.983	0.14265685		
SE11	4.07	0.682	0.14265685		
SE1	4.06	0.981	0.14230634		
SE8	4.03	0.500	0.14125482		
Total	28.53	6.12		28.53	0.09909691

Smart People

SP6	4.16	1.000	0.07843137		
SP10	4.14	0.937	0.0780543		
SP13	4.12	0.875	0.07767723		
SP11	4.11	0.844	0.07748869		
SP12	4.11	0.844	0.07748869		
SP14	4.11	0.844	0.07748869		
SP7	4.07	0.719	0.07673454		
SP17	4.07	0.719	0.07673454		
SP5	4.05	0.656	0.07635747		
SP8	4.03	0.594	0.07598039		
SP15	4.03	0.594	0.07598039		
SP4	4.02	0.562	0.07579186		
SP9	4.02	0.562	0.07579186		
Total	53.04	9.750		53.04	0.18423064

Smart Mobility

SM11	4.26	1.000	0.12819741		
SM5	4.17	0.690	0.12548902		
SM16	4.17	0.979	0.12548902		
SM6	4.14	0.586	0.12458622		
SM1	4.13	0.552	0.12428528		
SM2	4.12	0.517	0.12398435		
SM13	4.12	0.517	0.12398435		
SM17	4.12	0.517	0.12398435		
Total	33.23	5.358		33.23	0.11542202

Smart Living

SL7	4.19	1.000	0.09241288		
SL10	4.15	0.833	0.09153066		
SL4	4.14	0.792	0.0913101		
SL14	4.13	0.750	0.09108955		
SL16	4.12	0.708	0.09086899		
SL2	4.11	0.667	0.09064843		
SL3	4.11	0.667	0.09064843		
SL8	4.11	0.667	0.09064843		
SL11	4.11	0.667	0.09064843		
SL5	4.10	0.625	0.09042788		
SL13	4.07	0.500	0.08976621		
Total	45.34	7.875		45.34	0.15748524
Smart Governance					
SG3	4.17	1.000	0.14439058		
SG4	4.16	0.944	0.14404432		
SG2	4.15	0.889	0.14369806		
SG14	4.12	0.722	0.14265928		
SG1	4.10	0.611	0.14196676		
SG13	4.10	0.611	0.14196676		
SG12	4.08	0.500	0.14127424		
Total	28.88	5.278		28.88	0.10031261
Smart Environment					
SEn22	4.17	1.000	0.05987938		
SEn3	4.16	0.963	0.05973578		
SEn4	4.14	0.889	0.05944859		
SEn20	4.13	0.852	0.059305		
SEn5	4.12	0.815	0.0591614		

SEn13	4.12	0.815	0.0591614		
SEn14	4.10	0.741	0.05887421		
SEn11	4.09	0.704	0.05873062		
SEn12	4.09	0.704	0.05873062		
SEn21	4.09	0.704	0.05873062		
SEn19	4.08	0.667	0.05858702		
SEn1	4.07	0.630	0.05844342		
SEn17	4.07	0.630	0.05844342		
SEn8	4.06	0.593	0.05829983		
SEn16	4.06	0.593	0.05829983		
SEn18	4.05	0.556	0.05815623		
SEn7	4.04	0.519	0.05801264		
Total	69.64	12.370		69.64	0.24188955
Smart Services					
SS4	4.22	1.000	0.50238095		
SS6	4.18	0.852	0.49761905		
Total	8.40	1.852		8.4	0.0291768
Grand Mean Total				287.9	

Normalized Value $N_m = (M_n - M_{min})/(M_{max} - M_{min})$

9.4 Identification of Critical Success Criteria Groupings (CSCGs) for Smart City Projects

The 70 critical success criteria for smart city were determined by the deployment of the factor analysis technique. Usually, prior to conducting a factor analysis, a variable-to-sample size ratio of 1:5 is recommended (Dolnicar, 2020; Osei-Kyei, Chan and Dansoh, 2020). Hence, considering that the variable-to-sample ratio of this study is at least 1:7.1, the factor analysis technique is viewed as appropriate and suitable for the data set. However, preliminary test like correlation matrix and Cronbach's alpha tests have been conducted to further ascertain the suitability of the technique in this research.

9.5 Generating a Benchmarking Success Index for each of the CSCG for Smart City Projects

As previously noted, the FSE is the main tool used to develop a benchmarking success index for each CSCG, which then enabled the development of a benchmarking success index for smart city project. Prior to conducting the fuzzy modelling, two different levels are established. The first level is the eight CSCGs, whereas the second level is the seventy CSCs.

9.6 Appropriate weight of critical success criteria (second level) and critical success criteria grouping (first level) calculation

The weightings of the critical success criteria and critical success criteria groupings are calculated based on Eq. (1) using the mean values obtained from the survey (Table 9.1). For example, from Table 9.1, given that smart infrastructure consists of five critical success criteria with a total mean value of 20.84, the weighting of, for example, SI is given as:

$$W_{SI} = \frac{4.20}{4.30+4.19+4.17+4.15+4.13} = \frac{4.20}{20.84} = 0.2015$$

Therefore, the weightings of all the critical variables in Table 9.1, for smart city benchmarking, are computed using the same formula.

9.7 Membership Functions for critical success variables and critical success groupings determination

The membership function (i.e., the degree of an element's membership in a fuzzy set, normally ranging between 0 and 1) are derived from level 2 to 1. (Chudasama et al., 2022). This suggests that the membership functions of critical success variables are obtained first before the membership functions for each construct. Membership function for a critical success variable is obtained from the ratings furnished by the practitioners given the grades for selection (i.e., L_1 = not important to L_5 = very important). For example, 40.26 % of the respondents rated SI4 as very important, 38.25% as important and 21.48% as undecided. Therefore, the membership function for SI4 is given as follows:

$$MF_{SI4} = \frac{40.26}{L} + \frac{38.25}{L} + \frac{21.48}{L} + \frac{0.00}{L} + \frac{0.00}{L} \qquad (4)$$

This function is also expressed as 40.26, 38.25, 21.48, 0.00 and 0.00. Using the same approach, the membership functions for the seventy variables can be found in Table 9.2. Determining the membership functions of the variable at Level 2 set the basis to calculate the membership functions for each of the construct at Level 1 using Eq. (2), D = W_I^O R_i where W_i = weightings for all the variables within each construct and R_i is the fuzzy evaluation matrix.

Using the Smart Services (SS) as an example, its membership function is calculated as:

$$D_{SS} = (0.5024 \text{ and } 0.4976) \times \begin{vmatrix} 0.4362 & 0.3423 & 0.2215 & 0.0000 & 0.0000 \\ 0.4564 & 0.2752 & 0.2685 & 0.0000 & 0.0000 \end{vmatrix}$$

$$= (0.4463 \quad 0.3089 \quad 0.2449 \quad 0.0000 \quad 0.0000)$$

In a similar manner, the membership functions of the remaining seven constructs are derived as shown in Table 9.2 on column 4

After calculating the membership function at Level 1, the project success index for each construct is computed using Eq. (3). For example, the PSI for ‘smart service, is given as:

$$PSI_{(SMART\ services)} = (0.4463 \quad 0.3089 \quad 0.2449 \quad 0.0000 \quad 0.0000) \times (5, 4, 3, 2, 1)$$

$$= 4.2014$$

Using the same approach, the PSI for the remaining seven critical success criteria group are determined as follows and are shown in Table 9.2.

$$PSI_{(SMART\ infrastructure)} = (0.4080 \quad 0.3397 \quad 0.2509 \quad 0.0013 \quad 0.0000) \times (5, 4, 3, 2, 1)$$

$$= 4.1542$$

$$PSI_{(SMART\ economy)} = (0.3860 \quad 0.3107 \quad 0.3017 \quad 0.0019 \quad 0.0000) \times (5, 4, 3, 2, 1)$$

$$= 4.0817$$

$$PSI_{(SMART\ people)} = (0.3706 \quad 0.3423 \quad 0.2922 \quad 0.0000 \quad 0.0000) \times (5, 4, 3, 2, 1)$$

$$= 4.0988$$

$$PSI_{(SMART\ mobility)} = (0.4129 \quad 0.3206 \quad 0.2665 \quad 0.0000 \quad 0.0000) \times (5, 4, 3, 2, 1)$$

$$= 4.1465$$

$$PSI_{(\text{SMART living})} = (\,0.3930 \quad 0.3270 \quad 0.2793 \quad 0.0006 \quad 0.0000\,) \times (\,5, 4, 3, 2, 1)$$

$$= 4.1125$$

$$PSI_{(\text{SMART governance})} = (\,0.3981 \quad 0.3202 \quad 0.2808 \quad 0.0009 \quad 0.0000\,) \times (\,5, 4, 3, 2, 1)$$

$$= 4.1153$$

$$PSI_{(\text{SMART environment})} = (\,0.4086 \quad 0.3228 \quad 0.2689 \quad 0.0000 \quad 0.0000\,) \times (\,5, 4, 3, 2, 1)$$

$$= 4.1542$$

9.8 Developing the overall PSI for smart city project

An additive and linear model is used to produce a composite indicator for evaluating smart city project success. A linear model is chosen because the eight critical success constructs of smart city are not correlated with one another. This suggest that they are non-linear. As the correlation among the variables are insignificant, a linear model is deemed appropriate, given the scenario where the coefficient of correlation among the constructs is close to zero, a linear and additive approach is most appropriate. This is in line with earlier studies that developed a performance index using additive and linear models (Rezaei, van Roekel and Tavasszy, 2018).

However, before developing the composite indicator, the PSIs for all the smart city critical success criteria constructs that function as coefficients in the linear model are further normalized so that they sum to one or fit within unity as shown in Table 9.2 To understand the relative activities between each construct in a linear equation, it is normal and logical to normalise the PSIs for smart cities. Above all, it allows a different scale of measurement for critical success criteria to be used in the evaluation model.

The project success index for smart city project is hereby expressed in the following model:

$$PSI = (0.1257 \times \text{Smart Infrastructure}) + (0.1235 \times \text{Smart Economy}) + (0.1240 \times \text{Smart People}) + (0.1255 \times \text{Smart Mobility}) + (0.1244 \times \text{Smart Living}) + (0.1245 \times \text{Smart Governance}) + (0.1253 \times \text{Smart Environment}) + (0.1271 \times \text{Smart Services}). \quad (5)$$

Table 9. 2 Showing weighting and membership function level 1 and level 2

Variables	Weightings	Membership Function (Level 2)					Membership Function Level 1					Index	Coefficient
Smart Infrastructure							**0.4080**	**0.3397**	**0.2509**	**0.0013**	**0.0000**	**4.1542**	**0.1257**
SI4	0.2015	0.4026	0.3825	0.2147	0.0000	0.0000							
SI2	0.2011	0.4093	0.3624	0.2282	0.0000	0.0000							
SI10	0.2001	0.4295	0.2953	0.2685	0.0067	0.0000							
SI11	0.1991	0.4027	0.3221	0.2752	0.0000	0.0000							
SI3	0.1982	0.3960	0.3356	0.2685	0.0000	0.0000							
Smart Economy							**0.3860**	**0.3107**	**0.3017**	**0.0019**	**0.0000**	**4.0817**	**0.1235**
SE12	0.1451	0.4257	0.2770	0.2973	0.0000	0.0000							
SE5	0.1434	0.4027	0.2819	0.3107	0.0067	0.0000							
SE7	0.1427	0.3758	0.3087	0.3154	0.0000	0.0000							
SE9	0.1427	0.3758	0.3154	0.3087	0.0000	0.0000							
SE11	0.1427	0.4027	0.2617	0.3356	0.0000	0.0000							
SE1	0.1423	0.4027	0.3221	0.2752	0.0000	0.0000							
SE8	0.1413	0.3154	0.4094	0.2685	0.0067	0.0000							

		Smart People					**0.3706**	**0.3423**	**0.2922**	**0.0000**	**0.0000**	**4.0988**	**0.1240**
SP6	0.0784	0.4430	0.2685	0.2886	0.0000	0.0000							
SP10	0.0781	0.4161	0.2886	0.2953	0.0000	0.0000							
SP13	0.0777	0.4027	0.3087	0.2886	0.0000	0.0000							
SP11	0.0775	0.3691	0.3624	0.2685	0.0000	0.0000							
SP12	0.0775	0.3490	0.4027	0.2483	0.0000	0.0000							
SP14	0.0775	0.3557	0.3758	0.2685	0.0000	0.0000							
SP7	0.0767	0.3691	0.3356	0.2953	0.0000	0.0000							
SP17	0.0767	0.3784	0.3041	0.3176	0.0000	0.0000							
SP5	0.0764	0.3020	0.4430	0.2550	0.0000	0.0000							
SP8	0.0760	0.3289	0.3826	0.2886	0.0000	0.0000							
SP15	0.0760	0.4161	0.3289	0.3221	0.0000	0.0000							
SP4	0.0758	0.3423	0.3221	0.3356	0.0000	0.0000							
SP9	0.0758	0.3423	0.3289	0.3289	0.0000	0.0000							
		Smart Mobility					**0.4129**	**0.3206**	**0.2665**	**0.0000**	**0.0000**	**4.1465**	**0.1255**
SM11	0.1282	0.4497	0.3557	0.1946	0.0000	0.0000							

SM5	0.1255	0.3960	0.3691	0.2349	0.0000	0.0000							
SM16	0.1255	0.4362	0.2819	0.2819	0.0000	0.0000							
SM6	0.1246	0.4027	0.3289	0.2685	0.0000	0.0000							
SM1	0.1243	0.4497	0.2148	0.3356	0.0000	0.0000							
SM2	0.1240	0.4295	0.2550	0.3154	0.0000	0.0000							
SM13	0.1240	0.3423	0.4362	0.2215	0.0000	0.0000							
SM17	0.1240	0.3960	0.3221	0.2819	0.0000	0.0000							
Smart Living							**0.3930**	**0.3270**	**0.2793**	**0.0006**	**0.0000**	**4.1125**	**0.1244**
SL7	0.0924	0.4228	0.3423	0.2349	0.0000	0.0000							
SL10	0.0915	0.3960	0.3423	0.2617	0.0000	0.0000							
SL4	0.0913	0.4362	0.2617	0.2953	0.0067	0.0000							
SL14	0.0911	0.4027	0.3154	0.2819	0.0000	0.0000							
SL16	0.0909	0.3893	0.3289	0.2819	0.0000	0.0000							
SL2	0.0906	0.3557	0.3893	0.2550	0.0000	0.0000							
SL3	0.0906	0.4027	0.3020	0.2953	0.0000	0.0000							
SL8	0.0906	0.3893	0.3221	0.2886	0.0000	0.0000							
SL11	0.0906	0.3826	0.3289	0.2886	0.0000	0.0000							
SL5	0.0904	0.3758	0.3356	0.2886	0.0000	0.0000							
SL13	0.0898	0.3691	0.3289	0.3020	0.0000	0.0000							

Smart Governance							**0.3981**	**0.3202**	**0.2808**	**0.0009**	**0.0000**	**4.1153**	**0.1245**
SG3	0.1444	0.4161	0.3289	0.2550	0.0000	0.0000							
SG4	0.1440	0.4295	0.2819	0.2886	0.0000	0.0000							
SG2	0.1437	0.4295	0.2953	0.2752	0.0000	0.0000							
SG14	0.1427	0.3893	0.3356	0.2752	0.0000	0.0000							
SG1	0.1420	0.3490	0.3893	0.2617	0.0000	0.0000							
SG13	0.1420	0.3826	0.3221	0.2953	0.0000	0.0000							
SG12	0.1413	0.3893	0.2886	0.3154	0.0067	0.0000							
Smart Environment							**0.4086**	**0.3228**	**0.2689**	**0.0000**	**0.0000**	**4.1413**	**0.1253**
SEn22	0.0599	0.4564	0.2886	0.2550	0.0000	0.0000							
SEn3	0.0597	0.4161	0.3691	0.2148	0.0000	0.0000							
SEn4	0.0594	0.4161	0.3691	0.2148	0.0000	0.0000							
SEn20	0.0593	0.4161	0.3356	0.2483	0.0000	0.0000							
SEn5	0.0592	0.4161	0.3423	0.2416	0.0000	0.0000							
SEn13	0.0592	0.3885	0.3381	0.2734	0.0000	0.0000							

SEn14	0.0589	0.4027	0.3423	0.2550	0.0000	0.0000							
SEn11	0.0587	0.4295	0.2685	0.3020	0.0000	0.0000							
SEn12	0.0587	0.4027	0.3289	0.2685	0.0000	0.0000							
SEn21	0.0587	0.4094	0.3020	0.2886	0.0000	0.0000							
SEn19	0.0586	0.4027	0.3154	0.2819	0.0000	0.0000							
SEn1	0.0584	0.4094	0.2953	0.2953	0.0000	0.0000							
SEn17	0.0584	0.3691	0.3826	0.2483	0.0000	0.0000							
SEn8	0.0583	0.4295	0.2550	0.3154	0.0000	0.0000							
SEn16	0.0583	0.3557	0.4027	0.2483	0.0000	0.0000							
SEn18	0.0582	0.4295	0.2416	0.3289	0.0000	0.0000							
SEn7	0.0580	0.3960	0.3087	0.2953	0.0000	0.0000							
Smart Services							**0.4463**	**0.3089**	**0.2449**	**0.0000**	**0.0000**	**4.2014**	**0.1271**
SS4	0.5024	0.4362	0.3423	0.2215	0.0000	0.0000							
SS6	0.4976	0.4564	0.2752	0.2685	0.0000	0.0000							
												33.0517	**1.0000**

Table 9. 3 Showing the Project Success Index (PSI) and their Coefficient

Annotations	*Constructs*	*Project Success Index (PSI)*	*Coefficients*
SI	*Smart Infrastructure*	*4.1542*	*0.1257*
SE	*Smart Economy*	*4.0817*	*0.1235*
SP	*Smart People*	*4.0988*	*0.1240*
SM	*Smart Mobility*	*4.1466*	*0.1255*
SL	*Smart Living*	*4.1125*	*0.1244*
SG	*Smart Governance*	*4.1153*	*0.1245*
SEn	*Smart Environment*	*4.1413*	*0.1253*
SS	*Smart Services*	*4.2014*	*0.1271*

Coefficient = (PSI for Constructs / $\sum PSI\ for\ Constructs$ *)*

9.9 Testing of the Benchmarking Model

One of the objectives of this study is to validate the developed smart city benchmarking model using real-life test-cases of two smart cities in the United Kingdom, namely Bristol and Milton Keynes. In order to achieve this objective a survey of some professionals in the two cities were conducted by emails and the finding are shown in the table 6.3. This result suggest that Bristol with a project success index of 6.075468385 and Milton Keynes 3.117133109. Considering the two results, it is evident that Bristol has a higher value of smartness compared to Milton Keynes.

To understand the difference between Bristol and Milton Keynes, it would be necessary to examine the Table 6.3 to bring out the cogent reasons. Apart from smart infrastructure, smart economy, and smart governance where Milton Keynes scored, respectively, 0.2183748239, 0.4161079209, 0.3996454343, Bristol City performed better in the smart people, smart mobility, smart living, smart environment and smart services, scoring respectively 1.393520531, 0.5069912316, 0.9207846895, 2.273156999, and 0.02966696719.

Table 6. 3 Benchmarking Test of Bristol and Milton Keynes

Notation	Indicators	BRISTOL	Total weighting factor	Weighting	PSI coefficient	PSI FOR BRISTOL	MILTON KEYNES	Total weighting factor	PSI FOR MILTON KEYNES
Smart Infrastructure									
SI1	Power generating systems	5	0.361931225	0.072386245			4	0.28954498	
SI2	Availability of Utilities services	5	0.361931225				5	0.361931225	
SI3	Availability of IoT and embedded devices	3	0.217158735				5	0.361931225	
SI4	Availability of Cloud computing and Wi-Fi Services	5	0.361931225				5	0.361931225	
SI5	Enabling environment for human capital development, competition and innovation	5	0.361931225				5	0.361931225	
	Total		1.664883635		0.1257	0.2092758729		1.73726988	0.2183748239
Smart Economy									
SE1	Open and transparent economic activities	5	0.495484545	0.099096909			5	0.495484545	
SE2	Flexibility of the labour market	3	0.297290727				5	0.495484545	
SE3	Ability to transform ideas into valuable process, products and services	4	0.396387636				5	0.495484545	
SE4	Competitive skill of the people	4	0.396387636				5	0.495484545	
SE5	Ease of Digital business licensing and permission	5	0.495484545				5	0.495484545	

SE6	People with Innovative Spirit	4	0.396387636				5	0.495484545	
SE7	Economic make-up of the people	4	0.396387636				4	0.396387636	
	Total		2.873810361		0.1235	0.3549155796		3.369294906	0.4161079209
Smart People									
SP1	Creativity amongst the people	4	0.736922544	0.184230636			4	0.736922544	
SP2	Imaginative people	4	0.736922544				3	0.552691908	
SP3	Level of skill of the people	5	0.92115318				4	0.736922544	
SP4	Versatility of the people	5	0.92115318				3	0.552691908	
SP5	Engagement in public life and decision-making	5	0.92115318				5	0.92115318	
SP6	Open mindedness of the people	5	0.92115318				3	0.552691908	
SP7	Social innovation of the people	5	0.92115318				4	0.736922544	
SP8	Participation in public life without discrimination	5	0.92115318				4	0.736922544	
SP9	Attraction of high human capital into the system	5	0.92115318				5	0.92115318	
SP10	Competitiveness spirit of the city inhabitants	4	0.736922544				4	0.736922544	
SP11	Employment rate for graduate	5	0.92115318				3	0.552691908	
SP12	Social and ethnic plurality in the community	5	0.92115318				3	0.552691908	
SP13	Tolerance and engagement of the people	4	0.736922544				3	0.552691908	

	Total		11.2380688		0.124	1.393520531		8.843070528	1.096540745
Smart Mobility									
SM1	(Inter-)national accessibility of the transport services	5	0.57711011	0.115422022			3	0.346266066	
SM2	Availability of Digital public transit payment	5	0.57711011				5	0.57711011	
SM3	Use of smartphones for facilitating mobility demand and ticketing	5	0.57711011				5	0.57711011	
SM4	Existence of Autonomous vehicles in city transport architecture	2	0.230844044				3	0.346266066	
SM5	Good Urban planning	5	0.57711011				5	0.57711011	
SM6	Use of ICT in transportation logistics	5	0.57711011				5	0.57711011	
SM7	Availability of car-sharing, ride sharing, new biking systems	3	0.346266066				3	0.346266066	
SM8	Availability of pedestrian and bicycle path	5	0.57711011				3	0.346266066	
	Total		4.03977077		0.1255	0.5069912316		3.693504704	0.4635348404
Smart Living									

SL1	Enrolment of young people in general education and vocational training	5	0.78742619	0.157485238			5	0.78742619	
SL2	Promoting Social cohesion amongst the people	5	0.78742619				5	0.78742619	
SL3	Individual safety in the community	5	0.78742619				5	0.78742619	
SL4	Availability of world-class education	5	0.78742619				5	0.78742619	
SL5	Improved security for women, children and the vulnerable	5	0.78742619				4	0.629940952	
SL6	Availability of world-class health facilities to the people	4	0.629940952				4	0.629940952	
SL7	Telemedicine availability to the citizens	2	0.314970476				3	0.472455714	
SL8	High level of Employment	5	0.78742619				4	0.629940952	
SL9	Remote patient monitoring for the vulnerable	2	0.314970476				3	0.472455714	
SL10	High quality Housing availability	5	0.78742619				4	0.629940952	
SL11	Infectious disease surveillance	4	0.629940952				4	0.629940952	
	Total		7.401806186		0.1244	0.9207846895		7.244320948	0.9011935259
Smart Governance									

SG1	Transparency in governance activities	5	0.501563045	0.100312609			5	0.501563045	
SG2	Transparency in decision-making process.	5	0.501563045				5	0.501563045	
SG3	Availability of public and social services for the citizens	5	0.501563045				4	0.401250436	
SG4	Availability of E-government for transactions with government	4	0.401250436				5	0.501563045	
SG5	Participation of the citizens in government's decision-making	4	0.401250436				5	0.501563045	
SG6	Availability of e-Services for public engagement	4	0.401250436				4	0.401250436	
SG7	Clarity of environmental protection policy	4	0.401250436				4	0.401250436	
	Total		3.109690879		0.1245	0.3871565144		3.210003488	0.3996454343
Smart Environment									
SEn1	Minimising of health hazards arising from exposure to harmful materials (e.g., by pollution, accidents, noxious substances in food)	4	0.96755818	0.241889545			4	0.96755818	
SEn2	Efficient waste management systems	5	1.209447725				3	0.725668635	
SEn3	Leveraging smart meter for energy conservation in the city	4	0.96755818				4	0.96755818	

SEn4	Collaboration between government and people to monitor and manage environmental policies	4	0.96755818				5	1.209447725	
SEn5	Reliability of energy supply system to the citizens	5	1.209447725				5	1.209447725	
SEn6	Minimisation of exposure to health hazards	4	0.96755818				5	1.209447725	
SEn7	Remote health monitoring and intervention	2	0.48377909				3	0.725668635	
SEn8	Preservation of the unique natural resources, ecological system, and biodiversity	4	0.96755818				4	0.96755818	
SEn9	Ensuring a cohesive healthy community	5	1.209447725				4	0.96755818	
SEn10	Improvement in air quality, water, forest and soil conditions	5	1.209447725				4	0.96755818	
SEn11	Ensuring environmental aesthetics for the city	5	1.209447725				4	0.96755818	
SEn12	Intelligence distribution networks	5	1.209447725				4	0.96755818	
SEn13	Create a recreational opportunity for the people	5	1.209447725				4	0.96755818	
SEn14	Clean sources and distribution networks for water supply	5	1.209447725				4	0.96755818	

SEn15	Provision of abundant public open space with smart resource management	5	1.209447725				3	0.725668635	
SEn16	Reduction of pollutant emission in the environment	5	1.209447725				4	0.96755818	
SEn17	Good air quality in the environment	3	0.725668635				4	0.96755818	
	Total		18.14171588		0.1253	2.273156999		16.44848906	2.060995679
Smart Services									
SS1	Availability of waste recycling for resource reuse	5	0.145883985	0.029176797			4	0.116707188	
SS2	Real-time crime mapping to monitor criminal activities	3	0.087530391				3	0.087530391	
	Total		0.233414376		0.1271	0.02966696719		0.204237579	0.02595859629
	Grand Total					6.075468385			3.117133109

9.10 Summary of Chapter

The need to develop a comprehensive, reliable and objective approach to quantifying the success of smart cities project implementation in any part of the world is of high importance and the FSE is a handy tool for this purpose as it enable the estimation of the smart city success to be determined using known variables of the smart city constructs. The 70 critical success criteria CRC of the respective construct were determined using normalized value equal to or greater than 0.5. This normalization criteria was used because it allows the most significant criteria to be selected and use for the model development.

An additive and linear model is used to produce a composite indicator for evaluating smart city project success. A linear model was chosen because the eight success constructs of smart city are not correlated with one another. This suggest that they are non-linear. As the correlation among the variables are insignificant, a linear model is deemed appropriate, given the scenario where the coefficient of correlation among the constructs is close to zero, a linear and additive is most appropriate.

Before developing the composite indicator, the PSI for all the smart city critical success criteria constructs that function as coefficients in the linear model were further normalized so that they sum to one or fit within unity. To understand the relative activities between each construct in a linear equation, it is normal and logical to normalise the PSIs for smart cities. From the model, smart services has the highest PSI (4.2014) with a coefficient of 0.1271 and the lowest PSI (4.0817) and a coefficient of (0.1235) goes to smart economy.

Chapter 10: Proposed Smart city Benchmarking Model

10 Introduction

At the inception of this study, the aim was to develop a robust benchmarking framework/model that is capable of accurately measuring the smartness of cities across selected dimension. Having identified some key performance indicators through literature and interview and testing the acceptability of these indicators through a questionnaire instrument, the results of the analysis that was carried out through the SPSS were further critically evaluated using the Fuzzy Synthetic Evaluation technique which produced the critical success criteria for each of the dimension of a smart city.

10.1 Critical Success Criteria for smart infrastructure

The smart infrastructure has an item mean of 4.124 as shown in appendix I. The inter-item correlation majorly lies between 0.037 to 0.331, suggesting that the construct of smart infrastructure are not repetitive, they measure the coherent and underlying constructs, and the different aspects of the constructs can be distinguished, which was the specification in the ideal range of inter-item correlation of 0.15 t0 0.50 (Di Milia et al., 2005; Ge et al., 2021; Maindal et al., 2009; Ngooi et al., 2017; Sousa et al., 2010) .

In selecting the critical success criteria of the smart infrastructure construct, only variables with normalized value equal to or greater than 0.5 were considered. Hence, the most important smart infrastructure variable in the order of importance are five in number. They are ‘power generating systems’, ‘availability of utility services’, ‘availability of IoT and embedded devices’, ‘availability of cloud computing and wi-fi services’, and ‘enabling environment for human capital development, competition and innovation’. These are the most valuable construct of the smart infrastructure of a smart city and forms a valuable part of the essential component that must be available for the benchmarking of a smart city.

Table 10. 1 Critical Success Criteria for Smart Infrastructure (Source: field study 2022)

notation	variables
SI4	Power generating systems
SI2	Availability of Utilities services
SI10	Availability of IoT and embedded devices
SI11	Availability of Cloud computing and Wi-Fi Services
SI3	Enabling environment for human capital development, competition and innovation

10.2 Critical success criteria for Smart Economy

The smart economy has an item mean of 4.038, suggesting that the constructs are 'important' on the Likert scale. It has an inter-item correlation that lies between 0.091 to 0.259. This suggests that the constructs are not repetitive.

In choosing the critical success variables of smart economy, only variables with normalized value equal to or greater than 0.5 were selected. This produced the following seven smart economy construct in the order of the value of their mean ranking. They are 'open and transparent economic activities', 'flexibility of the labour market', 'ability to transform ideas into valuable process, products and services', 'competitive skill of the people', 'ease of digital business licensing and permission', 'people with innovative spirit', and 'economic make-up of the people'

Table 10. 2 Critical success criteria for smart economy (source: field study 2022)

Notation	Variables
SE12	Open and transparent economic activities
SE5	Flexibility of the labour market
SE7	Ability to transform ideas into valuable process, products and services
SE9	Competitive skill of the people
SE11	Ease of Digital business licensing and permission
SE1	People with Innovative Spirit
SE8	Economic make-up of the people

10.3 Critical success factor for smart people

Smart people has an item mean of 4.034 as shown in appendix I, suggesting that the variables are ranked "important" on the Likert scale. The inter-item correlation is -0.101 to 0.277. This also suggests that the item are well correlated and not repetitive.

In identifying the critical success criteria for smart people, only variable with normalized value equal to or greater than 0.5 were selected and there were thirteen in total. They include‘ creativity amongst the people’, ‘imaginative people’, ‘level of skill of the people’, ‘versatility of the people’, ‘engaging in public life and decision-making’, ‘open mindedness of the people’, ‘participation in public life without discrimination’, ‘social innovation of the people’, ‘attraction of high human capacity into the system’, ‘competitiveness spirit of the city inhabitants’, ‘high employment rate for graduates’, ‘social and ethnic plurality in the community’, and ‘tolerance and engagement of the people’.

Table 10. 3 critical success criteria for smart people (source: field study 2022)

Notation	Variables
SP6	Creativity amongst the people
SP10	Imaginative people
SP13	Level of skill of the people
SP11	Versatility of the people
SP12	Engagement in public life and decision-making
SP14	Open mindedness of the people
SP7	Social innovation of the people
SP17	Participation in public life without discrimination
SP5	Attraction of high human capital into the system
SP8	Competitiveness spirit of the city inhabitants
SP15	Employment rate for graduate
SP4	Social and ethnic plurality in the community
SP9	Tolerance and engagement of the people

10.4 Critical success criteria for smart mobility

The smart mobility has an item mean of 4.087, suggesting that it is 'important' on the Likert scale as shown in appendix I. it has an inter-item correlation of 0.103 to 0.376, suggesting that the construct are not repetitive and also measuring the construct.

In selecting the critical success criteria of smart mobility, only construct with normalization value equal to or greater than 0.5 were considered lead to the selection of eight criteria for smart mobility which include '(inter-)national accessibility of the transport services', 'availability of digital transit payments', 'use of smartphone for facilitating mobility demand and ticketing', 'existence of autonomous vehicles in city transport architecture', 'good urban planning', 'use of ICT in transportation logistics', 'availability of car-sharing, ride sharing, new biking systems', and 'availability of pedestrian and bicycle path'.

Table 10. 4 critical success criteria for smart mobility (source: field study 2022)

Notation	Variables
SM11	(Inter-)national accessibility of the transport services
SM5	Availability of Digital public transit payment
SM16	use of smartphones for facilitating mobility demand and ticketing
SM6	Existence of Autonomous vehicles in city transport architecture
SM1	Good Urban planning
SM2	Use of ICT in transportation logistics
SM13	Availability of car-sharing, ride sharing, new biking systems
SM17	Availability of pedestrian and bicycle path

10.5 Critical success criteria for smart living

The smart living has an item mean of 4.086 as shown in appendix I. The inter-item correlation that majorly lies between -0.149 to 0.338, suggesting that the construct of smart living are not repetitive and well correlated.

In selecting the critical success criteria of the smart living construct, only variables with normalized valued equal to or greater than 0.5 were considered. Therefore, the most important smart living variables in the order of importance are ten in number. They are ‘enrolment of young people in general education and vocational training’, ‘promoting social cohesion amongst the people’, ‘individual safety in the community’, ‘availability of world-class education’, improved security for women, children and the vulnerable’, ‘availability of world-class health facility to the people’, ‘telemedicine availability to the citizens’, ‘high level of employment’, ‘remote patient monitoring for the vulnerable’, and ‘high quality housing availability’

Table 10. 5 Critical success criteria for smart living (Source: field Study 2022)

Notation	Variables
SL7	Enrolment of young people in general education and vocational training
SL10	Promoting Social cohesion amongst the people
SL4	Individual safety in the community
SL14	Availability of world-class education
SL16	Improved security for women, children and the vulnerable
SL2	Availability of world-class health facilities to the people
SL3	Telemedicine availability to the citizens
SL8	High level of Employment
SL11	Remote patient monitoring for the vulnerable
SL5	High quality Housing availability
SL13	Infectious disease surveillance

10.6 Critical success criteria for smart governance

The smart governance has an item mean of 4.078, suggesting that the construct is 'important' on the Likert scale. It also has an inter-item correlation that lies between -0.062 to 0.341. This suggests that the constructs are not repetitive. In choosing the critical success criteria of smart governance, only variables with normalized value equal to or greater than 0.5 were selected. This produced the following seven smart governance constructs using their mean ranking. They are 'transparency in governance activities', 'transparency in decision making process', 'availability of public and social services for the citizens', 'availability of E-government for transaction with government', 'participation of the citizens in government's decision-making', 'availability of e-services for public engagement', and 'clarity of the environmental protection policy'.

Table 10. 6 Critical success criteria for smart governance (Source: field study 2022)

Notation	Variables
SG3	Transparency in governance activities
SG4	Transparency in decision-making process.
SG2	Availability of public and social services for the citizens
SG14	Availability of E-government for transactions with government
SG1	Participation of the citizens in government's decision-making
SG13	Availability of e-Services for public engagement
SG12	Clarity of environmental protection policy

10.7 Critical success criteria for smart environment

The smart environment has item mean of 4.060, suggesting that the construct is 'important' on the Likert scale. It has an inter-item correlation of between -0.198 to 0.236. This suggests that the constructs are not repetitive. In picking the critical success criteria of smart environment, only variables with normalized value equal to or greater than 0.5 were selected. This produced the following seventeen smart environment constructs in the order of the value of their mean ranking. They are 'minimising of health hazards arising from exposure to harmful materials (e.g., by pollution, accidents, noxious substances in food)', 'efficient waste management systems', 'leveraging smart meter for energy conservation in the city', 'collaboration between government and people to monitor and manage environmental policies', 'reliability of energy supply system to the citizens', 'minimisation of exposure to health hazards', 'remote health monitoring and intervention', 'preservation of the unique natural resources, ecological system, and biodiversity', 'ensuring a cohesive healthy community', 'improvement in air quality, water, forest and soil conditions', 'ensuring environmental aesthetics for the city', 'intelligence distribution networks', 'create a recreational opportunity for the people', 'clean sources and distribution networks for water supply', 'provision of abundant public open space with smart resource management', 'reduction of pollutant emission in the environment', and 'good air quality in the environment'.

Table 10. 7 Critical success criteria for smart environment (Source: field study 2022)

Notation	Variables
SEn22	Minimising of health hazards arising from exposure to harmful materials (e.g., by pollution, accidents, noxious substances in food)
SEn3	Efficient waste management systems
SEn4	Leveraging smart meter for energy conservation in the city
SEn20	Collaboration between government and people to monitor and manage environmental policies
SEn5	Reliability of energy supply system to the citizens
SEn13	Minimisation of exposure to health hazards

SEn14	Remote health monitoring and intervention
SEn11	Preservation of the unique natural resources, ecological system, and biodiversity
SEn12	Ensuring a cohesive healthy community
SEn21	Improvement in air quality, water, forest and soil conditions
SEn19	Ensuring environmental aesthetics for the city
SEn1	Intelligence distribution networks
SEn17	Create a recreational opportunity for the people
SEn8	Clean sources and distribution networks for water supply
SEn16	Provision of abundant public open space with smart resource management
SEn18	Reduction of pollutant emission in the environment
SEn7	Good air quality in the environment

10.8 Critical success criteria for smart services

The smart services have an item mean of 4.050, suggesting that the construct is 'important' on the Likert scale. It also has an inter-item correlation value that lies between -0.098 to 0.292. this suggests that the variables are not repetitive. In choosing the critical success criteria of smart services, only variables with normalization value equal to or greater than 0.5 were selected. This produced only two of the constructs of the smart services which are 'availability of waste recycling for resource reuse', and 'real-time crime mapping to monitor criminal activities'.

Table 10. 8 Critical success criteria of smart services

Notation	Variables
SS4	Availability of waste recycling for resource reuse
SS6	Real-time crime mapping to monitor criminal activities

10.9 Mean ranking of the dimensions of smart city

Table 10. 9 Mean ranking of the dimensions of smart city

Annotations	Constructs	Project Success Index (PSI)	Coefficients	rank
SS	Smart Services	4.2014	0.1271	1
SI	Smart Infrastructure	4.1542	0.1257	2
SM	Smart Mobility	4.1466	0.1255	3
SEn	Smart Environment	4.1413	0.1253	4
SG	Smart Governance	4.1153	0.1245	5
SL	Smart Living	4.1125	0.1244	6
SP	Smart People	4.0988	0.1240	7
SE	Smart Economy	4.0817	0.1235	8

The mean ranking of the smart city dimensions suggests that smart services have the highest coefficient (0.1271), then smart infrastructure (0.1257) followed by smart mobility (0.1255) and then by smart environment (0.1243) which was also followed by smart governance (0.1245) and later followed by smart living (0.1244), smart people (0.1240) and the last coefficient was that of smart economy (0.1235). This suggest that the most important dimension of smart city was the smart services followed by smart infrastructure and smart mobility.

10.10 The proposed smart city benchmarking framework

Following the aim of this study which is to propose a robust benchmarking framework/model that is capable of accurately measuring the smartness of cities along selected dimensions, the framework for the benchmark of smart cities is to ultimately make the smart city sustainable socially, environmentally and economically, optimizing the use of natural and artificial materials and above all, improving the quality of life of the citizens. For this to be achieved the primary mission is to produce a scheme as shown in Table 10.10 comprising of all the variable in the dimensions of the selected dimensions. Using the mean ranking to order the arrangement of the variables in the order of their importance, it was easy to see from the variable list of each dimension the variable with the highest mean ranking to the ones with the least mean ranking. In the Fuzzy Synthetic Evaluation, (FSE), the most critical variables for the smart city for each dimension were selection using a normalization factor of 0.5. This produced some group of critical variables for each of the dimensions of the smart city. Like in most framework, it is the goal of this project to define the taxonomy with five level of smartness so that each can be classified based on its level of smartness and the respective characteristics of each level.

As the variables had been ranked using their mean and the most critical variables for each dimension defined using the normalization factor of 0.5, the mean ranking was adopted as the equivalence of the level. Hence, the first mean ranking is equal to level one up to the fifth ranking while other variables with mean ranking greater than five are all grouped into the fifth ranking and classified as level five. This scenario was adopted as variable in the first rank are regarded as the most important, according to this study, hence, they are regarded as fundamental and the bedrock of the smart city while the fifth rank variable and the subsequent rankings are secondary to the smart city.

Table 10. 10 Proposed Smart City Benchmarking Framework

Taxonomy	Dimensions	Notation	Variable required by each level of Smart City

Foundation	Infrastructure	SI4	Power generating systems
	Economy	SE12	Open and transparent economic activities
	People	SP6	Creativity amongst the people
	Mobility	SM11	(Inter-)national accessibility of the transport services
	Living	SL7	Enrolment of young people in general education and vocational training
	Governance	SG3	Transparency in governance activities
	Environment	SEn22	Minimising of health hazards arising from exposure to harmful materials (e.g., by pollution, accidents, noxious substances in food)
	Services	SS4	Availability of waste recycling for resource reuse
Developing	Infrastructure	SI2	Availability of Utilities services
	Economy	SE5	Flexibility of the labour market
	People	SP10	Imaginative people
	Mobility	SM5	Availability of Digital public transit payment
		SM16	use of smartphones for facilitating mobility demand and ticketing
	Living	SL10	Promoting Social cohesion amongst the people
	Governance	SG4	Transparency in decision-making process.

	Environment	SEn3	Efficient waste management systems
	Services	SS6	Real-time crime mapping to monitor criminal activities
Established	Infrastructure	SI10	Availability of IoT and embedded devices
	Economy	SE7	Ability to transform ideas into valuable process, products and services
		SE9	Competitive skill of the people
	People	SP13	Level of skill of the people
	Mobility	SM6	Existence of Autonomous vehicles in city transport architecture
	Living	SL4	Individual safety in the community
	Governance	SG2	Availability of public and social services for the citizens
	Environment	SEn4	Leveraging smart meter for energy conservation in the city
Advanced	Infrastructure	SI11	Availability of Cloud computing and Wi-Fi Services
	Economy	SE11	Ease of Digital business licensing and permission
	People	SP11	Versatility of the people

		SP12	Engagement in public life and decision-making
	Mobility	SM1	Good Urban planning
	Living	SL14	Availability of world-class education
	Governance	SG14	Availability of E-government for transactions with government
	Environment	SEn20	Collaboration between government and people to monitor and manage environmental policies
Exemplary	Infrastructure	SI3	Enabling environment for human capital development, competition and innovation
	Economy	SE1	People with Innovative Spirit
		SE8	Economic make-up of the people
	People	SP14	Open mindedness of the people
		SP7	Social innovation of the people
		SP17	Participation in public life without discrimination
		SP5	Attraction of high human capital into the system
		SP8	Competitiveness spirit of the city inhabitants
		SP15	Employment rate for graduate
		SP4	Social and ethnic plurality in the community

		SP9	Tolerance and engagement of the people
	Mobility	SM2	Use of ICT in transportation logistics
		SM13	Availability of car-sharing, ride sharing, new biking systems
		SM17	Availability of pedestrian and bicycle path
	Living	SL16	Improved security for women, children and the vulnerable
		SL2	Availability of world-class health facilities to the people
		SL3	Telemedicine availability to the citizens
		SL8	High level of Employment
		SL11	Remote patient monitoring for the vulnerable
		SL5	High quality Housing availability
		SL13	Infectious disease surveillance
	Governance	SG1	Participation of the citizens in government's decision-making
		SG13	Availability of e-Services for public engagement
		SG12	Clarity of environmental protection policy
	Environment	SEn5	Reliability of energy supply system to the citizens
		SEn13	Minimisation of exposure to health hazards

		SEn14	Remote health monitoring and intervention
		SEn11	Preservation of the unique natural resources, ecological system, and biodiversity
		SEn12	Ensuring a cohesive healthy community
		SEn21	Improvement in air quality, water, forest and soil conditions
		SEn19	Ensuring environmental aesthetics for the city
		SEn1	Intelligence distribution networks
		SEn17	Create a recreational opportunity for the people
		SEn8	Clean sources and distribution networks for water supply
		SEn16	Provision of abundant public open space with smart resource management
		SEn18	Reduction of pollutant emission in the environment
		SEn7	Good air quality in the environment

Hence, when a smart city is on Level 1 of the smartness framework, all the variables on Level 1 are expected to be available in the city. These are ‘Power generating systems’, ‘Open and transparent economic activities’, ‘Creativity amongst the people’, ‘(Inter-)national accessibility of the transport services’, ‘Enrolment of young people in general education and vocational training’, ‘Transparency in governance activities’, ‘Minimising of health hazards arising from exposure to harmful materials (e.g., by pollution, accidents, noxious substances in food)', and the 'Availability of waste recycling for resource reuse'.

For a smart city on Level 2 of the model, it is expected to have the following attributes: 'Availability of Utilities services', 'Flexibility of the labour market', 'Imaginative people', 'Availability of Digital public transit payment', 'Use of smartphones for facilitating mobility demand and ticketing', 'Promoting Social cohesion amongst the people', 'Transparency in decision-making process', 'Efficient waste management systems', and the 'Real-time crime mapping to monitor criminal activities'.

For a Level 3 smart city the following attributes are expected to be abound: 'Availability of IoT and embedded devices', 'Ability to transform ideas into valuable process, products and services', 'Competitive skill of the people', 'Level of skill of the people', 'Existence of Autonomous vehicles in city transport architecture', 'Individual safety in the community', 'Availability of public and social services for the citizens', and 'Leveraging smart meter for energy conservation in the city'.

A Level 4 smart city is expected to be imbued with the following qualities: 'Availability of Cloud computing and Wi-Fi Services', 'Ease of Digital business licensing and permission', 'Versatility of the people', 'Engagement in public life and decision-making', 'Good Urban planning', 'Availability of world-class education', 'Availability of E-government for transactions with government' and the 'Collaboration between government and people to monitor and manage environmental policies.

And finally the Level 5 attributes of a smart city are the following: 'Enabling environment for human capital development, competition and innovation', 'People with Innovative Spirit', 'Economic make-up of the people', 'Open mindedness of the people', 'Social innovation of the people', 'Participation in public life without discrimination', 'Attraction of high human capital into the system', 'Competitiveness spirit of the city inhabitants', 'Employment rate for graduate', 'Social and ethnic plurality in the community', 'Tolerance and engagement of the people', 'Use of ICT in transportation logistics', 'Availability of car-sharing, ride sharing, new biking systems', ‘Availability of pedestrian and bicycle path’, ‘Improved security for women, children and the vulnerable’, ‘Availability of world-class health facilities to the people’, ‘Telemedicine availability to the citizens’, ‘High level of Employment’, ‘Remote patient monitoring for the vulnerable’, ‘High quality Housing availability’, ‘Infectious disease surveillance’, ‘Participation of the citizens in government’s decision-making’, ‘Availability of e-Services for public engagement’, ‘Clarity of environmental protection policy’, ‘Reliability of energy supply system to the citizens’, ‘Minimisation of exposure to health hazards’, ‘Remote health monitoring and intervention’, ‘Preservation of the unique natural resources, ecological system, and biodiversity’, ‘Ensuring a cohesive healthy community’, ‘Improvement in air quality, water, forest and soil conditions’, ‘Ensuring environmental aesthetics for the city’, ‘Intelligence distribution networks’, ‘Create a recreational opportunity for the people’, ‘Clean sources and distribution networks for water supply’, ‘Provision of abundant public open space with smart resource management’ and ‘Reduction of pollutant emission in the environment’ and ‘Good air quality in the environment’.

Therefore, for a city to be classified as a smart city, the availability of the foregoing factors must be present, whereby a city cannot be on a higher level when examined and found to be lacking in the basic factors of the lower levels. This presupposes that a city must be prequalified for lower level before moving to the upper level of smartness.

Chapter 11: Findings and Result Discussion

11 Overview of Chapter

This chapter discusses the findings of this study in line with the research aim and objectives laid out at the onset of the research. At the literature review, the background of the smart city was examined which led to the concept of smart city and the various definition of smart city which have been very divergent partly due to the perspective of the different scholar on the subject matter. Then the dimensions of smart city which Giffinger et al., (2007), gave to be six factors but which the literature search and opinion of the experts has updated to eight were also examined. Also, benchmarking and its concept were examined and also the critical review of some benchmarking model were looked into in order to gain some insight into these models. Arising from the literature review and the interview with expert in the field of smart city, indicators for the different dimensions of smart city were enumerated and these were used for the questionnaire instrument that was administered on the field. The questionnaires were analysed using SPSS and the finding was further critically examined using the Fuzzy Synthetic Evaluation methods which produced a model that can be used to examine the success of a smart city project and by extension benchmark them. Other findings germane to the study will be presented in the following section.

11.1 Discussion of the Findings

The importance of benchmarking of smart cities was discussed in the literature review. Despite this importance of benchmarking smart cities, there are gaps in some of the models that have been associated with smart city benchmarking and if these challenges are not addressed it would lead to a defectiveness in the mechanism for smart city benchmarking.

The main aim of this study, as enunciated in the introductory chapter, is to develop a robust benchmarking framework/model that is capable of accurately measuring the smartness of cities across some selected dimension. To achieve this aim, a number of research objectives were developed as strategy to achieve the stated aim. Also, efforts were made to articulate the research questions that helped in achieving the research objectives. In this section, the discussion of the findings based on statistical analysis from both the qualitative and the quantitative data and some literature findings were discussed in order to gain insight into the available facts.

11.2 Impact of city smartness

The study has brought to the fore the impact of city smartness on the environment, economy, People, living standard of the people, governance, mobility, infrastructure and services in the city. The city Authority are able to measure their own performance, and objectives against verifiable indicators of smart city in any particular dimension. These indicators would give the city authority a clue as to how they are meeting their objectives and what needs to be put in place when they fall short of their targets.

11.3 The importance of Smart Services.

During the literature review and interviews with professionals and stakeholders in the smart city, eleven important variables were generated. These are provision of efficient emergency services for the citizens; efficient services for the community; efficient municipal waste disposal; waste recycling for resource re-use; predictive policing to reduce crime; real-time crime mapping to monitor criminal activities; digital tracking and payment for waste disposal to ensure successful waste disposal; gunshot detection in order to apprehend criminals; smart surveillance of the city in order to pre-empt crime and pollution; body-worn cameras to reduce police brutality; and disaster early-warning systems in order to save lives in emergencies. Of all these variables only two which were "availability of waste recycling for resource reuse" and "real-time crime mapping to monitor criminal activities" had a normalization factor greater than 0.5 and were therefore the critical success criteria when a smart city is to be benchmarked. This brings to the fore the issue of waste and security in a smart city. This suggests that cleanliness and security are the one of the most important factors when benchmarking the smart cities.

11.4 Indicators for Smart City Assessment

The indicator generated from literature review, updated by interviews with stakeholders and experts and subjected to pilot test before being tested in a widely administered questionnaires were able to assess the smartness of the city. However, some of these indicators may need to be altered to suit different city in different region of the world in order to meet their local requirements.

11.5 The Result of the Assessment of Bristol and Milton Keynes

On testing the model on Bristol and Milton Keynes some obvious realities emerged. These includes difference in the infrastructure level between the two cities where Milton Keynes is about 4.167 % better. In term of economic activities, the survey suggests that Milton Keynes is also about 14.706 % more economically buoyant than Bristol. However, in term of the smartness of the people, Bristol is 21.311 % ahead of Milton Keynes. When mobility was examined, the data from the survey suggests that Bristol is ahead by 8.714% and also by 2.128% in term of the smartness of the people of Bristol being smarter than the residents of Milton Keynes. When governance was examined, the survey suggest that governance at Milton Keynes performs better than Bristol by 3.125%. On the environment, the survey suggest that Bristol is 9.333% better than Milton, particularly with the recently introduced emission charges by the Bristol City Council at the City Centre to promote clean and carbon free environment at the centre of the city with high level of traffic. In term of services, the survey suggests that Bristol surpassed Milton Keynes by 12.500%.

This model allows the smart city to know where it is deficient for improvement to be made and where it is up to date for it to keep it up and maintain the improvement. City could also use this model monitor their pace of keeping up with smartness in every sphere of the city through policy, budgetary allocation and monitoring.

11.6 Discussion Arising from the Model

From Eq. (5), it was observed that smart services have the highest coefficient (0.1271) in the evaluation equation, followed by smart infrastructure (0.1257), this was closely followed by smart mobility (0.1255), then smart environment (0.1253), which was followed by smart governance (0.1245), smart living (0.1244), smart people (0.1240) and finally smart economy (0.1235). These coefficient fits within the unity and their sum is one. Overall, this success index equation developed would, to a great extent, enable practitioner in the field of smart city benchmarking to evaluate the success of smart city projects in a more realistic and reliable manner. The model makes is possible for practitioners to compare the success level of multiple smart city projects on the same basis and thereby improve the quality implementation practices of smart city project development.

Previous models have not ranked their constructs in order of importance. The different constructs were selected without ranks (Pozdniakova, 2017). This therefore makes the current model very vital in prioritising smart city programme and policy and enables them to have a clear insight on the quality of smart city that they plan to achieve. Based on this rank, the city may decide which construct are germane to their own peculiarities. Also, the smart cities in the current model have a taxonomy with which they can be addressed unlike the earlier model where such are not available. In addition, the current model is adaptable to any smart city, be it small, medium, large, or mega cities.

In developing the current model for benchmarking the smartness of cities, adequate consideration had been put into existing model and their methodologies. In comparison to the existing models, like that of the Organization for Economic Co-operation and Development (OECD) (Carli et al., 2013), which aims to support cities and countries in assessing and benchmarking their urban policy within a holistic framework, the current model differs in terms of specific indicators, data collection methods and evaluation criteria.

Another important study that proposes a comprehensive framework for benchmarking of smart cities was bases on the smartness of the transport system (Debnath et al.,). The method focuses directly on transportation areas of smart cities. In contrast, the current framework encompasses broader dimensions of city smartness such as governance, people, living, economy, environment, mobility, infrastructure, and services.

Also, there is a proposed framework that leverage crowdsourced data to produce urban knowledge and city benchmarking service (Moustaka et al.,). The laudable approach emphasized the value of utilizing crowdsourced data to evaluate smart cities. The current model may incorporate similar principles but could also integrate other data sources or emphasize different aspects of development of smart cities. Hence, the current framework in comparison to the existing ones offers a unique contribution or improvement in term of scope, methodology, indicators used, or the integration of different dimensions relevant to smart city benchmarking.

11.7 Smart Services

This Smart Services construct has a PSI of 4.2014 and a coefficient value of 0.1271 in the evaluation model. This coefficient, being the highest, suggests the paramount importance of smart services in the scheme of things in the smart city. The fact that contemporary smart services need to be pre-emptive rather than reactive (Asghar et al., 2017), as a way of alerting of the occurrence of an event before it actually happen. This is further reinforced by the fact that new type of values are established whereby the consumer are saved the hostile surprises of unexpected exhaustion of their consumables and the firm gain extraordinary insight into customer’s needs and can provide ongoing value (Allmendinger & Lombreglia, 2005).

Of all the variables under the smart services construct only two constitute the critical success criteria for the success of the smart services, they are availability of waste recycling for resource re-use with a mean of 4.22 and real-time crime mapping to monitor criminal activities with a mean of 4.18.

11.7.1 Availability of waste recycling for resource re-use

The availability of waste recycling for resource re-use has been one of the major goals of the United Nations to promote sustainability of resources, the environment, the social milieu and the elimination of significant quantities of resources lost to inefficient waste management practices (Gravagnuolo et al., 2021). The extraction and production of material resources have great impact on the environment and human health, plants, animals as well as the economy. It is vital to reuse such resources in the smart city, keeping their value high, delivering value for longer periods, and reducing the need to use virgin constituents (Khoshgoftar Manesh et al., 2020). Also, expert have observed that increasing extraction poses tremendous risks to the environment and human health and that loss of resources is associated with loss of critical raw materials that are fundamental to the functioning of key industrial sectors and applications. The reduction of resource losses, some experts believe, is essential to ensure our well-being (Chai et al., 2021).

11.7.2 Real-time crime mapping to monitor criminal activities.

Real-time crime mapping to monitor criminal activities which was the next critical success variable in the smart services construct is an effective and proactive policing system that is better than simply reacting to criminal acts. Despite the availability of other methods that would help the law enforcement agent respond to crime and conduct investigation more efficiently, predicting when and where a crime is likely to occur, and most importantly who was involved in previous crimes- has recently become widely accepted. Expert noted that police are employing a range of predictive policing methods, in the United States of America, which, fortuitously had attracted a lot of commendations (Haupt, 2019).

11.8Smart Infrastructure

The Smart Infrastructure Construct has a project success index (PSI) of 4.1542 and a coefficient value of 0.1257 in the evaluation model. This is the second highest coefficient after the smart services. This suggests that smart infrastructure which includes public realm and sensor (Govada, Cheng, & Chung, 2019), roads ports, railways, power generating systems including non-physical infrastructure such as data, information, communication, social and knowledge capital (Hall, 2000; Metos, et al., 2017; Caragliu, et al., 2009; Dameri and Ricciardi, 2015), are the backbone of a smart city.

From the mean ranking in this study, the order of importance of Smart infrastructure consists of five critical success criteria (csc) like “power generating system availability”, “availability of Utilities services”, “availability of IoT and embedded devices”, “availability of cloud computing and wi-fi services”, “prevalence of 5g internet network”. The csc have been listed in their order of importance. The most important being Power generating system availability while the least important is Prevalence of 5g internet network.

11.8.1 Power Generating Systems Availability

Power generating system availability is the most important criteria as it is the heart and brain of energy system. All the things we use or consume requires energy to produce and package, and also to distribute to sale outlets or to operate and eventually get them to their final disposal. Experts have observed that the general demand for energy is expected to multiply but the conventional energy sources are limited, and they add carbon emissions to the environment (Raihan et al., 2022). . Experts have expressed interest in the use of renewable energy sources like solar energy, wind energy, hydro energy, and many others (Raihan et al., 2022). However, some other experts have also noted that these renewable sources are arbitrary and unstable leading to frequency fluctuations, grid instability, total or partial loss of load power supply (Kenyon et al., 2020). These inadequacies, experts say, can be overcome using static converter as output interface of the generating plants introduces voltage and current harmonics into the electrical system that adversely affect system power quality (Kenyon et al., 2020).

In the contemporary scenario, the power generation system integrates different type of energy conversion technologies such as solar, hydropower, thermal and wind. The power generation system is also diversified in terms of the geographical distribution; massive conventional units have the advantage of being centralized, however, renewable resources must be collected from dispersed areas with small-sized units. The different sizes of the system are restricted by technical, geographical, and environmental constraints, but respond to optimal economic solution. The major advantage of the power generating system is the diversification of the generation technologies like market providing security of supply and technologies, allowing more freedom of fossil energy sources, and mixing alternative energy resources (Jayachandran et al., 2022).

11.8.2 Availability of Utility Services

Availability of utility services which is the second critical success criteria (CSC) includes services like natural or manufactured gas, water, sewerage, high temperature hot water, chilled water, steam, hot water, and provision of electricity. In recent times, some newer network goods like broadband internet connectivity have also been included (Moore, Boardman and Vining, 2017). These services, according to experts, are daily needs and vital for human survival and are now being provided by some government through public-private participation or by government regulated private-owned utilities instead of being fully owned by government where they are poorly managed and maintained (Cordova & Stanley, 2021).. Their provision in the smart city will help to alleviate social malaise and create a sense of inclusivity for the local city citizens.

11.8.3 Availability of IoT and embedded Devices

Availability of IoT and embedded devices is the third CSC in smart infrastructure. According to experts, the availability of IoT and embedded devices ensures that every infrastructure where sensors are incorporate to common and daily used devices that register, treat, modify, transfer and interact data with other devices or system make use of their connection capabilities to communicate between the device and other devices as well as with domain host to ensure security, accountability and management of the supply chain.(Alam, 2021; Butpheng, Yeh and Xiong, 2020)

11.8.4 Availability of Cloud Computing and Wi-Fi Services

Another CSC is the "availability of cloud computing and wi-fi services". Cloud computing is an on-demand delievery of IT resources over the internet with pay-as-you-go pricing or permanent hosting which involves once-and-for-all purchase and maintaining a pseudo-physical data centre and server (Kaur, 2019). Through this cloud computing capacity, experts observed that one can have access to huge computing power, storage, and database from the cloud providers like OneDrive, Google drive and Amazon Web Services. The Wi-Fi is the avenue through which a connection to the cloud can be made and this suggest that the Wi-Fi should have an appreciable speed of 4g network to be able to facilitate internet connectivity and online streaming (Kaur, 2019b)

11.8.5 Enabling Environment for Human Capital Development, Competition and Innovation

The development of any city, particularly a smart city, in education, medicine, employment and labour, is based upon human capital development. The human capital development is the aggregate of skills, knowledge, competencies and innovative abilities possessed by the citizens (Mondisa, Packard and Montgomery, 2021; Kucharčíková, 2011). It could also be seen as talent, competencies, skills and other advantages which the citizen have and can be channelled to better use to give a city or nations more benefits (Guruge, Kadel and Halder, 2021; Achugbue and Ochonogor, 2013).

The increasing importance of knowledge of economic growth and the advent of world-wide labour market and the global and political transformation are amongst the most important changes that have characterise the 21st century. Ultimately, the human capital could be viewed as the fundamental infrastructure from technological development and by inference economic development (Bronzini and Piselli, 2009).

Hence, it is vital to note that the people that have achieved high economic development and those that have positively harnessed their human capital are the leading light in world affairs and nation-building. For instance, there are no known mineral deposit in South Korea, but they have taken advantage of their human capital to propel their meteoric economic development. This suggests that human capital is a catalyst of economic development (Dallas et al., 2021).

Competition and innovation can thrive where there is abundance of human capital, as the commodity of human capital development within a favourable environment, like the smart city, is competition and innovation leading to the development of cutting-edge technologies, new ideas, skills, creation of new inventions for the improvement of human lives, protection of the environment and facilitation of social cohesion (Dallas et al., 2021).

11.9 Smart Mobility

The project success index of smart mobility is 4.1466 and it has a coefficient of 0.1255 in the evaluation model. It occupies the third position as the most important construct of smart city as it affects the way people move in the smart city environment due to the development of e-commerce, e-business and other online services (Kaluarachchi, 2019). New urban mobility systems have been created by the infusion of ICT into the transport services which reduces the volume of motorized traffic and also give the citizen real-time schedule of buses.

There are eight critical success criteria for smart mobility from the mean ranking. In order of the mean ranking, the most important critical success criteria are as following order: (inter-)national accessibility of the transport services; availability of digital transit payments; use of smartphone for facilitating mobility demand and ticketing; existence of autonomous vehicles in city transport architecture; good urban planning; use of ICT in transportation logistics; availability of car-sharing, ride sharing, new bike systems; and availability of pedestrian and bicycle path.

11.9.1 (Inter-)national Accessibility of the Transport Services

The highest ranked critical success criteria is the (inter-)national accessibility of the transport services and it is concerns with the accessibility of transport to schools, hospitals, large employment centres, town centres, parliamentary constituency, local enterprise partnership, and international airport. The time estimated for the journey must be accurate within the city. For international travels the departure and arrival coupled with the check-in and check-out time plus luggage retrieval must be within an estimated time. Allied to this is the repercussion of the changes in the mode, cost, time, interchanges, quality and reliability of the transport system on the shopping, health services, recreation of the people (Karatas et al., 2022).

11.9.2 Availability of digital transit payments

The next item is the availability of digital transit payment. This is the backbone of mass transit system as it prevents fraud by both users and staffs in the buses, it saves time, reduce cost and revenue leakages, reduce delay engender in cash transaction, provide real-time insight on service delivery, enhances economic mobility, lay the foundation for transforming smart city administration, organization and planning; facilitate data-driven decisions, and encourage digital adoption (Ammar, 2018).

11.9.3 Use of Smartphones for Facilitating Mobility Demand and Ticketing

The third highest ranked mean is the "use of smartphones for facilitating mobility demand and ticketing". Since information and communication technology has come to disrupt industrial and commercial activities, its foray into the mobility arena should not come as a surprise to the discerning public. It has undoubtedly enhanced the collection of transit mobility data from smartphones and push information back to people is changing everything from operation to traveller journey experience (Milne & Watling, 2019).. New transportation ecosystem comprising of information technology companies, application creators and ridesharing are the grassroot player in the mobile technology adoption in the transportation industry (Kocher, 2015). The digital transformation is changing how people now use public transport including acquiring their ticket. Tickets could be bought ahead of trips, for any mode of transport on the smartphone, at a cheaper rate and in some instances, such tickets could be swap or revoked (Kocher, 2015).

11.9.4 Existence of Autonomous Vehicles in City Transport Architecture

The fourth mean-ranked critical success criteria is the "existence of autonomous vehicles in smart city transport architecture" which (MODELUR, 2019), say will reduce car usage on the highway by 80% leading to fewer traffic congestion, less emissions to the environment, reduced travel times, reduce car parking spaces thereby making available spaces for social parks that could serves as sources of carbon sequestration. Despite these ambitious prospects of autonomous vehicles in smart city transport architecture, some scholars like, Stead & Vaddadi, (2019) are of the opinion that there are lots of unknowns and uncertainties in how autonomous vehicle will affect the urban morphology.

11.9.5 Good Urban Planning

The fifth mean-ranked critical success criteria of the smart mobility is a "good urban planning" that is vital for the successful implementation of smart mobility as it impact the smart city infrastructures; the city layout; image of the city; transportation system; the densities of the residential, commercial and industrial areas and the harmonious functioning of the smart city's transport architecture in consonance with the entire city framework.

Good urban planning can include urban renewal, and by adapting urban planning methods to existing smart cities suffering from decay and lack of investment (Huang et al., 2020; Webb et al., 2006), the quality of life in the smart city can be enhanced . Environmental protection and conservation are vital to many planning systems all over the world. Not only are the direct effect of development to be alleviated, but efforts are made to lessen the overall influence of development on local and global environment (Ali, Anufriev and Amfo, 2021). This is generally completed through the assessment of the sustainable urban infrastructure and microclimate.

11.9.6 Use of ICT in Transportation Logistics

The sixth mean-ranked critical success criteria is the "use of ICT in transportation logistics" which is the synchronisation of the flow of movement of both information and physical products throughout the supply chain and enabling the respond to market change more rapidly. Nowadays, logistics organizations are using the social media to build communities around their services in an effort to bring employees and clients together in order to elevate efficiency of work. ICT has transformed the transportation logistic structure as it provide organizations with new competitors. In order to improve their performance, employees deploy social media like WhatsApp and Twitter, to connect with the customers (Subhashini and Preetha, 2018) .

11.9.7 Availability of Car-sharing, Ride sharing, new Biking Systems

The seventh mean-ranked critical success criteria variable is the "availability of car-sharing, ride sharing, new biking systems", which is an innovation in the mobility industry, and a means of reducing vehicle emissions on the road, promote sustainable transportation, reduce traffic congestion and create efficient mode of transport communication within the smart city (Mitropoulos, Kortsari and Ayfantopoulou, 2021). It is not limited to car-sharing, ride sharing and biking system but also include scooter-sharing, and moped-sharing. This, however, has its own challenges, such as vandalism which can be overcome true proper public sensitisation (van Waes et al., 2020).

11.9.8 Provision of Efficient Emergency Services for the Citizens

The "Provision of efficient emergency services for the citizens" is the eight mean-ranked critical success criteria. The goal is to reduce damage to buildings, stock and equipment; protect the community and environment while fast tracking the resumption of normal operations; it also include the prevention of injuries and fatalities (Krausmann and Cruz, 2013). There should be concerted efforts by government agencies and other corporations to meet the national waiting time for the rescue mission and relief to victim (Goswami et al., 2018). Apart from this there should be clear emergency roles and responsibilities, unambiguous emergency procedures like raising alarm and informing the public, a tested emergency plan, evacuation procedures for vulnerable people and adequate routes and exits (Zhu et al., 2020).

11.10 Smart Environment

Smart environment has a project success index (PSI) of 4.1413 and a coefficient value of 0.1253 in the evaluation model. It has a mean rank of 4 which suggest its importance relative to the other construct of smart city. Using a weighting of 0.5 on the variable result in seventeen critical success criteria which are as follows: Minimising of health hazards arising from exposure to harmful materials (e.g. by pollution, accidents, noxious substances in food); Efficient waste management systems; Leveraging smart meter for energy conservation in the city; Collaboration between government and people to monitor and manage environmental policies; Reliability of energy supply system to the citizens; Minimisation of exposure to health hazards; Remote health monitoring and intervention; Preservation of the unique natural resources, ecological system, and biodiversity; Ensuring a cohesive healthy community; Improvement in air quality, water, forest and soil conditions; Ensuring environmental aesthetics for the city; Intelligence distribution networks; Create a recreational opportunity for the people; Clean sources and distribution networks for water supply; Provision of abundant public open space with smart resource management; Reduction of pollutant emission in the environment; and Good air quality in the environment.

11.10.1 Minimising of Health Hazards Arising from Exposure To Harmful Materials (e.g., by pollution, accidents, noxious substances in food)

The first critical success criteria of the smart environment is the "minimising of health hazards arising from exposure to harmful materials (e.g., by pollution, accidents, noxious substances in food)" so as to prevent ill health. This can be achieved through appropriate training of personnel to know the different hazardous materials and their handling precaution. There should also be adequate general ventilation; ways of working including operating procedure, supervision and training by the line manager ensuring that risks associated with exposure to any hazardous substance to health are assessed and identify suitable and sufficient control measures, which must be executed and maintained (Ajayi et al., 2021).

11.10.2 Efficient Waste Management Systems

"Efficient waste management systems" is the second critical success criteria in the smart environment variables. By mean ranking it comes second. It is about the entire life cycle of product such as minimizing the quantity of waste and keeping as many materials as possible in the resource chain to ameliorate the negative impact of our modern consumption on our environment. The waste hierarchy consists of prevention, reuse, recycling, recovery and final disposal. Great effort must be dispensed in preventing, reuse, recycling and recovery of waste so as to reduce to barest minimum the final quantity of waste to be disposed. In current dispensation, smart waste management solution use sensor and data to optimize the way the waste is dealt with (Nanda and Berruti, 2021). The fill levels of the bins are monitored by sensors which provide a digital update on waste generation. Once the bins are filled, the sensor send signal to the waste collection vehicle inviting it to come and collect the waste. This eliminates unnecessary trip by the waste vehicle and ensure prompt disposal of waste (Nanda & Berruti, 2021).

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11.10.3 Leveraging Smart Meter for Energy Conservation in The City

The third critical success criteria on the mean rank of the smart environment variables is “leveraging smart meter for energy conservation in the smart city”. With the deployment of the smart meters, consumers are now able to monitor their energy consumption and also eliminate the energy consumption during the peak-time thereby reducing their energy bills, facilitating the use of renewable energy sources, and reducing the impact of energy consumption on the environment (Francisco, Mohammadi and Taylor, 2020). Though, this claim of saving energy by the use of smart meter was not actually fulfilled, as only 2.3% of energy was conserved instead of the 3.0% that was touted, nevertheless, the adoption of smart meter created awareness of energy consciousness that led to the acquisition of low energy consumption facilities by residents (Every, Li and Dorrell, 2017).

11.10.4 Collaboration between Government and People to Monitor and Manage Environmental Policies

The “collaboration between government and people to monitor and manage environmental policies” is the fourth on the mean ranking of smart environment variables. This has become the method adopted by government and non-governmental agencies, citizen, and businesses to developing planning, environmental policies, and management of environmental issues such as farmland, forests, rivers, endangered species habitats and watershed. At the end of the day government agencies are accountable for the outcomes, it enable a wholistic and an all-encompassing and inclusive decision to be made that is impactful and successful (William, 2000).

11.10.5 Reliability of Energy Supply System to The Citizens

"Reliability of energy supply system to the citizens" forms the fifth on the mean ranking of critical success criteria in the smart environment. To guarantee the reliability and affordability of the energy supply system, the International Energy Agency (IEA) has directed that a reserve of ninety days be held in stock to forestall supply disruption. Meanwhile, with cost reduction and favourable policy, there has been an increase in the availability of renewable sources in the recent past, leading to the transition of the energy sector to a cleaner and environmentally friendly generations (IEA, 2022).

11.10.6 Minimisation of Exposure to Health Hazards

The sixth critical success criteria of smart environment using the mean ranking is "minimisation of exposure to health hazards" in all spheres of human endeavours. Institutions and government can improve the health of the local communities by initiating surveillance and assessment programs and conducting health promotion programmes that are designed to cut exposure to environmental health risks. There has been issue of huge losses to the government and businesses due to exposure of people to dangerous noise environment, unsafe work practices, and hazardous toxin. This, in turn, had caused untold hardship to live, businesses and the social environment (Arif et al., 2021).

11.10.7 Remote Health Monitoring and Intervention

"Remote health monitoring and intervention" is ranked seventh on the mean rank of the critical success criteria on the environment. The remote health monitoring and intervention is a recent development in connected health technology where healthcare can be delivered to patient, particularly those with long term medical conditions (e.g., diabetes, heart diseases or vulnerable groups like elderly and women with high risk of pregnancies). However, the method of implementation and how patient should be educated to enable active participation is still at its infancy (Aldahmash et al., 2019)

11.10.8 Preservation of the Unique Natural Resources, Ecological System, And Biodiversity

The survival of man on earth depends on the "preservation of the unique natural resources, ecological system, and biodiversity". These resources comprise of water, life of other forms, plants, trees, the atmosphere, and soil. As many of these natural resources, ecological system and biodiversity have not been documented, though, about 1.75 million have been identified (Weiskopf et al., 2020). Scientists are of the opinion that the natural resources, ecological system and biodiversity is being threatened by extinction and once this occur the species are irreplaceable (Weiskopf et al., 2020). The "preservation of the unique natural resources, ecological system, and biodiversity" is a critical success criteria that has been ranked eight on mean rank of smart environment due to its significance for man survival (Weiskopf et al., 2020). This is further buttressed by the report of the United Nations which suggest that nature is declining at an unprecedented rate in the history of humanity and most importantly the extinction of species, with around one million plant and animal species at risk of extinction within decades (Weiskopf et al., 2020).

11.10.9 Ensuring a Cohesive Healthy Community

"Ensuring a cohesive healthy community" should be one of the long-term goals of leadership and it should be mainstream in the services of local authorities. It is the nineth mean ranked critical success criteria of the smart environment. It involves having a common vision and a sense of belonging by the community members; appreciating the circumstances and different background of different people; giving equal opportunities to people of different backgrounds; and ensuring the development of strong and positive relationship between people of different background in schools, workplaces and with the neighbourhood (Prah Ruger, 2020). The implementation of these laudable objective should recognise the dynamics between different communities. However, the task of promoting cohesive healthy community involves addressing fractures, removing barriers and encouraging positive interaction between different groups with diverse orientation (Local Government Association (England and Wales), 2004).

11.10.10 Improvement in Air Quality, Water, Forest and Soil Conditions

Our environment can become very sustainable through the protection of our natural resources of water, soil and the air (Defra, 2009). To make the city safer and better to live in for people and animals, there is the urgent need to have green vegetation as an integral part of the smart city ecosystem particularly because of the sequestration that is easily facilitated by the green plants. Tree plants also have the capacity to provide shading, prevent soil erosion, remove particulate matters (PM) using their leaves, filter atmospheric pollutants like sulphur dioxide and nitrogen dioxide through their leaves, and reduce surface temperature which reduces the need for air-conditioning in buildings that is the source of greenhouse gas emissions (Demirel et al., 2018). Therefore the “improvement in air quality, water, forest and soil conditions” is a critical success criteria of the smart environment. It is ranked tenth on the mean rank.

11.10.11 Ensuring Environmental Aesthetics for The City

The eleventh mean-ranked critical success criteria in smart environment is “ensuring environmental aesthetics for the city”. Environmental aesthetics is one of the major new areas of aesthetics to have emerged in the last part of the twentieth century which is paying attention to philosophical issues concerning appreciation of the global environment as it is organised with both natural and human environment. Though scholars see aesthetics as a branch of philosophy concerned with understanding the intrinsic value we ascribe to works of art and to natural beauty, others see aesthetic as an area of philosophy that studies the ways in which humans experience the world through their senses. The physical world that encompasses humans in their day-to-day experience constitutes the everyday environment. Hence the environmental aesthetics is the appreciation of natural environments, the work of fine art such as landscape painting, the work of art situated in nature, for instance, landscape paintings, that are of or about nature (Weinberger et al., 2021).

11.10.12 Intelligence Distribution Networks

The twelfth critical success criteria on the mean rank of smart environment is "intelligence distribution networks" which is a process that keeps a system running and able to self-correct itself in an emergency situation so that the entire system or part of it is not shut down. For instance, in a power distribution system that route power to residential and commercial utilities through power lines, switches and transformers. These utilities rely on complex power distribution schemes and manual switching to keep power flow to the customers. Any brake in the transmission due to storm, bad weather or sudden changes in electricity demand can lead to outages (Ahmad et al., 2022). The smart grid distribution intelligence counter this energy fluctuation and outages by automatically identifying problems and rerouting and restoring power delivery. Utilities can further use distribution intelligence to predict and manage electricity usage with the cooperation of their customers leading to lower production cost (U.S. DEPARTMENT OF ENERGY, 2022).

11.10.13 Creation of a Recreational Opportunity for People

Recreation facilities and parks are very vital for a healthy, and vibrant community. Hence the "creation of a recreational opportunity for people" which is the thirteenth critical success criteria on the mean rank of smart environment provide a succour for the citizens. The recreation facilities should focus on inclusivity and leading the way in education about conservation (Pivik, McComas and Laflamme, 2002), wild life health, general well-being and nutrition of the community (Jenkins et al., 2015); it should also aim to be a beacon of social responsibility for the community residents

(Cintron, 2021), it should strengthens the comradery and fraternity among the youth and the elderly in the community (Marques da Silva and Pinheiro, 2021) even though there had been some report of hoodlum carrying out some social vices like rape and drug addiction in some recreation facilities (Adu-Gyamfi, 2021).

11.10.14 Clean Source and Distribution Network for Water Supply

Water distribution infrastructure and water resources are continuously coming under immense pressure from economic development, migration and urbanization and population growth (Wang et al., 2022). Assuring everyone access to a continuous supply of clean water all day and year-round has become an important task for local authorities, Professional in the sector and the citizens (Ghaderi, Michael Hall and Ryan, 2022), even though this is practically impossible in our prevailing scenario. To achieve this goal, a "clean source and distribution network for water supply" must be guaranteed by the local authorities and stakeholder. The "clean sources and distribution networks for water supply" form the fourteenth critical success criteria on the mean rank of smart environment. This suggest that the sources of water supply in the global arena which include groundwater, surface water, brackish and saline water must be wholesome, free from pathogen and impurities, and must be potable. The Water distribution system consist of interconnected series of components such as storage facilities, pipes which can guarantee adequate storage and supply for both domestic and industrial consumption (Saucedo-Ramírez, Mahlknecht and González-Bravo, 2022).

11.10.15 Provision of Abundant Public Open Space with Smart Resource Management

Policies must be introduced to manage urban growth and protect open space at the local, regional, state and national levels using instrument such as public acquisition of lands, regulatory approaches and incentive-based approaches with overarching coordination of the local, state, and regional levels by the national or federal agency so as to ensure a well-coordinated process and outcomes. This makes the "provision of abundant public open space with smart resource management" ranked fifteenth on the critical success criteria of the smart environment. Allied to public open space is the smart resource management. The smart resource management involves the ability to schedule and manage multiple tasks, locations and people simultaneously, collaborate effectively and tracking the progress of each task without clashes, forecasting project completion time on budget and support the growing needs of the organization or individuals (Razmjoo et al., 2021).

11.10.16 Reduction of Pollutant Emission in The Environment

With the current alarm of global warming due to the emission of greenhouse gases, there should be measure and policy guidelines to monitor and manage the emission of air pollutants like nitrogen dioxide, sulphur dioxide, ammonia and other noxious gases that have been reported to elevate the global temperature leading to a lot of environmental related crisis. Hence, the sixteenth mean ranked critical success criteria on the smart environment construct is "reduction of pollutant emission in the environment", so that the concentration of these emissions do not exceed the tolerable level for living things including plants and animals. This is one of the key objectives of National Emission Reduction Commitment in Europe which expects the transport, energy and agricultural sectors that are the sources of these emissions to cut back on their emissions (European Environment Agency, 2021) so as to reduce premature death which is the consequence of air pollution and to delivering the zero-pollution ambition under the European Green Deal. However, despite this emission limits, majority of the countries are unable to meet their 2020 emission reduction commitments for particulate matter, nitrogen oxide and ammonia (Solarin, Yilanci and Gorus, 2021).

11.10.17 Good Air Quality in the Environment

Significant burden on the environment, well-being, health and national economy of Europe is caused by air pollution (Yerema and Managi, 2021). The most harmful air pollutants are particulate matter of 10 or 2.5 microns in aerodynamic diameter (Guo et al., 2022). According to the Organization for Economic Cooperation and Development (OECD) on the one hand and the World Health Organization on the other, about 1.6 trillion dollars was the economic cost of diseases and deaths from air pollution in 2015 (World Health Organization, 2017). A "good air quality in the environment" which forms the seventeenth on the mean rank of the critical success criteria for smart environment become vital and need to be adequately provided for with good policy instrument.

11.11 Smart Governance

The project success index (PSI) of Smart governance is 4.1153 and it has a coefficient value of 0.1245 on the evaluation model. This makes smart governance the fifth on the hierarchy of smart city benchmarking emphasising the relevance of participatory governance and citizen involvement in running and managing their affairs (Albino et al., 2015). Using a weighting factor of 0.5 on the variable of smart governance leads to the emergence of seven critical success criteria which are the following in order of importance based on the mean ranking of the variables: Transparency in governance activities; Transparency in decision making process; Availability of public and social services for the citizens; Availability of E-government for transaction with government; Participation of the citizens in government's decision-making; Availability of e-services for public engagement; and Clarity of the environmental protection policy. Each of this critical success criteria is briefly expatiated upon.

11.11.1 Transparency in Governance Activities

Transparency in governance is a governance arrangement where the government official act openly with the people's being aware of the decisions that the government is taking on their behalf (Mansoor, 2021). The availability of data on government actions and policies, a clear sense of organizational responsibility, and a guarantee that government are well ran and free of systemic corruption are essential part of transparent governance (Furstenberg and Moldalieva, 2022). In order to prevent corruption, promote effective services, and promote public ethics at local, regional and national levels, the issue of "transparency in governance activities" should be place on the from burner. Hence, it is ranked first on the critical success criteria of smart governance. This afford the citizens to be aware of processes and management, income and expenditure profile of their institutions and authorities. Transparency in governance prevent the misallocation of resources, promote private and public sector development, and clearly enunciate public policy.

For transparency in governance to be adequately implemented at different strata of governance, several different stakeholders must exercise oversight and control. These stakeholders may be state and national-level agencies that allocate resources and audit the respective government (de Almeida, dos Santos and Farias, 2021). This government must themselves implement internal controls and monitoring mechanism, like code of ethics and performance measures(Vu and Nga, 2022). Most importantly, the provision of mechanism to enable citizens to provide input to and receive feedback from the government is an essential part of transparent government process.

11.11.2 Transparency in decision making process.

Transparency is the absence of hidden agendas or conditions, and it is accompanied by the availability of complete information required for cooperation, collaboration, and collective decision-making and it is an essential condition for a free and open exchange whereby the rules and reasons behind every regulatory measures are clear and fair to all the stakeholders (Oats & Tuck, 2019). Transparency in decision making is an activity that requires maintaining, fostering, and producing dialogue and communication amongst all those affected by a decision and those producing these decisions. The matter raised in this discourse will refer to what is right and what is considered to be good in the community and also concern technical efficiency. Social policies, especially those of extensive social importance, are in one form or another the consequence of numerous meaning creation processes, reflecting their many spheres of influence, from the disciplinary to the multi- and transdisciplinary and from the local to the global. Each of these processes requires transparency (Oats & Tuck, 2019).

For transparency in decision making to be entrenched in the governance administration, there should be a strong civil society, effective and transparent financial management, a fair and open bidding and adequate information flow (Oats & Tuck, 2019). This process can be promoted through legislation that promotes transparent procurement processes. Also, the government budgetary process must be open and transparent and incorporate the participation of the citizens.

11.11.3 Availability of Public and Social Services for The Citizens

Statistics suggest that for the first time in the history of mankind, there will be more people over sixty years of age than those under fifteen years. It was estimated that at the age of 60, 60% of individuals are still healthy, at the age of 70, it is about 40%, at the age of 80, about 20% while at the age of 90 only about 5% of senior citizens are in good health and without major health issues (Mirzaei et al., 2020; Zhu et al., 2019). In a situation where the elderly is unable to function properly, they depend on the assistance of others that are provided through social services.

Public services are any service directed to address certain needs pertaining to the aggregate member of a city. Public services are available to people under a particular government authority as provided directly through public sector organisations or through a voluntary bodies or public financing. Other public services are provided in the interest of the citizens or undertaken on behalf of the government's residents. Public service is usually associated with social consensus that certain services should be provided to all citizen, irrespective of mental acuity, income, social status, or physical ability (Ozili, 2021). The public service could be paramedics, air force, fire brigade or the police. On the other hand, social services are some public services that are meant to assist and support a particular group, which may include the physically challenged like the elderly. These social services may be provided by government agency, private and independent organisations, and individuals. Social services include education, housing and medical care. These social services are to enable children, families, adults, groups and communities to function, participate and develop in society. With the presence of social services, a sense of inclusiveness is assumed by the citizens which produce cohesiveness of the community and ensure a sense of belonging (Ozili, 2021).

11.11.4 Availability of E-government for Transaction with Government

The main aim of e-government is to increase agency efficiency and provide abundant benefit to the citizens (Othman and Razali, 2018). In the contemporary dispensation, business are going through a revolutionary transformation due to the availability of information and communication technologies for work, leisure and businesses. In the government sector, ICT are promising to enhance the delivery of public good and services to the people not only by improving the process and management of government, but also by redefining the traditional concepts of citizenship and democracy. Hence, the e-government is the employment of information technology for free movement of information to surmount the physical bounds of traditional paper and physical based systems to the use of technology to enhance the access to and delivery of government services to benefit citizens, business partners and employees." The common theme behind these definitions is that E-government involves the computerization or automation of existing paper-based procedures that will initiate new styles of leadership, new methods of debating and deciding strategies, new methods of transacting business, new methods of listening to citizens and communities, and new methods of organizing and delivering information,

Eventually, E-government aims to improve access to and delivery of government services to benefit citizens (Sharma et al., 2021). Above all, it aims to help reinforce government's drive toward effective governance and increased transparency to better managing city's social and economic resources for progress and development. The key to E-government is establishment of a long-term, organization-wide strategy to hitch free operations with the view of fulfilling people's needs by transforming internal operations such as workflow management, staffing, processes and technology.

Four main areas are the target of E-government services: government agencies, business communities, citizens, government employees. E-government aims to make interaction with government agencies, business communities, citizens, government employees and other governments more friendly, convenient, inexpensive, transparent and effective (Oumkaltoum, Mohamed Mahmoud and Omar, 2019). In an E-government system, individuals can initiate a request for a specific government service and then receive that government service through the internet or some computerized mechanism. In some cases, the government service is delivered through one government office, instead of many. In other cases, a government transaction is completed without direct in-person contact with a government employee.

11.11.5 Participation of the citizens in government's decision-making

The argument that citizen participation in government decision-making produces many benefits cannot be overstated. Citizen's involvement is intended to produce better decisions and thus more efficiency benefits to the rest of the society. Hence, there are two tiers of benefits to consider which are process and outcomes and two beneficiaries which are the government and the citizens when assessing the effectiveness of the citizen-participation process. An in-depth citizen-participation process can assist to transcend the hurdle to effective policy created by our sound-bite media culture. Informed and involved citizens become citizen-experts, understanding technically difficult situations and seeing holistic, communitywide solutions. Administrators are able to explain their reasons for pursuing policies that, at first glance, would not be popular to the public. It is assumed that more participants with a more sophisticated level of technical and social understanding will yield better policy decisions, and thus better social and environmental outcomes. Administrators also benefit from receiving education on specific community groups' positions. The administrators, through regular contact with citizens who might otherwise not be engaged in the policy process, learn which policies are likely to be explosively unpopular and how to avoid such policy failures. A policy that is well grounded in citizen preferences might be implemented in a smoother, less costly fashion because the public is more cooperative when the policy is implemented (Gao & Yu, 2020a).

What motivated government entities to abdicate part of their decision-making responsibilities to participatory groups may not have been a sincere desire to improve policy outcomes by becoming better educated about community preferences. Instead, the more powerful motivating factor may be the prospect of a more cooperative public. Often, the impetus for public involvement comes from a need to obtain acceptance as a prerequisite to successful implementation (Belkahla Driss et al., 2019).

Despite the huge benefits embedded in the citizen participation model, there some drawbacks may be overcome by effective structuring, provided the resources are available. Other challenges are contextual, suggesting that some communities are poor candidates for citizen-participation initiatives, and measurable outcomes may be better achieved with other decision-making methods.

11.11.6 Availability of E-services for Public Engagement

The e-services is not solely the speciality of organizations which have a commodity or product to sell. E-services is ideal candidate for many service provision sectors and content/information supply, like: home renovation, real estate and home automation; tourism, travel, and event services; employment services; finance, banking, and funding services; education such as in the open university; messaging, monitoring and communication services; government services like digital government initiatives by Holland, South Korea, Australia and Hong Kong; marketing and advertising; computer services; information portals, references and knowledge centres; digital publishing ; product development , 3D modelling , scanning, design and printing; traffic intelligence and car rental and sales services; restaurant booking services; online dating services; entertainment; and E-health (Hübl & Šepeľová, 2022).

Of the twenty websites, based on the web traffic, that are in the services domain, eighteen are the most reputable, and the remaining two are Amazon.com and T-mall (Dolega, Rowe and Branagan, 2021). The eighteen include www.facebook.com (online communities), www.google.co.jp (information search engine), www.google.com (information search engine), www.wikipedia.org (online references), www.taobao.com (e-marketplace), www.weibo.com (microblogs), www.yahoo.com (Internet information portal), www.baidu.com (information search engine), www.twitter.com (online microblogs), www.google.co.in (information search engine), www.qq.com (Internet service portal), www.hao123.com (Internet information portal), www.linkedin.com (online communities), www.live.com (online search engine), www.sina.com.cn (Internet information portal), www.blogspot.com (blogs), www.sohu.com (Internet information portal), and www.youtube.com (online entertainment),

11.11.7 Clarity of the Environmental Protection Policy

For the environment to be sustainable, the government must put in place policy and commitment that will bind the government as well as individuals, businesses, and organizations. The environmental protection policy must state clearly what role to be performed by the government, its agencies, individual citizen, corporate institutions and other stakeholders. The punishment for violation of environmental protection policy must clear and be a deterrent (Liu & Liu, 2022). The environmental protection policy adherent must be rewarded with annual honours to serve an encouragement for law abiding citizen or organization and a morale booster for environment supporters. The policy must specify environmental legislations, regulations, and code of practice relevant to different industrial sectors, there should be regular audit and review of the section of the policy to update it in line with current global best practices (Liu & Liu, 2022). Above all, the environment protection policy must address the following: Autonomously audit the different practices, and determine whether their goals have been reached; Work with the entire supply chain in order to gain mutual benefits of incorporating environmentally sustainable goals into everyday business; make available posters/training/newsletters to staff on implementing the sustainable policies (Gunningham & Sinclair, 2019); Frequently review business practices, and determine whether each practice is suitable in an environmental context; abide with any laws governing the environment, and actively look for ways to improve on these guidelines; Purchasing environmentally-friendly products and services that reduces environmental impacts; imbibe the attitude of reducing, recycling and using of wastes; Disseminate environmental awareness throughout all operations of the organization; work toward the conservation of water, energy and resources in all the processes of the organization; and Endeavour to better understand both the direct and indirect impact that an organization may have on the environment (Liu & Liu, 2022).

11.12 Smart Living

The smart living construct has a project success index (PSI) of 4.1125 and a coefficient of 0.1244 in the evaluation model. This makes it the fifth rank on coefficient level, despite the fact that man is always making efforts to make his living smart as much as he can (Pathan et al., 2019). It is made of eleven critical success criteria ranked in their order of importance using their mean values. There eleven critical success criteria are as follows: Enrolment of young people in general education and vocational training; Promoting social cohesion amongst the people; Individual safety in the community; Availability of world-class education; Improved security for women, children and the vulnerable; Availability of world-class health facility to the people; Telemedicine availability to the citizens; High level of employment; Remote patient monitoring for the vulnerable; High quality housing availability; And Infectious disease surveillance.

11.12.1 Enrolment of Young People in General Education and Vocational Training

As matter of urgent importance, the legislation now requires that young people must continue in education and vocational training until the age of 18 (Gürdür Broo, Kaynak and Sait, 2022; Crul et al., 2019). This law was introduced to improve the career and life prospects for young people due to the benefit of longer time in training or education. Some of these benefits include the development of greater range of skills; to empower the young ones with skill so that they can be employable; increase their earning potential; afford the chance for young people who are disengaged with mainstream education to develop new skills in an alternative setting.

The effort of educating the young people must be supported by the local authorities through the provision of strategic leadership in their communities to ensure that there is a network of support available which encourage, enables and assist the participation of young people in education and vocational training through liaison with partners like employer and sector organization. The local authority are to collect data on young people who are not participating in the training to assist them with intensive support to remedy their situation (Korber & Oesch, 2019).

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11.12.2 Promoting Social Cohesion Amongst the People

Several stakeholders have made effort to identify a term that sufficiently explains the complexity and multi-dimensionality of the force, or bond, that holds a society together and allows its members to peacefully coexist and develop (Spoonley et al., 2005). The term "social cohesion" has been used to describe this force, but there is no agreement on a unifying definition of social cohesion. Social cohesion means different things depending on the culture, context, identity and social and political dynamics.

One of the many interrelated but distinct terms that is used to describe the process of strengthening peace and development in conflict-affected and post-conflict situation is social cohesion. Owing to the broadness of the term, practitioners have begun to transit away from this term to a more specific concept focused on the broader community. Social cohesion also differs from the process of peace building (Fonseca et al., 2019a).

Peace building wishes to transform or change negative relationships and institutions while underpinning national capacities at all levels in order to better manage conflict dynamics, support the cohesiveness of society and build sustainable peace from the bottom up. Though the two terms are occasionally used interchangeably, social cohesion is frequently viewed as the desired outcome of effective peace building interventions and is inextricably linked in many perspectives to the wider scope of democratic governance including thematic topics such as, but not limited to, human rights and social accountability. The local setting often determines which term is used based on political sensitivity. However, economists, sociologists, and peace builders generally agree that social cohesion is an important quality for any society (Fonseca et al., 2019a).

Numerous governments and multilateral organizations have sought to define it. The United Nations defined a cohesive society as one where all the different groups have a sense of belonging, legitimacy, recognition, and participation (Fonseca, Lukosch and Brazier, 2019). Such society may not necessarily be demographically homogenous, but they harness the potential domicile in their society by accommodation of different ideas, opinions and skill.

One of the determinants of a peaceful, prosperous, and democratic community and state is social cohesion. It generates stronger bonds within and across different groups and foster greater trust in the institution of government. Strengthening or fostering social cohesion needs to be an essential part of government policy and civil society engagement in countries where several identity groups share geographic space. It is seen even more critical where there is a record or current context of conflict, hostility, or mistrust between different identity groups or the state and its citizens (Fonseca, Lukosch and Brazier, 2019).

11.12.3 Individual Safety in the Community

Individual safety in the community pertain to the safety of children, youth, adult, women, the elderly, the physically challenge and the vulnerable and their safety at home, on the streets, while riding public transportation, at the ATM and relating to vehicle (Afifi et al., 2021; Pitt, 2019). It also includes molestation of the opposite sex, sexual harassment, verbal and physical abuse. The overall aim is to cultivate an environment where children are empowered, adult are informed, and our community is safer for children and families to flourish.

When out, stay alert, stand tall and act with confidence; this make would-be criminals to change their mind about approaching you. When you feel uneasy walking alone, walk in company of others or have a whistle handy or carry other personal safety alarm. At night, use well-lit busy streets, and keep to the middle of the sidewalk. Individual must avoid carrying huge amount of liquid cash. However, if you must carry cash, ensure that it is just the amount that you need in case of unexpected needs (Drescher et al., 2021).

11.12.4 Availability of World-class Education

The Council of Chief State School Officers in 2006 published it Global Education Policy Statement which goes thus: that for student to best achieve their potential and contribute effectively to the global community, they must have access to a complete system of education that recognises and incorporate best practices from around the world, acquire skills and knowledge necessary to stay afloat in the twenty first century, using high quality and rigorous curricula, including instructions in international languages and cultures (Webb et al., 2006).

As the world is shrinking, businesses, educationists, and leader across the different geopolitical spheres are grappling with the question of how to produce worker and citizens who can remain competitive (Jammulamadaka et al., 2021). Contemporary student will be working in a global marketplace and living in a globalized community. To become leaders in the new dispensation and also to succeed, the student must acquire an exceptional set of skills, knowledge and perspectives than their predecessors (Nyamunda, 2021). They must have what it takes to compete and collaborate with their global counterparts in different parts of the world.

As it dawns on us the need to better prepare our students for the new global challenges, authorities at the national and state levels are working assiduously to integrate international knowledge and skills into the school curriculum (Lareau, Weininger and Warner-Griffin, 2021). In this regard, States are pivotal in creating internationally competitive education systems that will support vibrant economics. They progressively appreciate the need for a worldwide competent workforce.

States are no longer competing with neighbouring state -they are competing with countries around the globe for job creation, foreign direct investment, and trade. State are also major financier in human capital. Although most education is delivered at the local level, State have the fundamental responsibility for guaranteeing that children receive adequate education. Through elementary and secondary education, and university, technical school, state colleges, state are funding a major percentage of this investment. Educational institution also receives major final support, and often have jurisdiction over rights of way for broadband and other technology investments (Alajoutsijärvi et al., 2022).

11.12.5 Improved Security for Women, Children and the Vulnerable

According to the World Health Organization, one in three women suffer violence within their lifetime and more than fifteen million girls aged 15-19 years have experience rape (Weret, 2021). Economic and social inequality magnify this vulnerability. Women, girls, children and the vulnerable in low- and middle-income countries are usually susceptible to different forms of violence by their acquaintance, as well as by total strangers and law enforcement agents enforcing curfew and lockdowns (Bau et al., 2022).

Issues of gender based-violence and cases of sexual assault are rarely reported by victims especially in low- and middle-income countries, and prosecution for the crimes are rarely carried out. Conflicts and displacement only heighten the problem. As children, vulnerable, girls and women lose their support systems and homes and are placed in an insecure environment and in new roles, their risk of gender-based violence including abuses sexual assault increase (Bau et al., 2022).

A panacea for the improvement of the security of the children, girl and women, is that the girl child must be encourage to speak out when assaulted; adequate provision of lighting on street and corners; provision of mobile services that could easily dispense justice when an incidence occur;

on the conviction of offender, deterrent punishment must be mated out; frontline health workers should be properly trained to support survivor of gender-based violence, with skills on survivor-centred communication and clinical management of rape (Bau et al., 2022).

11.12.6 Availability of World-class Health Facility to the People

Good services or exceptional performance is usually expressed in non-health, industries, education and athletic competition as world class. Being considered as world class is a high distinction accorded to an elite few and is commonly taken to mean that one has attained a level of performance excellence that, in the world, is ranks among the very best (Nadia et al., 2020)..

In the healthcare system, the term world class has been increasingly used in a self-designation manner without a specified criterion. Attaining world class performance is very tough, requiring a clear concept, determination, unwavering commitment, and a consistent performance at the upper limit of what has been demonstrated to be possible. It also requires doing many things remarkably well, including applying evidence-based facility design principles; utilizing high-tech processes and the latest advances in informatics, engineering sciences and biomedical; providing care in the most conducive setting; having rational but visionary leadership; and employing the right number of well-trained, compassionate, and competent caregivers who are attuned to patients' and their families' culture, individual needs and life experiences (Kizer, 2010).

Other important criteria that project a healthcare as world class is the invisible architecture which is explained as what catalysis the synergies between and among the personnel like doctors, nurses, and other staff and the facility's physical environment and the technologies that drives it to achieve world-class excellence (Kizer, 2010).

11.12.7 Telemedicine Availability to the Citizens

Health institutions are offering virtual appointment and are expanding their telehealth options, most especially during the COVID-19 pandemic. This has been made a reality due to improved technology. Telemedicine allows a video or phone appointment between a patient and their healthcare practitioner. It has a lot of benefits which included the comfort and convenience of not driving to the doctor's clinic or office, walk or sit in a waiting room when you are ill. You can consult the doctor from the comfort of your house or bedroom. One's busy schedule can be made to accommodate virtual visit. The other good thing is that you may not need to take a leave time from work or arrange for a childcare in order to deal with urgent health challenges (Weißenfeld et al., 2021).

One other benefit of telemedicine is the control of infectious diseases. Infectious ailment such as flu, and COVID-19 can be pre-screened with a telehealth appointment. Hence, sick people are saved the stress of leaving their home to see the doctor on appointment. This result in less exposure to other people's germ which in turn protect people like the pregnant women, elderly, or chronically ill (Weißenfeld et al., 2021).

Telemedicine enable some health specialists to have some advantage by taking a cue from the home environment of the patient in their diagnosis. For instance, things that cause allergies may be easily discern by the allergist by looking at the immediate surround of the patient. Also, one`s ability to manage one's health at home can be assessed by the neurologist and physical and occupational health therapists upon the observation of the surroundings. Mental health patient assessment and counselling are most easily achieved through telemedicine as it saves the patient the hassle of going to and waiting for consultation. Other benefits include the fact that a family member can be looped in from any part of the globe to listen to the discussion between the patient and the doctor and this person can also take note of the doctors' responses to the patient (Nadia et al., 2020).

11.12.8 High Level of Employment

Based on contract, employment is the agreement which is performed between employer and employee which determines the duty, the work role, the method of service and the contribution the employer must offer to the corporation. Based on the job role and various other aspects, a certain amount of remuneration and facilities is decided by employee which is provided in exchange of his service (Eliyana et al., 2019). For employment level to be high, however, it must have certain quality which include increased employee earning that lead to a higher rate of consumer spending, which benefits other businesses who depend on consumer sale to stay open and pay vendors. Employing additional employee for a small business can achieve these effects on a small scale and increase the money circulating in the economy (Eliyana et al., 2019).

The number of people engaged in productive activities in an economy is called the employment level. It includes both the self-employed and the employees. Bigger employee earnings results in a higher rate of consumer spending, which assists other businesses who depend on consumer sales to stay open and pay vendors. Engaging extra employees for one’s small business can achieve these effects on a small scale and increase the money circulating in the marketplace (Spurk & Straub, 2020).

11.12.9 Remote Patient Monitoring for the Vulnerable

The desire of every human being, no matter their gender, location, age, or health conditions is to be independent and living a healthy life. This may not be possible due to limitation due to hospitalization, epidemic, age and illness. Given these circumstances, health monitoring systems has also evolved to assist communication between healthcare givers and patients for adequate monitoring, convenient healthy living, routine consultation and measurement of vital health parameters (Akkaş et al., 2020). This is made possible with the prevailing progress recorded in ICT through the adoption of internet of things to remotely monitor patient and support them to have a healthy living. Hence, remote patient monitoring is the use of technology for monitoring of patient in the own residence and it is majorly aimed at decreasing the cost of healthcare delivery and increasing access to quality healthcare services (Taiwo and Ezugwu, 2020)(Taiwo and Ezugwu, 2020). Though this has a major challenge of cyber security, if the necessary protection mechanism are put in place, it will go a long way in facilitating healthcare delivery (Ondiege, Clarke and Mapp, 2017).

The adoption of remote patient monitoring becomes more expedient with the exponential increase in the population of older citizens and patient that require constant monitoring. This is also buttressed by a study by (Zikali, 2018), where he found that the population of the senior citizens will exceed that of children and young adults by the year 2045. However, due to the impending shortage of caregivers and home health helper, assisting the elderly becomes more expensive, hence, the introduction of remote patient monitoring system which of necessity will reduce queuing, and physical contact with patient becomes a sine qua non.

This system will provide services to the elderly, physically challenged in the comfort of their homes instead of confinement, hospitals or nursing homes. This eliminates the depression suffered by patients due to loneliness in hospital wards. Patients can be prescribe medications by their doctors from the comfort of their offices and also viewed vital health parameters measure by the patient for remote diagnosis. Above all, the current progress in smart phone has made it possible for the elderly or physically challenged to control some home appliances with ease from their tablets or smart phones (Taiwo and Ezugwu, 2020).

11.12.10 High Quality Housing Availability

Housing is a basic human right, enshrine by the United Nations as the right not just to basic shelter but to adequate housing in terms of legal security of tenure; availability of services, materials, facilities, and infrastructure; affordability; habitability; accessibility; and location and cultural adequacy (Oren and Alterman, 2021). Housing is linked to good health (Shaw, 2004). The material conditions of housing affect the physical health and well-being of an individual, hence low-quality housing can be potentially harmful to the individual on the micro scale and to the larger community on the macro level (Shaw, 2004). This makes housing to be the key social determinant of health and a central element of the relationship between health and poverty. This can be buttressed by the fact that some of the earliest interventions of public health was the improvement in housing as a fundamental element of tackling poverty.

A house or apartment, apart from a car, is usually the most expensive investment embarked upon by an individual in his lifetime (Maliene and Malys, 2009). It fulfils a major need in one's personal life and hence, can be described as a major factor influencing the quality of life, and the social and economic status of an individual. With the changing global political and economic environment in the world, the problems of housing has become more pronounced coupled with population growth and increase in the real disposable income. There has been disproportionate increase in the price of houses which has made housing the prerogative of only some few.

Going by the universal declaration that state that "everyone has the right to a standard of living adequate to the health and well-being of himself and his family, including food, clothing, housing and medical care and necessary social services" (Zandy, 2019), hence, the right to housing should not be narrowly viewed as the mere provision of a roof over one's head. Rather, it should be seen as the right to live somewhere in security, peace and dignity. Adequate housing means an adequate space, adequate lighting, adequate privacy, adequate ventilation, basic infrastructure and adequate location with regards to work and basic facilities- all at affordable cost (Oren and Alterman, 2021).

11.12.11 Infectious disease surveillance

Following the 2001 epidemic of foot-and-mouth disease (FMD) in the UK and intensified national and international consciousness of bioterrorism, some reports have called for increased surveillance directed at early detection of exotic and foreign animal diseases. Although available information on the design of infectious disease and conceptual architectural surveillance systems is small, especially those linked to detection of foreign animal disease (FAD) agents. In view of new outcry for biosecurity and of recent technologies that allows rapid detection of infectious agents, an effort in rethinking surveillance function and operation is specified to motivate continued development of surveillance systems that would address emerging animal health needs (Thurmond, 2003).

The formal, systematic, active and ongoing process that is aimed at timely recognition of specific disease or agent in a population or timely forecast of elevated risk of a population acquiring an infectious disease, with a prespecified action that would follow the finding of disease is called surveillance (Ost et al., 2022; Perez et al., 2009). This meaning is similar to that proposed by others for active surveillance, as opposed to passive surveillance. The fundamental objective of surveillance is to intentionally track as early as possible the disease incidents or target agent to detect an elevated risk in order to maximize control, treatment, prevention, or the likelihood of eradication and to ameliorate the effects of the disease. Surveillance usually focuses on agents and diseases for which a rapidly directed, prespecified action at the herd or population level is warranted if the disease, agent, or elevated risk is identified. An essential working feature of surveillance, therefore, is that the system should get and process information rapidly, with minimal time elapsing between collection of information and communication of results. Immediate detection also is a function of the temporal sensitivity of the system and its capacity to accurately identify an agent at any given time in a population (Sims & Kasprzyk-Hordern, 2020). The design of Surveillance system should aim at maximizing the possibility of true early detection, should the agent be present, while curtailing the possibility of false-positive detection, in case the agent is not present. Hence, a basic concept in surveillance system design and function is that the system should be highly probability-driven. Critical probability elements in maximizing surveillance accuracy are incorporated in 2 main structural components of a system. One factor is the sampling architecture and design used to categorise which samples, animals, or herds should be tested at what times in order to capture the agent if it is present, and the other is the precision of the assay employed to detect the agent in the samples obtained (Ost et al., 2022).

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The dimension and scope of surveillance systems can change, based on targeted agents, populations, or risk groups. An agent in a single herd or flock may be targeted in Surveillance, or it may involve multiple assays or tests addressing several agents in many herds or locations globally, nationally or regionally. Systems can be embedded or nested within other systems in a hierarchical design, whereby one system might serve as an activator to activate initiation of a nested system (Ost et al., 2022). An example would be production surveillance systems that would trigger activation of infectious disease surveillance when production dropped to some threshold level, as might be envisioned for reduced egg production in layer flocks triggering testing for avian influenza or exotic Newcastle disease viruses. Covariate information, such as clinical stage of disease or age, obtained through collateral testing can enhance predictability and confidence of surveillance outcomes. Surveillance systems can operate within the population or be external to the population of interest. Pre-emptive, external or risk surveillance systems would be intended to protect a susceptible, native population by identifying, or ‘‘catching’’ the agent before it enters the population and by identifying changes in risk of the disease being transmitted from an external source to the population. At customs, pre-emptive surveillance, involve the confiscation and identification of meat products potentially concealing FMD and other FAD agents. Repeated, regular estimation of FMD entering the USA from different sources during some given time constitute risk surveillance for FMD. Before the agent is transmitted to other animals or herds, the internal, or post facto system is used to detect the agent after it has entered the population. An example of post facto surveillance is the current program that examines culled cows for evidence of bovine spongiform encephalopathy (Ost et al., 2022).

11.13 Smart People

The project success index (PSI) of smart people is 4.0988 and it has a coefficient value of 0.1240 on the evaluation model. This makes smart people the seventh on the hierarchy of smart city benchmarking suggesting the importance that is placed on citizens of smart cities and thus emphasising the factors involved at the societal, organizational, individual and cultural levels (Gil-Garcia, Vivanco, & Luna-Reyes, 2014).

There are thirteen critical success criteria under the smart people construct. They are Creativity amongst the people; imaginative people; level of skill of the people; versatility of the people; engaging in public life and decision-making; open mindedness of the people; participation in public life without discrimination; social innovation of the people; attraction of high human capacity into the system; competitiveness spirit of the city inhabitants; high employment rate for graduates; social and ethnic plurality in the community; and tolerance and engagement of the people.

11.13.1 Creativity amongst the people

There are a lot of myths surrounding creativity. Few of them are harmless, for instance, it does not matter whether you believe that creativity is located in the right brain (VYGOTSKY, 2004). Other views are that creativity requires exceptional talent and is limited to genius.

Creativity can be found in many disciplines and culture as a highly coveted quality of human cognition. It has become an established component of the 21st century and is rooted in human psychology, science, literature and the arts. The increasing interest in creativity has occurred during a time of significant societal change due to rapid shifts and developments in technology (Khilji and Roberts, 2015; Geels, 2005). Technology is affecting how people work, create, play, live, think and interact faster than now. It is no surprise, therefore, that this interest in digital technologies has emerged alongside creativity as vital to contemporary education.

A pivotal construct generally employed across disciplines in academic work, policy framework and practice is creativity. Temporarily, there are new focus between different understandings of creativity, as well as transdisciplinary and hybrid approaches to creativity, design and technology. What is less assured is how these new alignments and approaches relate to the uneasy space of classroom implementation.

Interest in creativity has been energised by the advantage provided by digital technologies, including, but not limited to, massive connectivity and the creation of virtual environments with new possibilities for learning. Digitalism has altered how we work, connect with one another and live. Arguably, technological change is motivated by human capacity, which in turn provide new contexts and tools for creative turnout. Researchers have suggested that educators and scholars must better comprehend and underscore this reciprocal connection (Chan & Lee, 2021).

11.13.2 Imaginative people

One of the hallmarks of imaginative people is their originality and inventiveness (Mumford et al., 1997). To be imaginative requires the willingness to try something new and different and to see things in different ways (Torrance, 1965). An imaginative person must have four qualities such as being highly motivated, having high level expertise, being able to take risks and having social skills (Bruggeman et al., 2021).

Studies have demonstrated that imaginative people are highly self-motivated and show some degree of self-satisfaction (Pan & Zhang, 2021). They usually feel that they can make a difference to the way things happen or they can make a difference on any issue. Imaginative people want to feel that they are contributing to the success of an assignments. Usually, they are passionate, fascinated by the challenge and feel that they are working on something that is vital. Though money is important, however, their primary motivation is not usually pecuniary, as their principal focus is making a difference by impacting their environment (Pan & Zhang, 2021).

For imaginative people to be creative in an organization setting, there is need for the acquisition of expertise. It is a challenge to be imaginative and creative without a critical body of knowledge related to the organization’s speciality. This expertise is often set against a wider understanding of other fields and this permit for the taking of an idea from one situation and extending it to another. Imaginative people are risk takers because they are ready and willing to try something different and to see things in different ways. Above all imaginative people are good listeners, sociable and broadminded. This is in consonance with the ability of imaginative people to draw upon idea from outside their core area of specialisation through their ease of building relationship and accessing essential information from this relationship to solve new challenges (Bruggeman et al., 2021).

11.13.3 Level of Skill of the People

People skill also known as soft skill, interpersonal or social skill are one of the most underappreciated areas of career success (Vanessa, 2022). It consists of three ability that a person must have, such as personal effectiveness, interaction ability and easy intercession. Personal effectiveness is the ability to make a memorable impression at first contact and exhibiting confidence in the presence of people they meet. Interaction ability is the ability to predict and decode other people's behaviour and showing empathy while easy intercession is the ability to lead, influence and build bridge between people within an organization or their locality.

There are about ten skills that people have that distinguishes and enables them to make progress professionally, create social cohesion and enhance their social status. These skills are social assertiveness, crafting a memorable presence, master communication, sustain lasting confidence, be highly likable, exceptional at decoding emotions, pitch your ideas, being charismatic, and being an influential leader (Vanessa, 2022).

11.13.4 Versatility of the People

A versatile person is a person with many different skills. The versatile person must exhibit competence, self-correction, resilience, vision and attentiveness (Nayak et al., 2019). Versatility can be enhanced by qualities such as astuteness, ethical, professional, clear communication, inquisitive and intent listeners, and excellent work ethics. The quality of education of the people and the mentorship received would increase the versatility of the people. The availability of social, financial and economic environment would help to bring out the versatility of the individuals in the community leading to the development of the smart city.

11.13.5 Engaging in Public Life and Decision-making

There is increased urgency by policy makers in government and businesses to seek the citizen's or people's input into crucial decision that affect public life not only because of the legislative mandate but also because of its benefits. The citizens or people involved in taking these decisions are called the stakeholders.

Engagement in public life involve participation in solving problems or making decisions that affect the public. It is also the accommodation of interested parties in the making of decisions of the public which contribute to the competence of the authority through the generation of better decision, provides better legitimacy to those decisions through greater accountability on the part of the authority, and constitute part of the proper conduct of an egalitarian society (Gao & Yu, 2020b).

Previously, decisions touching the public, particularly decisions with a meaningful technical component, have been made with input from nominated stakeholders only- largely those with public responsibility of the decisions and those with appropriate technical expertise in the applicable areas (experts and consultants). These groups, however, account for only a part of the entire stakeholder community for a particular issue. Often quantifiable data are not generated with participation from other type of stakeholder groups. However, as the public is composed of a broad spectrum of needs and desires, participation emanating from stakeholders are not easy to manage (Trischler et al., 2019).

11.13.6 Open mindedness of the people

In order to think critically, rationally, and be positive, an individual need to imbibe the culture of open-mindedness. It is a commonly used term for a person who is non-prejudiced or tolerant. Psychologically, the term is used to describe how willing people are to consider other views or try other novel experiences. Open-mindedness is an attribute of being receptive to a wide and diverse arguments, ideas, and information. Open-mindedness also involve being inquisitive and keenly searching for information that test the status quo. It also embraces the belief that other people should be uninhibited to express their beliefs and arguments, even if you do not necessarily agree with those opinion (Kendra, 2022).

Open-minded people have some qualities which include being able to accept the fact that others have a right to share their belief and thoughts; to hear what other members have to say; curious to hear what others have on their mind; hear what other member have to contribute; are humble about their knowledge and skill; receptive to the challenge to their thought; not feel angry when they are wrong; show empathy to other member of the group; and receptive to the views of other member of the group (Kendra, 2022).

Being open-minded challenges your existing beliefs and considering new ideas can give you fresh insight into the world and also teach you new things about yourself. It enables the open-minded person to try new things. The open-minded personality develops his personality and intellect though learning new things about the world and the human being around which, makes the open-minded person to become mentally strong, and more vibrant with the benefit of new knowledge and experiences. This further enhances his optimism as he learns new things in order to push the frontier of his capacity leading to more positive contribution to his community (Al-Abrrow et al., 2021).

11.13.7 Participation in Public Life without Discrimination

Guaranteeing that minorities have a say in the major decisions that touch their lives is important for the protection of their rights. Promoting the participation of indigenous peoples and minorities in public life therefore permeates all the work of Minority Rights Group (MRG) International. Progressively, policy-makers at both the international and national level are realizing its importance too, not least in the post-conflict reconstruction of multi-religious and multi-ethnic societies, including most lately, Iraq and Afghanistan (Ghai, 2001).

The price that a society pays can often be enormously high, in terms of conflict and ruined lives, economic cost, missed opportunities, where indigenous and minorities peoples are excluded from economic, social and political decisions that have major repercussions on their lives. Information about participation mechanism from consultation to power sharing and the legal standard that govern them had been requested from MRG for some years back. Besides the recognition of their right to a distinctive group identity, indigenous and minorities people are increasingly realising that they are entitled to participate in the economic, social, cultural, economic and political life of the country in which they live. Equality in the community is accepted by member of the majority community to promote equity, stability and peace. The United Nations Declaration on the Right of Minorities of 1992 (Caruso and Hofmann, 2015) and the Council of Europe's Framework Convention for the Protection of National Minorities (Rechel, 2008) which became effective in 1998 were some of the international standards that referred to the right of minorities participation in public affairs.

Every human being has an inalienable right to take part in the conduct of public affairs, directly or through freely chosen representatives; and vote and be elected at periodic elections, which guarantee the free expression of the will of the electors; and have access, on general terms of equality, for appointment to the public service and public office.

11.13.8 Social innovation of the people

Both the Grameen Bank and Muhammed Yunus who established the microcredit scheme were awarded the Nobel Peace Prize in 2006 for their efforts to create economic and social development from below (Sengupta and Aubuchon, 2008). This prize was a reward for a simple idea which became a global social innovation, i.e., the development of a microcredit which gives the less privilege access to banking serviced. Apart from this microcredit scheme, other social innovations are e-learning, neighbourhood nurseries and fair trade.

For at least two reasons, some authors think that every innovation can labelled as social innovation. First, one of the things that contribute to the improvement of people's life which may be goods and services is the discovery of new vaccine to combat the COVID-19 virus which benefit humanity in general. The second one is technological or business social innovations since they require the participation of different social actors and the transformation of social structures in order to be diffused and adopted. For instance, certain transformations occurring in an organization can be understood using social innovations. This suggest the instrumental perspective of social innovations which (Zahoor et al., 2022), defined as the reorganization of labour as a key factor of the innovative capacity of the firm without any regard for the well-being of workers. The promotion of technical innovation and the creation of knowledge is also referred to as social innovation.

Social innovation, according to (Pless *et al.*, 2021) is a new solution to a social problem that is very efficient, sustainable and effective, or just as existing solutions and for which value created accrues primarily to the society as a whole instead of an organization or a private individual. This definition suggest that an innovation is social in nature if it is new or novel but may not necessarily be original. However, they must be new to the user, their context, or application. The other quality is that it must offer improvement such that the solution it offers must be more effective, more efficient than the pre-existing alternative and also sustainable whereby it is environmentally as well as organizationally sustainable so that it can continue to work over a long time to come (Sharra and Nyssens, 2010).

11.13.9 Attraction of High Human Capacity into the System

Attracting high-capacity individuals is to create attractiveness through the overall instruments and strategies in management and development of human resources of organisations in order to create positive conditions in all aspect to attract those who have exceptional experience, skills in working in a niche of the business. Attracting high-capacity individuals is done in the form of internal attraction and external attraction through highly competitive, rigorous and scientific processes (Nguyen et al., 2021).

The manager has the responsibility of retaining high capacity individual. The cost of recruiting new people is far higher than the cost of retaining high-capacity individuals (Nguyen et al., 2021). Many organizations, however, still accept a high proportion of employees leaving their jobs, and content with spending little time training and creating opportunities for new employees to integrate.

The policy of attracting high human capacity entails the implementation of preferential policies and regimes, promoting corporate image, and create a friendly workplace worthy of the workers dream. Once this good mechanism had been put in place to meet the requirements of the workers, it will inevitably bring tremendous advantages to the business. Part of the benefit will be a competitive advantage to the business in the process of seeking high human capacity which enhances their capacity to the business to attract high human capacity at low cost (Mustafayeva et al., 2020).

11.13.10 Competitiveness Spirit of the City Inhabitants

The competitive spirit of the city inhabitants drives them to be better, deliver a higher level of performance and ultimately lift them to be the best of themselves on any given occasion. To be competitive is rarely being interpreted as a personality attribute that is adversely impacting our body and mind (Palapa, 2020). Being competitive assists us in pursuing our dreams and in becoming our true selves. We all wish to win, be it in sport, a job, a career or game. This is part of human nature as it gives us tremendous pleasure and satisfaction. Consciously or not, we craving to be champion or to continuously be the best is a very strong inner desire for every individual. The intensity of individual competitiveness is different. People that are emphatically competitive will not halt persisting until they reach their desired target, achieve their yearnings. In a bid to surpass the best rivals, competitors will always acknowledge the best from surrounding in which they are set. Competitive spirit is helpful in enhancing confidence, perseverance, and in getting to one's desired goal. Despite the virtues of competitive spirit of people to thrive to succeed despite all challenges and also to become better every day, it is also bad to allow it to get into one's head (GradesFixer, 2020).

When we triumph in some events, our brain activates and discharges testosterone and dopamine, which stimulate feelings of euphoria and pleasure, and control prize-inspiration behaviour. So, victory brings pleasure and a good feeling. Immediately we get the perception of victory, we always crave to win once more and feel good. Our competitiveness is emphasized by accomplishing everything by ourselves and showing it through our victory. Competitive spirited people are benchmarking themselves to others, generally with the image of the standards given to by the media, and there is a gigantic feeling of shame when they do not measure up to expectations. At the centre of this feeling of shame lies the conviction that others will be judging us as unsuitable and inferior because we have not attained specific standards of society. Women and men have an equally prominent competitive spirit. Therefore, the first and the most obvious disadvantage of being competitive is that competitive people do not know how to manage defeat. For instance, youngsters at young age begin experiencing competitive behaviour through videogames and sports. They commence playing seriously to triumph, no matter the antics they need to achieve it. If their competitive spirit is tough and they do not succeed in being first, they often start crying (Denton et al., 2021).If their competitive spirit is tough and they do not succeed in being first, they often start crying (Denton et al., 2021).

Equally, competitive spirit is profoundly expressed at more mature age such as adults and teens. The second place at some tournaments could even lead to a problem for a heavy competitor (Scully, 2021). Additionally, those people who cannot cope with defeat or not being the best tend to build aggression and frustration quickly. Being powerless to admit defeat, learn the lesson and be inspired for next challenge, accumulate aggression that could cause physical or emotional harm to others, ranging from physical assault to verbal abuse (Ustunel, 2022). People who are bad looser will often conveniently start damaging surrounding things, start blaming others, act immature or even engage in a fight with their competitors. Apart from the fact that aggression can increase the level of stress, aggressiveness can also lead an intense competitor to unleash attack on themselves or co-contestants. If the stress response is not properly managed, it may adversely affect the health of the individual leading to insomnia, headache and high blood pressure. Also, people with extreme levels of aggression and stress are at bigger risk of a heart stroke because of thickening of the neck arteries. In addition to resulting in bad health, being too competitive could also get one labelled as a conceited and self-absorbed. This may instigate difficulties in society, where people tend to avoid socialising with people with those personality traits (GradesFixer, 2020).

Furthermore, if our only ambition is to be better than others, we will quickly ostracize ourselves without anyone to support us. Moreover, competitors tend to ignore their value system with observing almost every setting as a challenge. This could occasionally be dangerous, as competitive people will compete purely for the sake of competition rather than appreciating what they do. Is it always essential to be better than others or should it be done because of the care and satisfaction? If the entire life is based on the spirit of competitiveness, whether being competitive in sports with friends, or at work, at a particular time someone else is going to be better and be victorious. It is imperative to balance competitive traits, accept the defeat and learn from it (Wardeh et al., 2021). Being a good looser and not to let the competitive nature to take over is a power that many people do not have. Optimistic outlook and reception of end results are more comforting than staying lonely in the constant conquest to be the finest (GradesFixer, 2020).

11.13.11 High Employment Rate for Graduates

The percentage of those among all college graduates who will attend graduates' schools, work or study abroad, who have already signed labour contracts, will start up their own businesses, and who have confirmed employer is called the initial employment rate. Whereas the labour economics definition of initial employment is different. It defines initial employment rate as a u-shaped scenario which commences at 59.8% in 2003, rising to 69.1% in 2005 and further to 71.1%, and then decline to 67.1% in 2009. Judging by the figure of 40.4%, 47.2% and 40.4% employment respectively in the years 2003, 2005, and 2007, it shows that the proportion of college graduates who have been engaged by employers when they graduate are generally below 50%. This data suggest the influence of the financial crisis on the college graduates (Xiaohao and Changjun, 2013).

The trend in the labour market suggests that student with higher degree tend to be more sort after by employers, suggesting the preference for graduate of higher degrees in the labour market. Overall, the change rate in the labour market appears to be reverse U-shaped. In the year 2009, there was a huge decline in the employment rate across the different strata of degree. A 15.2% drop in the employment rate of master's degree holders was the highest amongst all the graduates. However, for doctorate degree, higher vocational and junior college degrees, and bachelor's degree there are 12.12%, 4.0% and 2.4% rate of decline in their employment (Xiaohao and Changjun, 2013).

The Department of Education reports on graduates in the labour market noted that between 2007 and 2020, the employment rate has fluctuated slightly more for young population compared to the working age population. This suggest that the employment of young people is disproportionately influenced by changing structural conditions in the economy. The pay rate for graduates of ages between 21-64 held up when they found jobs to an average salary of £35,000, a salary which is £9,500 more than for people without university degree (Rachel and Richard, 2021).

People with high degree have fared better than graduates during the COVID-19 pandemic, with a 1.8%-point gap in total employment rates opening up compared with graduates. People with specialised skills employment rate were also 12.4% points higher for postgraduates than graduates, while median earning remained higher than those with just a first degree at £42,000, the same level as in 2019 (Rachel and Richard, 2021).

11.13.12 Social and Ethnic Plurality in the Community

A big global challenge is the issue of immigration and growing diversity (Wickes et al., 2014). Immigration, be it illegal or legal needs to be controlled (Griffiths and Yeo, 2021). This is reinforced by two mutually reinforcing argument: that increased diversity leads to conflicting identities and value which reduce social trust; and that immigration puts a strain on limited material and economic resources. Nevertheless, the fear with the costs of increased diversity is not narrow to political sphere, there is a claim that ethnic diversity has a deleterious effect on social capital in the short run (Méreiné-Berki, Málovics and Creţan, 2021).

There has been suggestions like the constrict theory of Putnam which indicate that ethnic diversity reduces trust, the development of network, and social cohesion in the contemporary neighbourhood (Wickes, Hipp and Laughland-Booÿ, 2021). The substantive argument here is that ethnic diversity reduces both in-group and outgroup solidarity and encourages hunkering or social withdrawal. Putnam provided robust evidence to support his thesis using cases from the United States, where he observed that individuals living in heterogeneous community report low level of both inter-racial and intra-racial trust when compared to those living in more homogeneous communities. Also, he noted that people in heterogeneous areas trust less, and many indicators of social capital are constricted in ethnically diverse communities. For instance, in community with high diversity, people have little confidence in the governing authority, have fewer friends, spend less time engaged in charity or voluntary work and avoid voting (Wickes, Hipp and Laughland-Booÿ, 2021).

While the relationship between ethnic diversity and social capital is not a straightforward affair some research in the United Kingdom and North America still provide some backing for the Putnam constrict thesis. However, there are limited agreement in literature that ethnic diversity is the most influential mechanism predicting lower social capital. The contradictory finding in the body of work can be explained by three reasons. The first is the contention by scholar that Putnam thesis are majorly explained by disadvantage. Even though there is evidence that individuals may report lower trust and hold negative feelings towards neighbour in diverse communities, a lot of studies in the Netherland and the U.K. find this relationship is a result of ethnic minority living in socially backward neighbourhoods(McNamee, Mendolia and Yerokhin, 2021).Secondly, research show that ethnic diversity may have differential impact on the behavioural and cognitive element of social capital. For instance, it was found that White majorities in the United States and Canada report lower interpersonal trust when they reside in ethnically diverse communities, suggesting that diversity has only a restricted impact on their neighbourly exchange. And finally, the lack of agreement discovered in literature may be owing to the differential effects of ethnic concentration and ethnic diversity on social capital. As some research focused on ethnic concentration (Pham and Mukhopadhaya, 2022; Powers, Matthews and Mowen, 2021), Wickes, Hipp and Laughland-Booÿ, (2021), argued that ethnic diversity is more consequential for social cohesion and trust. Social and ethnic plurality is a source of new ideas, innovation, progress and development in the community where it is domicile. It is one of the best ways of attracting foreign direct investments and creativity into the economy and facilitating human capital development.

11.13.13 Tolerance and Engagement of the People

Whereas training and education support prosperity and well-being through higher employment, income and wealth, research from around the globe has also discovered that education is a powerful forecaster of civic participation or engagement (Rahayu and Harmadi, 2016) and is associated with higher level of social capital (Sharma, Borah and Moses, 2021). The skills and knowledge of individual can be broadened and developed through education and training so that they can also have the requisite self-confidence. The ability to appraise and question information effectively, interact with others, seeing things from broader perspective, and communicate ideas can be more effectively done through adequate training and education. These capabilities can be expected to have firm root in the community yield the requisite benefits to the people. Hence, participation in the community activity is more likely to be carried out by the educated people in the community and this can build trust and tolerance of other people and public institutions.

Participation in political group, social or community activities is the closest measure of civic engagement. Educational attainment is positively associated with all for of civic engagement (Encina and Berger, 2021). People with higher levels of education attainment compared with those with lower levels can be two or three times more likely to be involved in political group, community or social activities. These trends hold after controlling for a wide range of confounding variables such as place of birth, where people live, employment, gender, and age. Also, positively but weakly associated with more people reporting a 'feeling of having a say on important issues within the general community' either all the time or most of the time is the higher level of educational attainment.

11.14 Smart Economy

The smart economy construct has a project success index (PSI) of 4.0817 and a coefficient of 0.1235 in the evaluation model. It has the lowest rank amongst all the construct of smart city. It is made up of seven critical success criteria which includes the following in order of their mean ranking: "open and transparent economic activities"; "flexibility of the labour market"; "ability to transform ideas into valuable process, products and services"; "competitive skill of the people"; "ease of digital business licensing and permission"; "people with innovative spirit"; "and economic make-up of the people".

11.14.1 Open and Transparent Economic Activities

The term transparency is usually implied to mean both normative and substantive connotations (Gardner et al., 2019). Normatively, transparency is usually used to serve the principle of accountability, democracy and participation. This implies that transparency is seen by some as having the potential to assist to overturn the asymmetries in how diverse stakeholders access information. Hence, transparency is usually interpreted as inherently positive, and of core value for efforts to create a more egalitarian environmental politics and promote bottom-up civil society action (Skrimizea et al., 2021). In the substantive sense, transparency is naturally viewed as encompassing a set of concrete criteria that are essential to improve standard and sustainability practice, including those related to monitoring, verification, complaint, marketing, mandatory and voluntary disclosure, surveillance, dissemination and reporting (Gardner et al., 2019).

The use of public resources and monitoring the quality of government services can be easily done by the citizens if they have access to government information. Since the social services provided by the government cannot be provided by any other organisation, it is essential for information about these services to be made readily available so that the citizens can demand more accountability from public servants. There have been plethora of studies attesting to how the quality of services provided by the government, such as education, public health and sanitation, can be improved through the availability of information about these service to the stakeholder. For instance, the monthly transfer of school grants in the local government in Uganda was published in the newspaper and this reduced the share of the grant lost through corruption from 80% to 20% as parent are able to monitor how local officials managed the grants (Harnois and Gagnon, 2022; Reinikka and Svensson, 2005). With transparency and more information, people can better assess different options and manage risks more effectively (Gardner et al., 2019).

The department of some government that are in charge of business regulations have not thoroughly understood the role of transparency in business regulations. This gap needs to fill as there is overwhelming evidence to suggest that badly implemented business regulations affect business registration and drastically reduce productivity. This is buttressed by the lower entry rate of new businesses and the operation of some businesses in the informal sector with draconian operating conditions (Geginat and Saltane, 2016).

The quality of services and accountability in business regulation has a lot of room for improvement going by the study done by the World Bank Enterprise Surveys (Mthimkhulu and Aziakpono, 2015). The senior manager in the companies surveyed spent 11% of their time battling with government policies. Over 50% of these senior managers do not agree with the fact that regulations are implemented predictably and consistently. This is made more disturbing as these firms had to pay bribe to government officials in order to get things done. The situation is further compounded by the fact that 19% of firms surveyed confirmed their payment of bribe in order to connect to the national grid or get an operating license (Mthimkhulu and Aziakpono, 2015).

To elucidate on the value of transparency in improving the quality of business regulation we present and examine a unique new dataset that captures the information practices of public agencies in charge of business regulation. The outcome was that transparency can be achieved in the city by the government making information available through brochures, billboards and online, such that total contact with government officials are non-existence in the process of business registration, building permit and electricity connections (Geginat and Saltane, 2016).

11.14.2 Flexibility of the Labour Market

Flexibility of the labour market is one of the needs of a modern knowledge-based economy. Information and communication technology and dynamic technological progress development can affect the labour market and contribute to the reduction of inequalities in different labour-oriented activities like career prospect and other work-related circumstances such as wages, income and working conditions (Liotti, 2020). The core element of labour market effectiveness is the challenge of balancing the flexibility of employers with the protection of the worker interest. Of particular importance in the context of the COVID-19 and its effect on the workforce is the concern for labour market flexibility. The usage of kits to permit for an ex-post benchmarking of flexibility across countries and, at some point, the examination of the efficacy of public policies to assist in best practices through markets will be necessary in building sustainable industrial relations in a post-pandemic era. Several studies have emphasized the importance of flexibility of a smooth labour functioning market. The importance of flexibility of the labour market is further emphasized by strategies statement by different countries, documents of the European Union and the International Labour Organization. Several international bodies are making efforts to study how labour markets, most especially businesses, adapt to external factors like the COVID-19 and reforms to assess the worth of the labour market flexibility process (Pavolini, 2022). An important aspect of the economic pillar when considering the United Nations Sustainability Development

Goals (SDGs) 2030 is the labour market flexibility (Montiel et al., 2021). Better functioning labour market and maximum benefits can accrue to stakeholders through labour flexibility. Essentially, flexibility that focus on increasing employment opportunity for the underprivileged like the physically challenged, can create a significant impact on the labour market and, in turn, limit the occurrence of economic sabotage and inequality (Galik et al., 2022).

Overall, the ability of the labour market to adapt to changing economic conditions is called flexibility of the labour market. Different economic theories, like Keynesian theory of natural rate of unemployment proposed by (Friedman, 1968), have lay credence to the value of a flexible labour market. There are both microeconomic and macroeconomic dimensions of labour market flexibility. Flexibility is the common feature of both macro and microeconomic dimensions, and it is defined through deregulation. The limiting state intervention and increasing the freedom of entrepreneurs in employees' policies has made deregulation of the labour market more flexible. There three main components that form the concept of labour market flexibility. They are labour supply, labour demand and labour price. The meaning of flexibility of labour is the flexibility of employment; while labour supply flexibility means labour market mobility and labour price flexibility is meant to refer to wage flexibility. The flexibility of the labour market is determined by institutional factors like industrial relations processes. Flexibility of the labour market can also be done using offensive or defensive approaches (Friedman, 1968). The defensive approach consist of excessively regulating the labour market so that it postulate deregulation while the offensive approach emphasise the need to equip the workforce with new skill and training in order to enhance the adaptability to changes.

A new dimensional trait of labour market flexibility was discovered in the 2020 under the COVID-19 pandemic. The preliminary assessment released by the ILO on the effect of COVID-19 on the labour market suggest the growth in unemployment from 5.3 million down to 24.7 million in severe situations, the decline in labour income and extreme increase in poor working conditions (I L O, 2020)(I L O, 2020). Through the pandemic period, superior labour market flexibility could have encouraged more inclusive labour force participation provided that structural changes including work security measures were carried out in parallel. In the report published in 2020, the European Foundation for the Improvement of Living and Working Conditions has recognised challenges and policy approached to find the right balance between flexibility and security in the labour market (Eurofound, 2020). Therefore, the ‘flexicurity’ (i.e., flexibility + security) idea is closely reflected. It is a multidimensional and complex phenomenon and is yet to be soundly and well-developed as an indicator-monitoring-based framework (Galik et al., 2022). It seems to be more political, at the moment, as noted in a number of EU policy documents like the EU Agenda of 2019-2024, rather than a socioeconomic real model (Galik et al., 2022).

11.14.3 Ability to Transform Ideas into Valuable Process, Products and Services

The process of innovation is tortuous and has the power to propel the owner of the idea into the business world and open new vista. The initial move in turning your idea into a product is sharing it with the world. For instance, when the idea of electricity was first mooted, many leading scientists denounced it as a fairy tale that could not be harnessed on a commercial scale. With an understanding of what it takes to invent new things and the right mind-set, an individual could be the creator of a new invention. However, success in the area of innovation is all about effective timing. A delay could mean that someone else with similar idea may capture the opportunity. Similarly, if the innovation is ahead of its time when the people are not ready for it, the innovator might have a herculean task to contend with, in order to make the innovation acceptable (Kuligowski, 2022).

This was the kind of challenge faced by Henry Helgeson, the co-founder of Cayan (now part of TSYS), when he developed the mobile payment platform technology in 2011, many years before the payment platform gained currency. Many of his contemporaries believed that mobile payment cannot be possible, however, with doggedness from Helgeson and his team, the mission was accomplished (Kuligowski, 2022).

For an innovation to see the light of the day, the innovator should seek assistance so that he can be assured that some parts of the process are in capable and experienced hands. Also, there is need to look for a good business partner who believed in the idea of the product and have complementary skill to take the idea forward. In addition, for a novel invention to succeed there should be a thorough investigation, particularly about existing copyright of existing product, process and services (Turnhout et al., 2020).

11.14.4 Competitive Skill of the People

Competitive skills are skills that keep you ahead of your present and potential competitors. People usually gain competitive skills by evaluating the strengths and weaknesses of their competitors and ensuring that they increase their own performance to obtain an advantage. Acquiring a competitive skill can set an individual apart from their peers during a job search or position him for a rapid career progression and increase emolument. Much as competitive skill is desirable, it is not achieved through hard work alone, rather, an individual must strategically keep himself above his peers by adding value to the company, develop new skills, communicate effectively, exceed expectations, maintain your skills, invest in yourself, belonging to a professional body, and sharpen your leadership skills (Indeed Editorial Team, 2020).

11.14.5 Ease of Digital Business Licensing and Permission

Progress of digital technologies has produced great innovative opportunities. This effect is seen across a number of industries, which are being redesigned by digital technologies. In order to compete in the ever-changing business environment, continuous digital innovation is the right approach for organizations. Digital innovation is defined as “the process of merging physical and digital components to produce new devices, services or business models, bundling them to constitute and enable market offerings, and embedding them in broader sociotechnical environments to permit their diffusion, function and use” (Wang, 2021).

For those in the digital business content, the exploitation of copyright protected works by mean of digital media presents both great risks and immense opportunities. There are chances for greatly increased customer bases and huge revenue streams when product are distributed digitally to the global market. The ease and accuracy with which digital content are produced brings down the manufacturing and distribution costs, which eventually lead to higher profit margin for the licensors and the licensees of digital content (Linde et al., 2020).

One of the backbones of digital content marketing is a license. It is the legal route through which the content creator can leverage the net worth of their assets and the content-hungry digital platforms and networks can obtain the essential content to drive traffic, market consumption and revenue (Boothroyd, 2007).

The issue of licensing is not a new development in the legal circle, but it is not very common, and people are not very conscious of its usefulness. The established legal framework does not easily accommodate digital licensing, despite attempt like the introduction of Directive on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society (EC/2001/29) (Chapter and Provision, 2001) and the imminent Audio-Visual Media Service Directive, and there are myriad of issues in harmonising in the commercial possibilities presented by swift expanding technology with well-known legal definitions and structures (Boothroyd, 2007).

11.14.6 People with Innovative Spirit

One word that has been used in all related fields and also become synonymous with creation and reform and is frequently used in the academics and the media, is innovation (Johnson et al., 2022). As innovation makes a smart city full of vitality, many smart cities in the world pay attention to innovation. Countries like Chine have placed tremendous emphasis on innovation, making it the propelling force for development and the strategic support for the development and building of modern socio-economic system. The Chinese aim to be the leader in cutting-edge research, science and technology so as to become leader in patenting new ideas. The lack of strong innovative spirit can be a drawback for a smart city as it rejuvenate the smart city through science and education.

Literally, innovation means setting up or creating new things which consists of innovative spirit, knowledge base and innovative thinking. Innovative spirit which, is the internal propelling force that runs through people's innovative activities and core of innovation, is a non-intelligence factor that determine scientific innovation as much as the intelligence and knowledge factors. In China, an important base for cultivating people's innovative spirit is through the strategy of rejuvenating China through science and education and this has made the construction of the science and technology museum a vital infrastructure. Hence, the Chinese attached great importance to the functional display and the educational importance of science and technology in their development (Xi, Liu and Hang, 2018).

The foundation of any country's development is innovation. The innovative spirit is the propelling force of people's innovative activities, and it is also the backbone of innovation. The people with innovative spirit should exhibit some qualities like being curious, practical spirit, passionate about his feelings, have an inquisitive spirit and be undaunted by failure (Xi, Liu and Hang, 2018).

11.14.7 Economic make-up of the people

The economic make-up of a smart city is an element of goods and services and how they are produced, distributed and consumed by the consumer. The disparity in earning between men and women is expected to be insignificant. The wages of the individual living in the smart city should be enough to cater for their living standard. The poverty level should be such that the basic necessities of live should be affordable by the residence of the smart city. Each family should be able to provide adequate housing, feeding and education for their children (Tonkin, 2019).

The human capital is the measure of the intrinsic value of people in a country and it is part of the economic make-up of the people. It is important when we are considering public policy. The human capital at a higher level have not only been linked with better and higher wages for the citizens, but also to good health, reduced crime rates and increased trust and community participation. The human capital has an important impact on the economy and when we are taking a global view of our community. For instance, the value of human capital in the UK for the year 2018 is a hooping £21.4 trillion, a figure that is about ten time the value of the gross domestic product for the UK (Tonkin, 2019).

Changes in economic growth can be easily assessed by measuring the human capital, while also helping us to see the gap in productivity in the economy. Vital information for developing wider policies on health, childcare and education can be obtained by looking at the trend of human capital over a specified period, and also assist employers in understanding their staff requirement and training (Tonkin, 2019; Hanushek, 2013).

Based on the projected worth of all potential of future earnings that individuals in the working age population may expect in their employed life, we now measure human capital in monetary terms (Arrow et al., 2012). In essence, we look at how much people earn and the skills they have in estimating how much longer they will continue to work. Hence, the value of human capital is usually higher in younger staff, as they have more years to spend in the labour market.

11.15 Validity and Reliability

For both qualitative and quantitative data, the process of validating and ensuring credibility and reliability differs (Patterson, Whelan and Worth, 2021). Trustworthiness features, in qualitative research, are generally used to address what quantitative studies would look at as credibility issues (Zarei, Khan and Abbassi, 2021). Regardless of the terminologies, which might include dependability, credibility, confirmability, validity and reliability among others, biases that could damage the design, implementation and analysis of data must be avoided by the researchers. From the perspective of readers, researchers and participants, the credibility of a research is an important phenomenon (Prosek and Gibson, 2021). According to (Morse et al., 2002), the issues dealt with in the credibility of a study is methodological and interpretive validity. How good the adopted research procedural approach is proper for the problem under assessment as well as the nature of explanation the researcher seeks to disseminate is describe in methodological validity. To critically evaluate the different components of the research design and the method used is one of the means of addressing methodological validity (Bolinger et al., 2022; Ming and Goldenberg, 2021).

For decreasing errors that could be due to measurement problems, reliability and validity of the research instrument are need in a quantitative study. In a quantitative research, validity, therefore, refers to precision and accuracy of both the research instrument and measurement procedure (Weakley et al., 2021). In the current study, stability of the research instrument pertaining to its face and content validity was ascertained through pilot study, which was executed with ten participants prior to the actual collection of data. To assess whether respondents' answers to closely related question would be consistent, the internal construct validity is required (Li, Shamsuddin and Braga, 2021; Lu and Chen, 2021). By evaluating the agreement between the measures and theoretical entity, the validity is benchmarked. Also, from the result of the pilot study, internal construct validity of the measurement taken on the Likert scale was assessed.

Once the data is collected, reliability of the whole data and the scale was enhanced through preliminary analysis such as multicollinearity screening, value analysis, detection of unengaged responses, and the reliability analysis. The overall reliability of the data and findings of the study was enhanced by the deletion of factors that were negatively affecting the reliability of the scale.

Chapter 12: CONCLUSION AND RECOMMENDATIONS

12 Chapter Overview

This chapter terminates this study by providing a synopsis of the entire study and the findings of the data collection and analysis. This is followed by a holistic summary of the study, including the goal, research design, data collection and data analytical procedures adopted in the study. This is subsequently followed by key findings of the study as earlier noted. Implications of the study for theory and practice, as well as its limitations are presented before the direction of future research is enunciated.

12.1 Summary of the study

The United Nation has projected that 66% of the world's population will live in cities by 2050 (United Nations, 2015), raising concern about world's environment, economy and social sustainability (OECD, 2012). This challenge is complemented by the rapid progress in the field of information and communication technology (ICT) which has made the prevalence of internet of things (IoT) and other embedded devices ubiquitous, making it easy to deploy ICT in the management of cities and facilitating human lives, hence the development of smart cities where ICT coupled with the deployment of innovation in human capital has produced a quantum improvement in the administration of cities. This has also led to the proliferation of smart city and these smart cities need to be benchmarked to understand how smart they are and their level of smartness.

In order to achieve the aim of the study, different methods of data collection and analysis were used in the study. The study adopted a mixed method of both qualitative and quantitative approaches following the tenets of critical realism philosophy. Interviews were conducted with twenty-five experts and stakeholders to elicit the indicator of smartness in a city. After combining the factors from literature and the interview, 22 distinct factors were proposed for smart environment, 12 for smart economy and 21, 17, 16, 14, 11, 11 respectively for smart mobility, smart people, smart living, smart governance, smart infrastructure and smart services.

The factors identified were used to develop a questionnaire, which was pilot tested before being administered to stakeholders and professionals in the Planning Authority. Through this questionnaire administration to two hundred participants, only one hundred and fifty-six questionnaires were returned out of which seven were knocked out because of insufficient data and the remaining one hundred and forty-nine responses used for the data analysis. The fuzzy synthetic evaluation was carried out on the factors of each dimension of the smart city, and in selecting the critical variables, only variables with normalized value equal to or greater than 0.5 were considered. This helped to identify the critical variable for each of the dimensions of smart city.

12.2 Key Findings of the Study

In line with the aim and objectives the study was design to achieve, the findings are discussed. The first objective is to examine the concept and dimensions of smart cities and the second objective is a comprehensive list of smart city indicators relevant for measuring the smartness of a city which were derived from literature review and interview with experts and professionals in the construction and Planning Authorities. The third objective was the concept of benchmarking within the smart city benchmarking, while the fourth objective is the development of a benchmarking framework for evaluating the smartness of cities and the last objective was the testing of the benchmarking model on Bristol and Milton Keynes.

12.2.1 Indicator for smart city benchmarking

After a comprehensive literature review which was validated by interviews with stakeholders and professionals in the field of smart city operation, the comprehensive list of smart city benchmarking indicators were produced which were then further tested in a sampling survey with the questionnaire instrument. The outcome of this survey produced respectively for smart infrastructure, smart economy, smart people, smart mobility, smart living, smart governance, smart environment and smart services a value of 4.124, 4.038, 4.034, 4.087, 4.086, 4.078, 4.060 and 4.050.

12.2.2 Critical success criteria for benchmarking smart city

The use of the fuzzy synthetic evaluation model enables the evolution of the critical success criteria for the benchmarking of smart city. These success criteria were produced after normalizing with a factor equal to or greater than 0.5 which produced critical success criteria (CSC) of five for smart infrastructure and these are: Power generating systems; Availability of Utilities services; Availability of IoT and embedded devices; Availability of Cloud computing and Wi-Fi Services; Enabling environment for human capital development, competition and innovation. The CSC for smart economy are: Open and transparent economic activities; Flexibility of the labour market; Ability to transform ideas into valuable process, products and services; Competitive skill of the people; Ease of Digital business licensing and permission; People with Innovative Spirit; And Economic make-up of the people. The CSC for smart people are: ‘ creativity amongst the people’, ‘imaginative people’, ‘level of skill of the people’, ‘versatility of the people’, ‘engaging in public life and decision-making’, ‘open mindedness of the people’, ‘participation in public life without discrimination’, ‘social innovation of the people’, ‘attraction of high human capacity into the system’, ‘competitiveness spirit of the city inhabitants’, ‘high employment rate for graduates’, ‘social and ethnic plurality in the community’, and ‘tolerance and engagement of the people’. The CSC for smart mobility are: ‘(inter-)national accessibility of the transport services’, ‘availability of digital transit payments’, ‘use of smartphone for facilitating mobility demand and ticketing’, ‘existence of autonomous vehicles in city transport architecture’, ‘good urban planning’, ‘use of ICT in transportation logistics’, ‘availability of car-sharing, ride sharing, new biking systems’, and ‘availability of pedestrian and bicycle path’. The CSC for smart living are: ‘enrolment of young people in general education and vocational training’, ‘promoting social cohesion amongst the people’, ‘individual safety in the community’, ‘availability of world-class education’, improved security for women, children and the vulnerable', 'availability of world-class health facility to the people', 'telemedicine availability to the citizens', 'high level of employment', 'remote patient monitoring for the vulnerable', and 'high quality housing availability'. The CSC for smart governance are: 'transparency in governance activities', 'transparency in decision making process', 'availability of public and social services for the citizens', 'availability of E-government for transaction with government', 'participation of the citizens in government's decision-making', 'availability of e-services for public engagement', and 'clarity of the environmental protection policy'. The CSC for smart environment are: 'minimising of health hazards arising from exposure to harmful materials (e.g., by pollution, accidents, noxious substances in food)', 'efficient waste management systems', 'leveraging smart meter for energy conservation in the city', 'collaboration between government and people to monitor and manage environmental policies', 'reliability of energy supply system to the citizens', 'minimisation of exposure to health hazards', 'remote health monitoring and intervention', 'preservation of the unique natural resources, ecological system, and biodiversity', 'ensuring a cohesive healthy community', 'improvement in air quality, water, forest and soil conditions', 'ensuring environmental aesthetics for the city', 'intelligence distribution networks', 'create a recreational opportunity for the people', 'clean sources and distribution networks for water supply', 'provision of abundant public open space with smart resource management', 'reduction of pollutant emission in the environment', and 'good air quality in the environment'. And finally, the CSC for smart services are; 'availability of waste recycling for resource reuse', and 'real-time crime mapping to monitor criminal activities'.

12.3 Implications of the study for Practice

The concept of smart city has become increasingly important over the past decade, as cities around the world seek to improve their performance and create more vibrant, diverse, and sustainable urban environments. The challenge of creating a truly smart city is complex, requiring cities to evaluate and measure their performance in a variety of areas, from environment, services, economy, governance, infrastructure and mobility to sustainability and liveability. Benchmarking city smartness is a critical part of this process, providing cities with the information they need to assess their performance and identify areas for improvement.

The physical dimension of the framework evaluates a city's infrastructure, mobility, environment, economy, services, living conditions, the people and governance. The framework is designed to provide an objective assessment of city smartness. By using data from a range of sources, like stakeholders and experts and professionals in Planning Authorities, the framework can provide an accurate and comprehensive evaluation of a city's performance. The framework is also flexible, allowing cities to customize the evaluation criteria to meet their specific needs.

The framework will also provide a useful tool for researchers and policy makers. By understanding the performance of cities in different dimensions, it can help to identify areas that need improvement and also suggest areas in which cities can be improved. Moreover, the framework will also be used to inform the development of new policies and programs. By understanding the cities strengths and weaknesses, policy makers can tailor their policies to the specific needs of the city and ensure that they are appropriate. The framework will also be used by private investors and businesses. By understanding the performance of cities in different dimensions, it can help to identify cities that are likely to be attractive for investment and businesses. This can be especially useful for businesses looking to expand into new markets, as it can help to identify cities that are likely to be profitable and attractive for businesses. The framework will also help the administrator of local government to understand the needs of their city and make better decisions.

In conclusion, the study will provide a useful tool for researchers, policy makers, private investors, businesses, and citizens. By understanding the performance of cities in different dimensions, it will help to identify areas that need improvement, inform the development of new policies and programs, and identify cities that are attractive for investment and businesses. Ultimately, this framework will help cities to become more competitive, attractive, and sustainable.

12.4 Implications of the study on Theory

The concept of "smart cities" has gained traction in recent years as cities around the world strive to become more efficient and livable. As cities become increasingly complex, the need for a comprehensive and robust framework to evaluate their "smartness" has become ever more pertinent. The goal of this study is to develop a comprehensive and robust multidimensional evaluative framework for benchmarking city smartness and provide a preliminary outline of such a framework.

The notion of "smartness" for cities is difficult to define, as it is highly context specific and includes aspects such as technological advancement, economic efficiency, sustainability, livability, and governance. To assess the "smartness" of a city, there is a need to evaluate multiple dimensions of "smartness" and account for the differences in the context in which a city exists. The framework is comprehensive and robust to evaluate city smartness using a range of dimensions like economy, infrastructure, people, living, environment, mobility, services, and governance. It is flexible as it can be adapted to any context and city of any size. Additionally, the framework has also considered the larger context in which the city exists, including the national and global environment. This will ensure that the framework is able to capture the challenges that cities face in terms of their economic and social wellbeing, technological advancement, sustainability, livability, and governance in a comprehensive and robust manner.

In conclusion, this comprehensive and robust multidimensional evaluative framework is essential for benchmarking city smartness and assessing the smartness of a city. The framework had considered a wide range of criteria, including economic and social indicators, technological advancement, sustainability, livability, and governance, and is flexible and context-sensitive. It has also accounted for the larger context in which the city exists and ensure that the criteria used for assessing its "smartness" are applicable to a wide range of cities.

12.5Limitation of the study

The study titled "Benchmarking City Smartness: Towards Developing a Robust Multidimensional Evaluative Framework" has several limitations. First, the definition of 'smartness' is not clearly established in the study. The authors provide a descriptive explanation of what they consider to be a smart city, but there is a lack of consensus in the literature on this concept. Without an agreed-upon definition of 'smartness', it is difficult to develop a reliable evaluation framework. Additionally, the study is limited in its scope, as the research is focused on benchmarking cities in the United Kingdom alone. Therefore, the results and conclusions of the study may not be applicable in other countries and regions. Furthermore, the study fails to account for the unique economic and political contexts of different cities, which can influence the development of smart cities.

Also, the study does not take into account the potential for changes in the cities' smartness over time. This is important as cities are constantly evolving, and the factors that contribute to their smartness may change. Therefore, it is important to consider the potential for change over time in order to gain an accurate evaluation of a city's smartness. Additionally, the study does not consider the potential for bias in the evaluation process. It is important to consider the potential for personal biases, such as gender or cultural biases, which may influence the evaluation process and its results.

In conclusion, the study "Benchmarking City Smartness: Towards Developing a Robust Multidimensional Evaluative Framework" is limited by an unclear definition of 'smartness', a narrow scope of research, and a lack of consideration of contextual factors. These limitations should be addressed in future research on smart cities.

12.6 Direction for future research

The study has opened the door to numerous possibilities for further research. Cities are constantly evolving and the concept of smartness needs to be adopted and adapted to the changing environment. Cities have complex and diverse needs and there is still much to be explored in terms of the various dimensions of smartness. Hence, future research should focus on further developing a multidimensional framework that is able to evaluate the smartness of cities. This may involve identifying and analyzing more dimensions of smartness and developing more comprehensive methods of evaluation. It is important to keep in mind that smartness is a complex concept and involves the integration of multiple factors. Therefore, it is important to understand how different aspects of smartness are interrelated and how they mutually influence each other.

Also, future research should further focus on the application of the multidimensional evaluative framework. Specifically, the framework should be applied to a range of cities of different sizes and at different stages of smart city development. Future research should focus on the development of more sophisticated methods for the collection and analysis of data like the use of artificial intelligence and machine learning to collect and analyze data, as well as the use of big data. In addition to further exploring the concept of smartness, it would be beneficial to look into ways in which cities can actively work towards becoming smarter.

Finally, it is important to recognize that cities are made up of different stakeholders, including citizens, businesses, and the government. Therefore, it is essential to consider the perspectives of all stakeholders when considering the smartness of a city. This could involve looking into the way in which citizens, businesses, and governments interact with each other and how this impacts the overall smartness of a city.

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13 APPENDICES

13.1 Tables Correlation Matrices, Summary of Item Statistics

Inter-Item Correlation Matrix of Smart Infrastructure

	SI1	SI2	SI3	SI4	SI5	SI6	SI7	SI8	SI9	SI10	SI11
SI1	1.000	.243	.164	.160	.154	.147	.251	.092	.014	.149	.121
SI2	.243	1.000	.135	.162	.254	.331	.119	.003	-.037	.127	.116
SI3	.164	.135	1.000	.219	.136	.176	.064	.049	.074	.157	.224
SI4	.160	.162	.219	1.000	.105	.086	.131	.162	.015	.186	.117
SI5	.154	.254	.136	.105	1.000	.163	.099	.068	.073	.162	.092
SI6	.147	.331	.176	.086	.163	1.000	.252	.032	.101	.247	.212
SI7	.251	.119	.064	.131	.099	.252	1.000	.300	.120	.011	.127
SI8	.092	.003	.049	.162	.068	.032	.300	1.000	.262	.114	.101
SI9	.014	-.037	.074	.015	.073	.101	.120	.262	1.000	.287	.080
SI10	.149	.127	.157	.186	.162	.247	.011	.114	.287	1.000	.176
SI11	.121	.116	.224	.117	.092	.212	.127	.101	.080	.176	1.000

Inter-Item Covariance Matrix of Smart Infrastructure

	SI1	SI2	SI3	SI4	SI5	SI6	SI7	SI8	SI9	SI10	SI11
SI1	.791	.174	.120	.112	.115	.117	.187	.070	.010	.116	.091
SI2	.174	.644	.089	.102	.172	.237	.080	.002	-.024	.089	.079
SI3	.120	.089	.671	.142	.094	.128	.044	.035	.049	.112	.156
SI4	.112	.102	.142	.621	.070	.061	.086	.109	.009	.128	.078
SI5	.115	.172	.094	.070	.713	.123	.070	.049	.049	.119	.066
SI6	.117	.237	.128	.061	.123	.794	.188	.024	.072	.192	.161
SI7	.187	.080	.044	.086	.070	.188	.704	.216	.081	.008	.090
SI8	.070	.002	.035	.109	.049	.024	.216	.734	.181	.085	.074
SI9	.010	-.024	.049	.009	.049	.072	.081	.181	.648	.201	.055
SI10	.116	.089	.112	.128	.119	.192	.008	.085	.201	.762	.130
SI11	.091	.079	.156	.078	.066	.161	.090	.074	.055	.130	.721

Summary Item Statistics of Smart Infrastructure

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.124	4.054	4.201	.148	1.036	.002	11
Item Variances	.709	.621	.794	.173	1.278	.003	11
Inter-Item Correlations	.140	-.037	.331	.368	-8.976	.006	11

Inter-Item Correlation Matrix of Smart Economy

	SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8	SE9	SE10	SE11	SE12
SE1	1.000	-.076	.096	.116	.259	.186	.200	.124	.181	.037	.222	.222
SE2	-.076	1.000	.044	.149	-.017	.216	.075	.100	.122	.083	.108	-.026
SE3	.096	.044	1.000	.162	.179	.135	.183	.050	.112	.055	-.068	.068
SE4	.116	.149	.162	1.000	.028	.063	.104	.046	-.059	.107	.176	-.042
SE5	.259	-.017	.179	.028	1.000	.213	-.091	.174	-.037	.007	.072	.194
SE6	.186	.216	.135	.063	.213	1.000	-.001	.162	.130	.059	.067	.067
SE7	.200	.075	.183	.104	-.091	-.001	1.000	.119	.050	.177	.113	.138
SE8	.124	.100	.050	.046	.174	.162	.119	1.000	.233	.070	.046	.003
SE9	.181	.122	.112	-.059	-.037	.130	.050	.233	1.000	.168	.103	.109
SE10	.037	.083	.055	.107	.007	.059	.177	.070	.168	1.000	.044	.080
SE11	.222	.108	-.068	.176	.072	.067	.113	.046	.103	.044	1.000	.178
SE12	.222	-.026	.068	-.042	.194	.067	.138	.003	.109	.080	.178	1.000

Inter-Item Covariance Matrix of Smart Economy

	SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8	SE9	SE10	SE11	SE12
SE1	.670	-.054	.070	.080	.185	.122	.139	.080	.125	.026	.159	.155
SE2	-.054	.755	.034	.108	-.013	.150	.055	.068	.089	.061	.082	-.019
SE3	.070	.034	.788	.120	.138	.096	.138	.035	.084	.041	-.052	.051
SE4	.080	.108	.120	.701	.021	.042	.074	.030	-.042	.076	.129	-.030
SE5	.185	-.013	.138	.021	.761	.148	-.067	.119	-.027	.005	.055	.145
SE6	.122	.150	.096	.042	.148	.639	-.001	.102	.087	.041	.047	.046
SE7	.139	.055	.138	.074	-.067	-.001	.716	.079	.036	.128	.083	.100
SE8	.080	.068	.035	.030	.119	.102	.079	.618	.154	.047	.031	.002
SE9	.125	.089	.084	-.042	-.027	.087	.036	.154	.709	.121	.076	.078
SE10	.026	.061	.041	.076	.005	.041	.128	.047	.121	.727	.032	.058
SE11	.159	.082	-.052	.129	.055	.047	.083	.031	.076	.032	.763	.133
SE12	.155	-.019	.051	-.030	.145	.046	.100	.002	.078	.058	.133	.730

Summary Item Statistics of Smart Economy

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.038	3.919	4.135	.216	1.055	.003	12
Item Variances	.715	.618	.788	.170	1.276	.003	12
Inter-Item Correlations	.096	-.091	.259	.350	-2.849	.007	12

Inter-Item Correlation Matrix of Smart People

	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10	SP11	SP12	SP13	SP14	SP15	SP16	SP17
SP1	1.000	-.008	.120	.029	.098	-.039	.082	-.101	.030	.081	-.024	-.065	.101	-.024	-.027	.179	.041
SP2	-.008	1.000	.135	.139	-.063	-.039	.087	.123	.082	.097	-.062	.080	.018	.105	.037	.044	.112
SP3	.120	.135	1.000	.138	.097	.182	.134	.049	.043	.149	.073	.096	.101	.131	.056	.100	.110
SP4	.029	.139	.138	1.000	-.001	-.041	.075	.131	.113	.209	.084	.057	.044	.026	.152	-.083	.100
SP5	.098	-.063	.097	-.001	1.000	.195	.190	.066	.126	.021	.035	.013	.076	.209	-.024	.077	.277
SP6	-.039	-.039	.182	-.041	.195	1.000	.192	.022	.005	.125	.242	-.027	.140	.251	.124	.111	.240
SP7	.082	.087	.134	.075	.190	.192	1.000	.101	.056	.091	-.003	.090	.055	.098	.243	.077	.117
SP8	-.101	.123	.049	.131	.066	.022	.101	1.000	.081	-.027	.099	.059	.086	.099	.029	-.013	.057
SP9	.030	.082	.043	.113	.126	.005	.056	.081	1.000	.080	.016	.037	.120	.133	.134	.103	-.021
SP10	.081	.097	.149	.209	.021	.125	.091	-.027	.080	1.000	.151	.106	.163	.075	.079	.048	.078
SP11	-.024	-.062	.073	.084	.035	.242	-.003	.099	.016	.151	1.000	.209	-.010	.152	.093	.036	.142
SP12	-.065	.080	.096	.057	.013	-.027	.090	.059	.037	.106	.209	1.000	-.011	.085	.086	.120	.067
SP13	.101	.018	.101	.044	.076	.140	.055	.086	.120	.163	-.010	-.011	1.000	.185	.042	.173	.212
SP14	-.024	.105	.131	.026	.209	.251	.098	.099	.133	.075	.152	.085	.185	1.000	.152	.195	.277
SP15	-.027	.037	.056	.152	-.024	.124	.243	.029	.134	.079	.093	.086	.042	.152	1.000	-.003	.091
SP16	.179	.044	.100	-.083	.077	.111	.077	-.013	.103	.048	.036	.120	.173	.195	-.003	1.000	.171
SP17	.041	.112	.110	.100	.277	.240	.117	.057	-.021	.078	.142	.067	.212	.277	.091	.171	1.000

Inter-Item Covariance Matrix of Smart People

	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10	SP11	SP12	SP13	SP14	SP15	SP16	SP17
SP1	.713	-.006	.084	.021	.063	-.028	.057	-.067	.021	.059	-.017	-.044	.072	-.017	-.019	.124	.030
SP2	-.006	.695	.094	.099	-.040	-.028	.060	.080	.058	.070	-.042	.053	.013	.072	.026	.030	.080
SP3	.084	.094	.689	.098	.061	.131	.092	.032	.030	.107	.050	.063	.071	.090	.039	.068	.078
SP4	.021	.099	.098	.727	-.001	-.031	.053	.088	.081	.154	.059	.038	.032	.018	.108	-.058	.073
SP5	.063	-.040	.061	-.001	.576	.128	.119	.039	.081	.014	.022	.008	.049	.131	-.015	.048	.180
SP6	-.028	-.028	.131	-.031	.128	.749	.138	.015	.003	.094	.172	-.019	.103	.180	.090	.079	.178
SP7	.057	.060	.092	.053	.119	.138	.682	.065	.039	.065	-.002	.059	.039	.067	.168	.052	.083
SP8	-.067	.080	.032	.088	.039	.015	.065	.618	.054	-.018	.064	.037	.057	.064	.019	-.009	.038
SP9	.021	.058	.030	.081	.081	.003	.039	.054	.714	.058	.011	.025	.086	.093	.095	.071	-.015
SP10	.059	.070	.107	.154	.014	.094	.065	-.018	.058	.744	.107	.073	.120	.053	.057	.034	.058
SP11	-.017	-.042	.050	.059	.022	.172	-.002	.064	.011	.107	.674	.136	-.007	.103	.064	.024	.100
SP12	-.044	.053	.063	.038	.008	-.019	.059	.037	.025	.073	.136	.633	-.007	.056	.057	.078	.046
SP13	.072	.013	.071	.032	.049	.103	.039	.057	.086	.120	-.007	-.007	.720	.130	.030	.120	.154
SP14	-.017	.072	.090	.018	.131	.180	.067	.064	.093	.053	.103	.056	.130	.682	.105	.132	.196
SP15	-.019	.026	.039	.108	-.015	.090	.168	.019	.095	.057	.064	.057	.030	.105	.700	-.002	.065
SP16	.124	.030	.068	-.058	.048	.079	.052	-.009	.071	.034	.024	.078	.120	.132	-.002	.672	.120
SP17	.030	.080	.078	.073	.180	.178	.083	.038	-.015	.058	.100	.046	.154	.196	.065	.120	.736

Summary Item Statistics of Smart People

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.034	3.838	4.162	.324	1.085	.010	17
Item Variances	.690	.576	.749	.173	1.300	.002	17
Inter-Item Correlations	.085	-.101	.277	.377	-2.746	.006	17

Inter-Item Correlation Matrix of Smart Mobility

	SM1	SM2	SM3	SM4	SM5	SM6	SM7	SM8	SM9	SM10	SM11	SM12	SM13	SM14	SM15	SM16	SM17	SM18	SM19	SM20	SM21
SM1	1.000	.127	.122	.179	.168	.140	.351	.239	.087	.123	.165	.160	-.063	.166	.316	.225	.223	.059	.147	.082	.126
SM2	.127	1.000	.109	.263	.235	-.043	.159	.176	.055	-.055	.133	.272	.071	.116	.376	.109	.073	.222	.078	.041	.225
SM3	.122	.109	1.000	.113	.207	.133	.040	.107	.152	.188	.148	.119	.139	.134	.146	.125	.114	.053	.162	.057	.135
SM4	.179	.263	.113	1.000	.153	.136	.117	.317	.241	-.009	.095	.284	.240	.053	.283	.083	.084	.000	-.049	.050	.133
SM5	.168	.235	.207	.153	1.000	.171	.141	.048	.174	.095	.027	.144	.229	.071	.263	.068	.082	.156	.165	.128	.250
SM6	.140	-.043	.133	.136	.171	1.000	.110	-.003	.045	.002	.154	.111	.193	.071	.109	.052	.014	-.009	.002	.042	.048
SM7	.351	.159	.040	.117	.141	.110	1.000	.210	.156	.025	.104	.194	.050	.072	.291	.076	.176	.141	.212	.135	.112
SM8	.239	.176	.107	.317	.048	-.003	.210	1.000	.265	.041	.215	.204	.038	.165	.332	.244	.128	.090	-.008	.146	.051
SM9	.087	.055	.152	.241	.174	.045	.156	.265	1.000	.013	.109	.008	-.022	.198	.119	.123	.067	.074	.109	.299	.204
SM10	.123	-.055	.188	-.009	.095	.002	.025	.041	.013	1.000	.037	.047	.116	.059	-.026	.108	.155	.109	.231	.063	.084
SM11	.165	.133	.148	.095	.027	.154	.104	.215	.109	.037	1.000	.156	.003	.098	.161	.096	.045	.003	.152	.031	.303
SM12	.160	.272	.119	.284	.144	.111	.194	.204	.008	.047	.156	1.000	.071	.103	.211	.150	.138	.218	.064	.060	.228
SM13	-.063	.071	.139	.240	.229	.193	.050	.038	-.022	.116	.003	.071	1.000	.035	.003	.063	.086	.142	.003	.100	.046
SM14	.166	.116	.134	.053	.071	.071	.072	.165	.198	.059	.098	.103	.035	1.000	.152	.182	-.028	.139	.137	.212	.102
SM15	.316	.376	.146	.283	.263	.109	.291	.332	.119	-.026	.161	.211	.003	.152	1.000	.129	.062	.116	.004	.111	.093
SM16	.225	.109	.125	.083	.068	.052	.076	.244	.123	.108	.096	.150	.063	.182	.129	1.000	.133	.154	.200	.100	.099
SM17	.223	.073	.114	.084	.082	.014	.176	.128	.067	.155	.045	.138	.086	-.028	.062	.133	1.000	.085	.052	.034	.080
SM18	.059	.222	.053	.000	.156	-.009	.141	.090	.074	.109	.003	.218	.142	.139	.116	.154	.085	1.000	.274	.110	-.103
SM19	.147	.078	.162	-.049	.165	.002	.212	-.008	.109	.231	.152	.064	.003	.137	.004	.200	.052	.274	1.000	.089	.218
SM20	.082	.041	.057	.050	.128	.042	.135	.146	.299	.063	.031	.060	.100	.212	.111	.100	.034	.110	.089	1.000	.109
SM21	.126	.225	.135	.133	.250	.048	.112	.051	.204	.084	.303	.228	.046	.102	.093	.099	.080	-.103	.218	.109	1.000

Inter-Item Covariance Matrix of Smart Mobility

	SM1	SM2	SM3	SM4	SM5	SM6	SM7	SM8	SM9	SM10	SM11	SM12	SM13	SM14	SM15	SM16	SM17	SM18	SM19	SM20	SM21
SM1	.815	.099	.092	.131	.120	.104	.275	.187	.066	.089	.115	.128	-.043	.122	.238	.174	.167	.041	.110	.065	.095
SM2	.099	.756	.079	.185	.162	-.031	.120	.132	.040	-.039	.090	.209	.046	.082	.272	.081	.053	.149	.056	.032	.163
SM3	.092	.079	.690	.076	.136	.091	.029	.077	.106	.125	.095	.087	.086	.091	.101	.089	.079	.034	.112	.042	.094
SM4	.131	.185	.076	.655	.098	.091	.082	.222	.164	-.006	.059	.203	.144	.035	.191	.057	.057	.000	-.033	.035	.090
SM5	.120	.162	.136	.098	.627	.111	.097	.033	.116	.061	.017	.100	.135	.046	.173	.046	.054	.096	.108	.089	.165
SM6	.104	-.031	.091	.091	.111	.676	.078	-.002	.031	.001	.098	.080	.118	.047	.075	.037	.010	-.006	.001	.030	.033
SM7	.275	.120	.029	.082	.097	.078	.752	.158	.114	.018	.070	.148	.032	.051	.210	.056	.127	.095	.153	.103	.081
SM8	.187	.132	.077	.222	.033	-.002	.158	.749	.193	.028	.144	.156	.024	.116	.240	.181	.092	.061	-.005	.111	.037
SM9	.066	.040	.106	.164	.116	.031	.114	.193	.710	.009	.071	.006	-.014	.136	.084	.089	.047	.048	.076	.221	.144
SM10	.089	-.039	.125	-.006	.061	.001	.018	.028	.009	.647	.023	.034	.069	.039	-.017	.074	.103	.068	.154	.044	.057
SM11	.115	.090	.095	.059	.017	.098	.070	.144	.071	.023	.600	.106	.002	.062	.104	.064	.029	.002	.097	.021	.196
SM12	.128	.209	.087	.203	.100	.080	.148	.156	.006	.034	.106	.777	.046	.074	.155	.114	.101	.149	.047	.047	.168
SM13	-.043	.046	.086	.144	.135	.118	.032	.024	-.014	.069	.002	.046	.553	.021	.002	.040	.053	.082	.002	.065	.028
SM14	.122	.082	.091	.035	.046	.047	.051	.116	.136	.039	.062	.074	.021	.667	.104	.127	-.019	.088	.093	.152	.070
SM15	.238	.272	.101	.191	.173	.075	.210	.240	.084	-.017	.104	.155	.002	.104	.694	.092	.043	.075	.003	.081	.065
SM16	.174	.081	.089	.057	.046	.037	.056	.181	.089	.074	.064	.114	.040	.127	.092	.735	.094	.102	.142	.075	.071
SM17	.167	.053	.079	.057	.054	.010	.127	.092	.047	.103	.029	.101	.053	-.019	.043	.094	.688	.055	.036	.025	.055
SM18	.041	.149	.034	.000	.096	-.006	.095	.061	.048	.068	.002	.149	.082	.088	.075	.102	.055	.601	.176	.075	-.067
SM19	.110	.056	.112	-.033	.108	.001	.153	-.005	.076	.154	.097	.047	.002	.093	.003	.142	.036	.176	.688	.065	.151
SM20	.065	.032	.042	.035	.089	.030	.103	.111	.221	.044	.021	.047	.065	.152	.081	.075	.025	.075	.065	.772	.080
SM21	.095	.163	.094	.090	.165	.033	.081	.037	.144	.057	.196	.168	.028	.070	.065	.071	.055	-.067	.151	.080	.699

Summary Item Statistics of Smart Mobility

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.087	3.966	4.262	.295	1.074	.005	21
Item Variances	.693	.553	.815	.262	1.474	.004	21
Inter-Item Correlations	.121	-.103	.376	.479	-3.647	.007	21

Inter-Item Correlation Matrix of Smart Living

	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8	SL9	SL10	SL11	SL12	SL13	SL14	SL15	SL16
SL1	1.000	-.046	-.012	.130	-.002	.152	-.049	-.149	.076	-.030	.019	.086	.092	.180	.029	.094
SL2	-.046	1.000	.106	.113	.209	.191	.063	.229	.085	.214	.023	.002	.156	.030	.055	.103
SL3	-.012	.106	1.000	.209	.120	.089	.130	.169	.042	.105	.158	.087	.059	.068	-.015	.059
SL4	.130	.113	.209	1.000	.236	.065	.151	.273	.101	.018	.070	.139	.155	.067	-.050	.150
SL5	-.002	.209	.120	.236	1.000	.153	.152	.169	.013	.262	.119	.023	.148	.176	.062	.069
SL6	.152	.191	.089	.065	.153	1.000	.290	.042	.190	.256	.134	.059	.223	.338	.075	.225
SL7	-.049	.063	.130	.151	.152	.290	1.000	.090	.038	.018	.159	-.006	.052	.175	.118	.216
SL8	-.149	.229	.169	.273	.169	.042	.090	1.000	.138	.075	.187	.044	.029	.078	-.025	.175
SL9	.076	.085	.042	.101	.013	.190	.038	.138	1.000	.137	.137	.165	-.004	.012	.087	.031
SL10	-.030	.214	.105	.018	.262	.256	.018	.075	.137	1.000	.182	-.013	.065	.159	-.024	.062
SL11	.019	.023	.158	.070	.119	.134	.159	.187	.137	.182	1.000	.150	.039	.232	.100	.135
SL12	.086	.002	.087	.139	.023	.059	-.006	.044	.165	-.013	.150	1.000	.265	.160	.087	.234
SL13	.092	.156	.059	.155	.148	.223	.052	.029	-.004	.065	.039	.265	1.000	.186	-.076	.116
SL14	.180	.030	.068	.067	.176	.338	.175	.078	.012	.159	.232	.160	.186	1.000	.082	.084
SL15	.029	.055	-.015	-.050	.062	.075	.118	-.025	.087	-.024	.100	.087	-.076	.082	1.000	.062
SL16	.094	.103	.059	.150	.069	.225	.216	.175	.031	.062	.135	.234	.116	.084	.062	1.000

Inter-Item Covariance Matrix of Smart Living

	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8	SL9	SL10	SL11	SL12	SL13	SL14	SL15	SL16
SL1	.592	-.028	-.008	.089	-.001	.103	-.030	-.096	.049	-.019	.013	.050	.058	.115	.019	.061
SL2	-.028	.624	.069	.079	.138	.132	.040	.151	.056	.139	.015	.001	.101	.020	.037	.068
SL3	-.008	.069	.691	.154	.084	.065	.087	.117	.029	.072	.110	.055	.040	.047	-.011	.041
SL4	.089	.079	.154	.784	.175	.050	.108	.201	.075	.013	.052	.094	.112	.049	-.037	.111
SL5	-.001	.138	.084	.175	.699	.112	.102	.117	.009	.181	.084	.015	.101	.122	.043	.049
SL6	.103	.132	.065	.050	.112	.770	.204	.031	.141	.185	.098	.039	.160	.247	.055	.166
SL7	-.030	.040	.087	.108	.102	.204	.644	.060	.026	.012	.107	-.004	.034	.117	.080	.145
SL8	-.096	.151	.117	.201	.117	.031	.060	.691	.097	.052	.130	.028	.020	.054	-.017	.122
SL9	.049	.056	.029	.075	.009	.141	.026	.097	.715	.095	.097	.106	-.003	.008	.062	.022
SL10	-.019	.139	.072	.013	.181	.185	.012	.052	.095	.681	.126	-.008	.044	.109	-.016	.043
SL11	.013	.015	.110	.052	.084	.098	.107	.130	.097	.126	.705	.096	.027	.162	.070	.095
SL12	.050	.001	.055	.094	.015	.039	-.004	.028	.106	-.008	.096	.578	.165	.101	.056	.149
SL13	.058	.101	.040	.112	.101	.160	.034	.020	-.003	.044	.027	.165	.671	.127	-.052	.080
SL14	.115	.020	.047	.049	.122	.247	.117	.054	.008	.109	.162	.101	.127	.693	.058	.059
SL15	.019	.037	-.011	-.037	.043	.055	.080	-.017	.062	-.016	.070	.056	-.052	.058	.702	.044
SL16	.061	.068	.041	.111	.049	.166	.145	.122	.022	.043	.095	.149	.080	.059	.044	.702

Summary Item Statistics of Smart Living

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.086	3.946	4.195	.248	1.063	.004	16
Item Variances	.684	.578	.784	.206	1.356	.003	16
Inter-Item Correlations	.103	-.149	.338	.487	-2.259	.007	16

Inter-Item Correlation Matrix of Smart Governance

	SG1	SG2	SG3	SG4	SG5	SG6	SG7	SG8	SG9	SG10	SG11	SG12	SG13	SG14
SG1	1.000	.027	.248	.073	.201	.104	.154	.087	.081	.090	.051	.140	.164	.115
SG2	.027	1.000	.098	.190	.096	.101	.042	.112	.181	.197	.216	.111	.123	.211
SG3	.248	.098	1.000	.176	.096	.111	.249	.169	.092	.187	.325	.164	.158	.058
SG4	.073	.190	.176	1.000	.213	.212	.068	.069	.144	.214	.089	.341	.097	.152
SG5	.201	.096	.096	.213	1.000	.201	.137	.163	.154	.187	.039	.172	.124	.107
SG6	.104	.101	.111	.212	.201	1.000	.152	.239	.130	.155	.062	.075	.040	.194
SG7	.154	.042	.249	.068	.137	.152	1.000	.329	.166	.170	.123	.212	.185	.032
SG8	.087	.112	.169	.069	.163	.239	.329	1.000	.180	.091	-.002	.260	.092	.104
SG9	.081	.181	.092	.144	.154	.130	.166	.180	1.000	.098	.103	.120	.125	.195
SG10	.090	.197	.187	.214	.187	.155	.170	.091	.098	1.000	.053	.074	-.062	.163
SG11	.051	.216	.325	.089	.039	.062	.123	-.002	.103	.053	1.000	.029	.257	.048
SG12	.140	.111	.164	.341	.172	.075	.212	.260	.120	.074	.029	1.000	.178	.024
SG13	.164	.123	.158	.097	.124	.040	.185	.092	.125	-.062	.257	.178	1.000	.167
SG14	.115	.211	.058	.152	.107	.194	.032	.104	.195	.163	.048	.024	.167	1.000

Inter-Item Covariance Matrix of Smart Governance

	SG1	SG2	SG3	SG4	SG5	SG6	SG7	SG8	SG9	SG10	SG11	SG12	SG13	SG14
SG1	.645	.018	.165	.051	.134	.068	.103	.059	.055	.063	.033	.100	.111	.076
SG2	.018	.685	.067	.137	.067	.068	.029	.078	.126	.141	.144	.082	.086	.143
SG3	.165	.067	.686	.127	.066	.074	.171	.118	.064	.134	.217	.121	.111	.040
SG4	.051	.137	.127	.758	.154	.149	.049	.051	.105	.161	.062	.264	.072	.109
SG5	.134	.067	.066	.154	.696	.135	.095	.115	.108	.135	.027	.128	.087	.074
SG6	.068	.068	.074	.149	.135	.649	.101	.162	.088	.108	.041	.054	.027	.128
SG7	.103	.029	.171	.049	.095	.101	.689	.230	.116	.122	.082	.156	.130	.022
SG8	.059	.078	.118	.051	.115	.162	.230	.709	.127	.067	-.001	.194	.066	.072
SG9	.055	.126	.064	.105	.108	.088	.116	.127	.706	.071	.070	.090	.088	.135
SG10	.063	.141	.134	.161	.135	.108	.122	.067	.071	.748	.037	.057	-.045	.116
SG11	.033	.144	.217	.062	.027	.041	.082	-.001	.070	.037	.650	.021	.175	.032
SG12	.100	.082	.121	.264	.128	.054	.156	.194	.090	.057	.021	.791	.134	.017
SG13	.111	.086	.111	.072	.087	.027	.130	.066	.088	-.045	.175	.134	.713	.116
SG14	.076	.143	.040	.109	.074	.128	.022	.072	.135	.116	.032	.017	.116	.674

Summary Item Statistics of Smart Governance

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.078	3.987	4.174	.188	1.047	.004	14
Item Variances	.700	.645	.791	.146	1.226	.002	14
Inter-Item Correlations	.137	-.062	.341	.403	-5.496	.005	14

Inter-Item Correlation Matrix of Smart Environment

	SEn1	SEn2	SEn3	SEn4	SEn5	SEn6	SEn7	SEn8	SEn9	SEn10	SEn11	SEn12	SEn13	SEn14	SEn15	SEn16	SEn17	SEn18	SEn19	SEn20	SEn21	SEn22

SEn1	1.000	.083	.129	.029	.054	-.080	.070	.055	.172	-.011	.031	.129	.063	.163	.092	.151	-.143	.115	.023	-.014	.147	.130
SEn2	.083	1.000	.108	-.036	.067	.161	.059	.196	.157	.081	.007	.232	.054	-.003	-.162	.124	.077	.014	.217	.022	.105	.123
SEn3	.129	.108	1.000	.059	.089	-.004	.137	.117	-.113	.014	-.001	.137	.087	-.014	.051	.165	-.079	.042	-.042	.166	-.099	-.075
SEn4	.029	-.036	.059	1.000	.068	-.050	.139	.186	.004	.069	-.032	.013	.055	.094	.015	.106	-.005	.076	.085	-.019	.003	.019
SEn5	.054	.067	.089	.068	1.000	.147	.003	-.095	.024	.085	-.059	.163	-.078	.039	.056	.059	-.073	.086	.019	.057	.094	-.018
SEn6	-.080	.161	-.004	-.050	.147	1.000	.169	.062	.149	-.067	.186	-.038	.101	-.103	-.055	.125	-.008	.032	.055	.016	.127	.131
SEn7	.070	.059	.137	.139	.003	.169	1.000	.089	-.029	.071	.098	-.028	.199	.158	.004	.018	.097	-.033	.165	.002	-.005	.191
SEn8	.055	.196	.117	.186	-.095	.062	.089	1.000	-.048	.050	.003	-.028	-.062	.150	-.005	.016	.015	.113	-.017	-.022	.054	.058
SEn9	.172	.157	-.113	.004	.024	.149	-.029	-.048	1.000	.012	.095	.088	.023	.136	-.018	-.052	.067	-.069	-.081	-.090	.140	.171
SEn10	-.011	.081	.014	.069	.085	-.067	.071	.050	.012	1.000	.034	.134	.018	-.073	.044	-.070	.148	.048	.076	.187	.066	.110
SEn11	.031	.007	-.001	-.032	-.059	.186	.098	.003	.095	.034	1.000	-.034	.090	-.014	.102	.046	.077	-.046	.154	.132	.009	.039
SEn12	.129	.232	.137	.013	.163	-.038	-.028	-.028	.088	.134	-.034	1.000	.039	.130	-.045	.197	-.114	.177	.086	.171	.094	.009
SEn13	.063	.054	.087	.055	-.078	.101	.199	-.062	.023	.018	.090	.039	1.000	.127	.176	.185	-.025	-.101	.041	-.001	.103	.101
SEn14	.163	-.003	-.014	.094	.039	-.103	.158	.150	.136	-.073	-.014	.130	.127	1.000	.143	.130	-.198	.086	.021	-.021	.041	.236
SEn15	.092	-.162	.051	.015	.056	-.055	.004	-.005	-.018	.044	.102	-.045	.176	.143	1.000	.041	.042	.076	.040	.035	.040	.080
SEn16	.151	.124	.165	.106	.059	.125	.018	.016	-.052	-.070	.046	.197	.185	.130	.041	1.000	-.116	.081	.117	.104	.081	.074
SEn17	-.143	.077	-.079	-.005	-.073	-.008	.097	.015	.067	.148	.077	-.114	-.025	-.198	.042	-.116	1.000	-.038	.025	.172	-.065	-.142
SEn18	.115	.014	.042	.076	.086	.032	-.033	.113	-.069	.048	-.046	.177	-.101	.086	.076	.081	-.038	1.000	.055	.053	.103	.079
SEn19	.023	.217	-.042	.085	.019	.055	.165	-.017	-.081	.076	.154	.086	.041	.021	.040	.117	.025	.055	1.000	.039	-.073	.181
SEn20	-.014	.022	.166	-.019	.057	.016	.002	-.022	-.090	.187	.132	.171	-.001	-.021	.035	.104	.172	.053	.039	1.000	-.017	-.076
SEn21	.147	.105	-.099	.003	.094	.127	-.005	.054	.140	.066	.009	.094	.103	.041	.040	.081	-.065	.103	-.073	-.017	1.000	.073
SEn22	.130	.123	-.075	.019	-.018	.131	.191	.058	.171	.110	.039	.009	.101	.236	.080	.074	-.142	.079	.181	-.076	.073	1.000

Inter-Item Covariance Matrix of Smart Environment

	SEn1	SEn2	SEn3	SEn4	SEn5	SEn6	SEn7	SEn8	SEn9	SEn10	SEn11	SEn12	SEn13	SEn14	SEn15	SEn16	SEn17	SEn18	SEn19	SEn20	SEn21	SEn22
SEn1	.690	.054	.083	.019	.035	-.056	.048	.039	.113	-.007	.022	.087	.042	.109	.063	.097	-.092	.083	.016	-.009	.102	.089
SEn2	.054	.628	.066	-.022	.042	.107	.038	.133	.098	.053	.005	.150	.035	-.002	-.105	.076	.047	.010	.142	.014	.070	.081
SEn3	.083	.066	.598	.035	.054	-.003	.087	.078	-.069	.009	.000	.087	.054	-.009	.032	.098	-.048	.028	-.027	.103	-.064	-.048
SEn4	.019	-.022	.035	.588	.041	-.032	.088	.122	.002	.044	-.021	.008	.034	.058	.009	.063	-.003	.051	.054	-.012	.002	.012
SEn5	.035	.042	.054	.041	.624	.098	.002	-.065	.015	.055	-.040	.105	-.050	.025	.036	.036	-.045	.059	.013	.036	.062	-.012
SEn6	-.056	.107	-.003	-.032	.098	.709	.117	.045	.100	-.046	.133	-.026	.069	-.070	-.038	.082	-.005	.023	.039	.011	.089	.092
SEn7	.048	.038	.087	.088	.002	.117	.679	.063	-.019	.048	.068	-.019	.133	.104	.003	.012	.062	-.024	.113	.002	-.004	.130
SEn8	.039	.133	.078	.122	-.065	.045	.063	.736	-.032	.035	.002	-.020	-.043	.103	-.003	.011	.010	.084	-.012	-.015	.038	.041
SEn9	.113	.098	-.069	.002	.015	.100	-.019	-.032	.626	.008	.064	.057	.015	.086	-.011	-.032	.041	-.047	-.053	-.057	.093	.112
SEn10	-.007	.053	.009	.044	.055	-.046	.048	.035	.008	.671	.024	.089	.012	-.048	.030	-.044	.094	.034	.052	.122	.045	.075
SEn11	.022	.005	.000	-.021	-.040	.133	.068	.002	.064	.024	.723	-.023	.062	-.009	.071	.030	.051	-.034	.108	.089	.006	.028
SEn12	.087	.150	.087	.008	.105	-.026	-.019	-.020	.057	.089	-.023	.665	.025	.085	-.030	.124	-.072	.126	.058	.111	.064	.006
SEn13	.042	.035	.054	.034	-.050	.069	.133	-.043	.015	.012	.062	.025	.653	.083	.116	.116	-.016	-.071	.027	-.001	.070	.068
SEn14	.109	-.002	-.009	.058	.025	-.070	.104	.103	.086	-.048	-.009	.085	.083	.642	.094	.080	-.123	.060	.014	-.013	.027	.157
SEn15	.063	-.105	.032	.009	.036	-.038	.003	-.003	-.011	.030	.071	-.030	.116	.094	.670	.026	.026	.054	.027	.023	.027	.054
SEn16	.097	.076	.098	.063	.036	.082	.012	.011	-.032	-.044	.030	.124	.116	.080	.026	.597	-.070	.055	.075	.064	.052	.047
SEn17	-.092	.047	-.048	-.003	-.045	-.005	.062	.010	.041	.094	.051	-.072	-.016	-.123	.026	-.070	.603	-.025	.016	.107	-.042	-.092
SEn18	.083	.010	.028	.051	.059	.023	-.024	.084	-.047	.034	-.034	.126	-.071	.060	.054	.055	-.025	.758	.039	.037	.075	.057
SEn19	.016	.142	-.027	.054	.013	.039	.113	-.012	-.053	.052	.108	.058	.027	.014	.027	.075	.016	.039	.682	.026	-.050	.124
SEn20	-.009	.014	.103	-.012	.036	.011	.002	-.015	-.057	.122	.089	.111	-.001	-.013	.023	.064	.107	.037	.026	.635	-.011	-.051
SEn21	.102	.070	-.064	.002	.062	.089	-.004	.038	.093	.045	.006	.064	.070	.027	.027	.052	-.042	.075	-.050	-.011	.703	.051
SEn22	.089	.081	-.048	.012	-.012	.092	.130	.041	.112	.075	.028	.006	.068	.157	.054	.047	-.092	.057	.124	-.051	.051	.690

Summary Item Statistics of Smart Environment

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.060	3.899	4.165	.266	1.068	.006	22
Item Variances	.662	.588	.758	.170	1.290	.002	22
Inter-Item Correlations	.051	-.198	.236	.434	-1.193	.007	22

Inter-Item Correlation Matrix of Smart Services

	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SSS9	SS10	SS11
SS1	1.000	.171	.224	.292	.128	.147	.155	.020	.171	.213	.267
SS2	.171	1.000	.237	.113	.111	.134	.178	.171	.046	.043	.178
SS3	.224	.237	1.000	.230	.140	.093	.181	.040	-.077	.081	.151
SS4	.292	.113	.230	1.000	-.004	.081	.143	.075	.066	-.005	.216
SS5	.128	.111	.140	-.004	1.000	.189	.193	.217	.158	-.098	.158
SS6	.147	.134	.093	.081	.189	1.000	.152	-.035	.115	.166	.141
SS7	.155	.178	.181	.143	.193	.152	1.000	.156	-.055	.088	.093
SS8	.020	.171	.040	.075	.217	-.035	.156	1.000	.067	-.022	.105
SSS9	.171	.046	-.077	.066	.158	.115	-.055	.067	1.000	.150	.232
SS10	.213	.043	.081	-.005	-.098	.166	.088	-.022	.150	1.000	.126
SS11	.267	.178	.151	.216	.158	.141	.093	.105	.232	.126	1.000

Inter-Item Covariance Matrix of Smart Services

	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SSS9	SS10	SS11
SS1	.714	.116	.156	.199	.095	.103	.102	.014	.123	.150	.197
SS2	.116	.648	.157	.073	.078	.090	.112	.114	.031	.029	.125
SS3	.156	.157	.680	.153	.101	.064	.116	.027	-.054	.055	.108
SS4	.199	.073	.153	.651	-.003	.054	.090	.050	.045	-.003	.152
SS5	.095	.078	.101	-.003	.766	.138	.132	.157	.118	-.071	.121
SS6	.103	.090	.064	.054	.138	.694	.099	-.024	.081	.116	.103
SS7	.102	.112	.116	.090	.132	.099	.609	.101	-.036	.057	.063
SS8	.014	.114	.027	.050	.157	-.024	.101	.687	.047	-.015	.076
SSS9	.123	.031	-.054	.045	.118	.081	-.036	.047	.719	.106	.172
SS10	.150	.029	.055	-.003	-.071	.116	.057	-.015	.106	.695	.091
SS11	.197	.125	.108	.152	.121	.103	.063	.076	.172	.091	.760

Summary Item Statistics of Smart Services

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.050	3.953	4.223	.270	1.068	.007	11
Item Variances	.693	.609	.766	.157	1.258	.002	11
Inter-Item Correlations	.122	-.098	.292	.389	-2.986	.007	11

13.2 Participant Information Sheet

This appendix has been removed because it contains personal information

13.3 Consent Form

This appendix has been removed because it contains personal information