DEVELOPING A FRAMEWORK TO PROMOTE INNOVATION IN SOCIO-ECONOMIC DEVELOPMENT IN SMART CITIES

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Dedication

This thesis is dedicated to Almighty Allah who made everything possible. Also to the memory of my late father Pa Idris Egbunu Agbali who laid the right foundation for me.

Declaration

This thesis is submitted under the University of Salford's code of practice for postgraduate research degree programmes. During the research journey, some findings of this research study have been published in refreed conference proceedings and academic journals prior to the submission of this thesis.

I hereby declare that no part of this work has been submitted to any other university or academic institution for the purpose of assessment for the award of any degree or certificate. I confirm that all the intellectual contents of this thesis are the results of my personal efforts and no other individual.

Signature……………………………. Date……………………………………

Mohammed Agbali

LIST OF ACRONYMS

AAL	Ambience Assisted Living
AGIS	Abuja Geographical Information System
DHT	Distributed Hash Table
EDA	Event Driven Architecture
EoT	Internet of Everything
EU	European Union
FCT	Federal Capital Territory
FCTA	Federal Capital Territory Administration
GDP	Gross Domestic Product
ICD	Internet Connection Devices
ICT	Information and Communication Technology
IoT	Internet of Things
ISO	International Standardization Organisation
IT	Information Technology
ITU	International Telecommunication Union
KP	Knowledge Processor
M2M	Mobile to Mobile
QoL	Quality of Life
SCs	Smart Cities
SIB	Semantic Information Broker
SME	Small and Medium Enterprise
SOA	Service Oriented Architecture
UN	United Nations
WCCD	World Council on City Data
WHO	World Health Organisation
OECD	Organisation for Economic Co-operation and Development
KPI	Key Performance Indicator
CSF	Critical Success Factor
PCA	Principal Component Analysis
KMO	Kaiser-Meyer-Olkin

Abstract

The Smart City (SC) concept has emerged as an innovative response to the challenges and opportunities created by rapid urbanisation around the world. Consequently, city governments around the globe are embracing ‘Smart’ strategies as part of major steps towards making their cities more livable and sustainable. Despite global attention on the SC concept and its recognised potential to improve the circumstances of cities in any region, there is paucity of research on appropriate framework models to assess the impacts of smartness on cities in developing countries. Based on a systematic literature review and a pilot study with key SC stakeholders, the study initially built a conceptual framework for a multi-dimensional understanding of the critical success factors (CSFs) and indicators of Smart Cities (SCs) that aligned with stakeholders’ perceptions and experiences of SCs. Then, the study examined Smart Innovations in Boston, FCT-Abuja, and Manchester as cases studies of SC development. Through the conduct of in-depth face-to-face interviews across the cases, the field investigation gathered high quality feedbacks from knowledge-rich SC stakeholders. In doing so, the core components of SCs and their underlying CSFs and indicators were identified and examined. In order to validate the factors/indicators extracted from the literature, and interviews with experts, the study adopted a sequential methodology to further collect quantitative data using a survey instrument. The data analysis employed the Kruskal-Wallis H test and Spearman’s correlation with interpretive mean scores to highlight the priority CSFs and indicators of smartness based on their significance. Through a cross-case comparison of the variables emphasised in the analysis, three core components, 11 CSFs, and 32 core indicators of SC KPIs emerged. These established KPIs were modeled using a System Dynamics approach with Vensim PLE. The study highlighted some novel findings in terms of the different perspectives of SC vision and place-based innovation ecosystems that evolved across the cases investigated. The findings suggests conceptualisation of SC innovation around entrepreneurial development, effective and efficient service delivery systems in order for cities to retain sustainable development with strong emphasis placed on an improved quality of life, suitable to be applied both in developed and developing countries.

The study concluded with a strong recommendation for cities in developing countries to address the challenges of development infrastructure deficits as a starting point for SC deployment; it proposed a framework model based on the priority core components of Smart Infrastructure, Smart Institution, and Smart People. A particularly notable part of this study into ongoing SC evolution is that it highlights the major contributions of SC practitioners in theory, practice, and methodology.

CHAPTER 1

1.1 Introduction

The focus of the study is to develop a framework to promote socio-economic development in Smart and Sustainable Cities applicable both to developed and developing countries. This chapter introduces the concept of Smart City deployment in three world cities within Africa, Europe, and North America. The chapter provides an overview of the research undertaken including an outline of the systematic literature review. This provides a thorough understanding of the research area highlighting the research questions, research aim and objectives, the statement of the problem, the expected contributions to the body of knowledge, and a summary of the thesis structure.

1.2 Background to the Study

The recent advances in Information Technology (IT) and the need to build smart, sustainable and liveable cities have received considerable attention in recent years, especially amongst the developed economies of the world. Willis and Aurigi (2017) noted that cities have always been shaped by technological advancements; thus the emergence of modern cities in the information-age are essentially driven by the new possibilities offered by emerging technologies. Fundamental reasons for the widespread support for the concept of Smart City are undoubtedly related to the quest for a novel solution that will mitigate urban problems, such as congestion and global warming (Nam & Pardo, 2011a) with the primary objective of transforming cities into better places to live. This development has compelled city managers, planners, engineers and service providers to take on the methodological and procedural issues necessary to achieve improved spatial intelligence that will make cities more competitive and efficient.

However, at its inception, in the field of urban planning, few researchers believed in the term ‘Smart City’; indeed, some viewed it as a negative facet of the ‘urban label’ (Hollands, 2008). Similarly, other urban development scholars, such as Nam and Pardo (2011a), described the Smart City evolution as “a fuzzy concept” that is often improperly used. While acknowledging the critique sorounding Smart City concept (Graham and Marvin, 2001; Hollands, 2008 for instance), many areas of the world today are evolving to a stage where national governments and city mayors are investing heavily in Smart City projects. As T. Saunders and Baeck (2015) identified, China and India alone are currently planning about 300 Smart City pilot projects; this is additional to various efforts in the developed economies and a few in other developing economies. The Smart City concept therefore is emerging as a global strategy to address the challenges created by rapid urban population growth and speedy urbanisation processes, which are currently posing serious demand for resource utilisation and environmental sustainability . Thus, Smart City is no longer a concept but rather a reality that seeks to foster efficient and sustainable development that creates more opportunities for socio-economic growth.

In spite of the widespread adoption of the Smart City concept, very little literature has reported a Smart City project from the perspective of a city in a developing country and, in particular, from Nigeria. In a conceptual framework for assessing the relationship between local economic development (LED) indicators and various performance variables for local authority districts, Wong (2002) identified 11 factors and 29 indicator measures to inform local economic planning. The framework was based on evidence from the United States of America, Britain and other European countries, and the empirical data were drawn from major cities in England, and particularly those with a strong development infrastructure. However, no research from the field of Smart Cities has yet addressed the need for an all-inclusive framework adaptable to regions where infrastructure provision remains a critical challenge. Furthermore, few industry reports have mentioned any Smart City projects in Sub-Saharan Africa, with the exceptions of Nam and Pardo (2011a) who highlighted Cape Town (Nelson Mandela Bay, South Africa) as a Smart City project, and more recently (Watson, 2015) who outlined the “Eko Atlantic” urban vision of Lagos city.

In addition, research findings suggest that there is currently limited research on Smart Cities amongst developing countries - only 12% of published research on Smart Cities is from developing countries - which could hinder the full contextualisation for Smart and Sustainable City deployment across developing countries (Estevez, Lopes & Janowski, 2016). Estevez et al. argued that Smart City policy works are mainly conducted in the advanced countries of Europe and America; for example, they confirmed that 37% of Smart City framework/policy works originated from the United States, followed by 14% from the United Kingdom, and only 8% from developing countries, such as China, Chile, India, and Russia. Interestingly, no African countries were mentioned as contributors to Smart City policy work (Estevez et al., 2016). The apparent lack of indigenous Smart City policy among developing countries suggests that cities in developing countries tend to adopt frameworks based on developed countries, which are tested only on cities within developed countries (Estevez et al., 2016). Consequently, such frameworks are potentially less than optimal for different national contexts and therefore potentially advance the interests of ‘provider-countries’ over local interests. This issue highlights the importance of this study in informing locally-informed Smart City planning in Nigeria, and in particular, Federal Capital Territory--FCT--Abuja, which is widely recognised as the fastest developing city in Africa (Abubakar, 2014).

With regard to empirical research into Smart Cities, some aspects remain unexplored, especially those within the context of developing cities in Africa, such as Abuja. For instance, the relevance of the Smart City concept in the global quest to create urban environments to attract and retain global investment talents (Yigitcanlar & Velibeyoglu, 2008) provides significant opportunities for many African cities given that most on this continent are still developing. The lessons from how advanced European cities are aligning their regional economic strategies with the Smart City agenda in building innovative ecosystems (Komninos, Pallot, & Schaffers, 2013) needs to be exploited in the context of the socio-economic development goals of cities in developing countries, while also taking advantage of the opportunities afforded by such existing Smart City developments.

FCT - Abuja is an important hub of political activities in Africa hosting the ECOWAS and WATRA secretariats in addition to other multi-national organizations, which include offices of the United Nations, World Bank, International Labour Organisation, UNICEF, UNESCO, UNDP, European Union and all accredited foreign embassies to Nigeria. The population of Abuja metropolitan area was estimated to be 1.4 million people based on the official statistics from the last national and housing census 2006, (National Population, 2013). However, recent unofficial estimates revealed that Abuja metropolitan area is home to about 5 million people (G. K. Jiriko, D. G. Jy, & S. D. Wapwera, 2015). In addition, the IBM Corporation awarded the Smarter Cities Challenge Grant to FCT-Abuja as one of the key ‘world cities’ to benefit from the IBM’s largest philanthropic initiative (IBM, 2017b).

The point of departure for this study is the focus of research efforts on investigating a city in developing country with lessons from cities in developed countries where the use of new technologies -- with a special interest in ICT -- explore cutting edge issues in science, industry and commerce and integrate the complex systems of cities for greater effectiveness (Odendaal, 2003). This focus demonstrates the difference in experience between developing and developed countries, of which the latter are generally able to take advantage of the more widely available capacities, resources and sophisticated understandings of the technologies in development. Despite these differences, this provides some guidance for stakeholders in developing countries to evolve strategies to deploy technologies that help to address societal challenges, like climate change, energy efficiency, and environmental and health related issues (Solanas et al., 2014).

Although most of the published studies in this field tend to share the experiences of developed countries, where the provision of basic infrastructure is substantially addressed with sophisticated understanding (Odendaal, 2003), the relevance of infrastructure and the platform to promote innovation to improve the quality of life and socio-economic development are essential for developing economies. It is, however, imperative to reiterate that, although ICT is at the core of Smart Cities, the deployment of ICT does not necessarily translate to the Smart City without first addressing the disparities and inequalities that exist in cities, especially amongst developing countries, where the critical factors of basic infrastructure need to be addressed. Hence, the factor of smart infrastructure is a major focus in this study.

Nevertheless, there remains a lack of understanding of the implications of smart infrastructure in supporting Smart Cities, especially in the areas of knowledge creation, transfer, and the application of knowledge; these areas are particularly important as they represent a city's core driving engines. These have negatively impacted on the successful adoption of the Smart City concept among cities in developing countries generally, and amongst African countries particularly. According to Yigitcanlar et al. (2008), "knowledge based urban development has become an important mechanism for the development of knowledge cities". However, a limited understanding of the social and technological innovation required to transform a city into a hub for the intensive flow and exchange of knowledge amongst stakeholders has meant this has not progressed smoothly.

Thus, cities in developing countries are faced with key issues that range from their infrastructure to their political environment, which impact on efforts to transform these spaces into more sustainable and liveable places. A study of how the introduction of new technologies are changing the cities and KPIs for assessing the impacts of smartness on cities would thus provide necessary and timely research. This is particularly important as it becomes increasingly relevant to many cities across the world that adopt the concept as a means to implement new and innovative strategies for efficient service delivery to their citizens. Using both inductive and deductive techniques to explore case studies in Europe and America with a primary case study in Nigeria, this research explores how social and technological innovation can create new opportunities for socio-economic development in cities. This research would thus enable the development of a theoretical and practical framework for cities in developing countries to leverage the Smart City concept for urban sustainability. Eventually, the study will produce a framework model for assessing Smart Cities focusing on the core components of cities.

As this research is novel, exploratory efforts were undertaken by initially focusing on the experiences of advanced societies to understand how stakeholders understand the concept and its implementation. Given the limited literature from developing countries, the exploratory phase of the study attempted to create a better understanding of Smart Cities by addressing the gaps in theory and practice concerning the introduction of technologies to cities, including smart services and innovation. Based on a review of relevant literature and empirical evidence, many important questions concerning the Smart City concept remain unanswered. Paramount among them is the relevance of infrastructure in Smart Cities as a primary focus and priority area of interest.

The study fulfilled much of the described needs by bringing together the social and technological innovations in Smart Cities together and by discussing the introduction of emerging technologies to cities in the context of a framework model to assess the impact of ‘smartness’. This aimed to help stakeholders take advantage of new urban development strategies to build sustainable social and economic developments. By examining the issues and challenges of infrastructure as one of the core components of the Smart City KPI model for assessing the performance of Smart Cities, the research fills an existing gap in this field. In addition, by considering the importance of Smart City development and the need for city managers to develop their decision-making tool, a framework model with a System Dynamics approach is proposed to enable an assessment of the interrelationships among the core components of Smart City KPIs; this is particularly novel given that the context is a city in a developing country. A full review of relevant literature is presented in Chapter 2.

1.3 Statement of the Problem

As discussed in the literature review, the Smart City is still an emerging concept (Chourabi et al. 2012) . In the last two decades, the Smart City concept has become popular in scientific literature and international policies (Albino et al. 2015) . Nevertheless, although the Smart City initiative has expanded across the world, there is currently no reliable framework model of indicators to measure the impacts of smartness or to determine how intelligent cities have become; similarly, research effort has yet to address a summarisation of the existing index (Marsal-Llacuna et al. 2015) . In addition, most of the published studies in this field tend to share the experiences of developed countries (Odendaal, 2003), thus there is no detailed framework to address the major challenges of cities in the developing region (e.g. infrastructure) and to help create an enabling environment for all to actively participate in this evolution.

The existing KPI models, including the works of Cohen (2012), Giffinger and Gudrun (2010), and Wong (2002), have not been able to adequately address critical issues in the Smart City nor assess any impact from the perspective of cities in developing countries generally and Nigeria particularly. Existing frameworks tend to prioritise issues around: the Smart Economy - focusing on competitiveness; Smart Governance - based on participation; the Smart Environment - concentrating on natural resources; Smart Mobility - focusing on transport and ICT; Smart Living – prioritising the quality of life, and Smart People - considering social and human capital perspectives and ignoring the fundamental issues of development infrastructure which are major challenges for cities in developing countries including Nigeria. In contrast, for European and American cities, building Smart Economies, Smart Mobility, and Smart Living mean leveraging the existence of a Smart Infrastructure (e.g. broadband and electricity) and the access to Venture Capital in order to sustain any subsequent smart innovation. Again, cities developing Smart Governance strategies for participatory governance also require an enabling environment through Smart Institutions through which to drive the governance of all smart innovation (Agbali, Trillo, & Fernando, 2017).

The major cities in Nigeria, especially Lagos and Abuja, have recently demonstrated a keen interest in adopting the Smart City concept to address congestion challenges. In particular, FCT-Abuja has set out a vision to become one of the top 20 Smart Cities of the world by the year 2020 in terms of its urban mobility services (Opeifa, 2017). This means filling a gap in the existing frameworks which may not fit the Nigerian environment is imperative. Developing such a framework requires an assessment of the evidence-based solutions in theory and practice in order to lay a solid foundation for Smart growth in Abuja city. As Goodspeed (2014) argued, viewing urban problems holistically allows for the development of more fundamental solutions than urban cybernetics, which suggests the need for local innovation and stakeholder participation. Many existing studies have not been able to propose a summarised framework model to address a complex system of cities using a system dynamics approach. A framework model that analyses the causal relationship among the core components of Smart Cities is required as an interactive guide for stakeholders to assess the impacts of Smart innovation and thus enable timely decision-making.

Considering the complex interdependencies among the core components of a Smart City, Smart City initiatives are treated as dynamic systems. Using a novel dynamic system approach to model the summarised KPIs will help to explain the interrelationships among the Smart City components. Thus, considering the relevance of Smart City innovation to the economy of cities and stakeholders, there is a need for a dynamic system for decision-making.

Using a primary case study in Nigeria, this study therefore investigates the adoption of the Smart City concept in order to evaluate the role of social innovation and emerging technologies for socio-economic development in advanced societies. It also evaluates the embedded knowledge amongst Smart City stakeholders in both theory and practice, and, by building on the lessons learnt, develops a framework model for sustainable Smart Cities based on the context of Abuja, Nigeria.

1.4 Research Questions

The following research questions will be addressed in this study in line with the research problem discussed above:

a) What gaps need to be filled in current Smart City models in order to make them capable of promoting ‘smartness’ amongst cities in Nigeria?
b) How can cities in Nigeria, especially in the Abuja city region, leverage the concept of social innovation and emerging technologies in Smart Cities for sustainable social and economic development?

c) How is the Smart City concept understood and implemented in different city regions and how do the understandings differ among stakeholder with respect to specialization and education?

d) What underlying relationships exist among the critical success factors/indicators of Smart Cities, and how do cities prioritise these factors and indicators in assessing the impacts of their smartness?

e) What framework model is appropriate to assess Smart City initiatives in terms of the core components of infrastructure, institution, and people?

The above research questions are raised to help build an effective and in-depth understanding of the Smart City concept in theory and practice in different environments. The questions emerged through the analysis and systematic review of relevant literature in the field of Smart Cities.

1.5 Research Aim

The study aims to develop a Smart City framework with a KPI model to assess the impacts of social and technological innovations on the socio-economic development of cities in the context of FCT-Abuja, Nigeria. The specific research objectives are:

1) To investigate the current Smart City frameworks implemented in different city regions;
2) To identify and document the main social and economic challenges that have the potential to be addressed through Smart City technologies and innovation;
3) To review relevant standards and Smart City key performance indicators (KPIs) to identify current development and thinking on Smart City measurement metrics;
4) To evaluate the dynamic interrelationships among the core factors and indicators of Smart Cities with model flow diagrams, parameter estimation, and model validation;
5) To propose a Smart City framework model based on the core factors and indicators established from the empirical case study data, applicable both to developed and developing countries.

1.6 Scope and Limitation of the Research

The concept of the Smart City is complex to research due to its dynamic nature and emerging issues, which are largely due to new technologies. However, a number of challenges in Smart City deployment (e.g. governance and management) are being addressed in developed economies with experimental Smart City projects already under implementation in Europe, America and parts of Asia. Hence, this research is aims to develop a novel framework for Smart Cities in the context of cities in developing countries with a new model of core Smart City KPI metrics that will be applicable to cities in Nigeria and beyond. It will also introduce empirical evidence by applying the proposed framework in analysing and evaluating new ideas for social and economic development in cities. The research will be limited to a primary case study (Abuja) in Nigeria and two motivating case studies - one in USA (Boston) and another in Europe (Manchester) – in order to draw lessons. These core cases will be complemented with further international examples on Smart Cities drawn from secondary sources.

1.7 Research Approach and Methodological Steps

The phenomenon being studied, namely a framework to promote innovation in social and economic development in Smart and Sustainable Cities, is a contemporary issue which requires the participation of key stakeholders in real-life contexts. In this regard, the researcher adopted both inductive and deductive approaches to achieve the research aim and objectives stated in this chapter. Based on the philosophical assumptions of this research, the study adopts a sequential methodology in data collection and analysis to address the objectives and profer answers to the research questions raised. Table 1.1 summarises the research objectives and the related research questions as well as the methods adopted in this study. Chapter four discusses research philosophy and methods in details.

Table 1.1: Summary of Research Objectives, Questions, and Methods

Key: Secondary Data =1, Literature Review =2, Interviews =3, Survey Instrument =4, Archives =5						
Research Objectives	**Research Questions**	**Methods**				
		1	**2**	**3**	**4**	**5**
To investigate the current Smart City frameworks implemented in different city regions.	What gaps need to be filled in current Smart City models in order to make them capable of promoting ‘smartness’ amongst cities in Nigeria?	✓	✓	✓	x	✓
To identify and document the main social and economic challenges that have the potential to be addressed through Smart City technologies and innovation.	How can cities in Nigeria, especially in the Abuja city region, leverage the concept of social innovation and emerging technologies in Smart Cities for sustainable socio-economic development?	✓	✓	✓	x	✓
To review relevant standards and Smart City key performance indicators (KPIs) to identify current development and thinking on Smart City measurement metrics.	How is the Smart City concept understood and implemented in different city regions and how do the understandings differ among stakeholder with respect to specialization and education?	✓	✓	✓	✓	✓
To evaluate the dynamic interrelationships among the core factors and indicators of Smart Cities with model flow diagrams, parameter estimation, and model validation.	What underlying relationships exist among the critical success factors/indicators of Smart Cities, and how do cities prioritise these factors and indicators in assessing the impacts of their smartness?	x	✓	✓	✓	x
To propose a Smart City framework model based on the core factors and indicators established from the empirical case study data.	What framework model is appropriate to assess Smart City initiatives in terms of the core components of infrastructure, institution, and people?	x	✓	✓	✓	x

The research involved the use of a systematic literature review, a pilot study with Smart City stakeholders in Abuja - Nigeria, a field investigation into three world cities - one each from Europe, America, and Africa - using a semi-structured interviews and a survey instrument for the data collection. The data analysis phase involved the use of Nvivo version 11 for the content analysis, Statistical Package for the Social Sciences (SPSS) version 24 for the statistical analysis, and an assessment/evaluation of the dynamic relationship using Vensim as a modelling tool. The thesis structure and methodological processes for the study is depicted in Figure 1.1. The survey instrument and semi-structured interview guide are attached as Appendices B and C respectively.

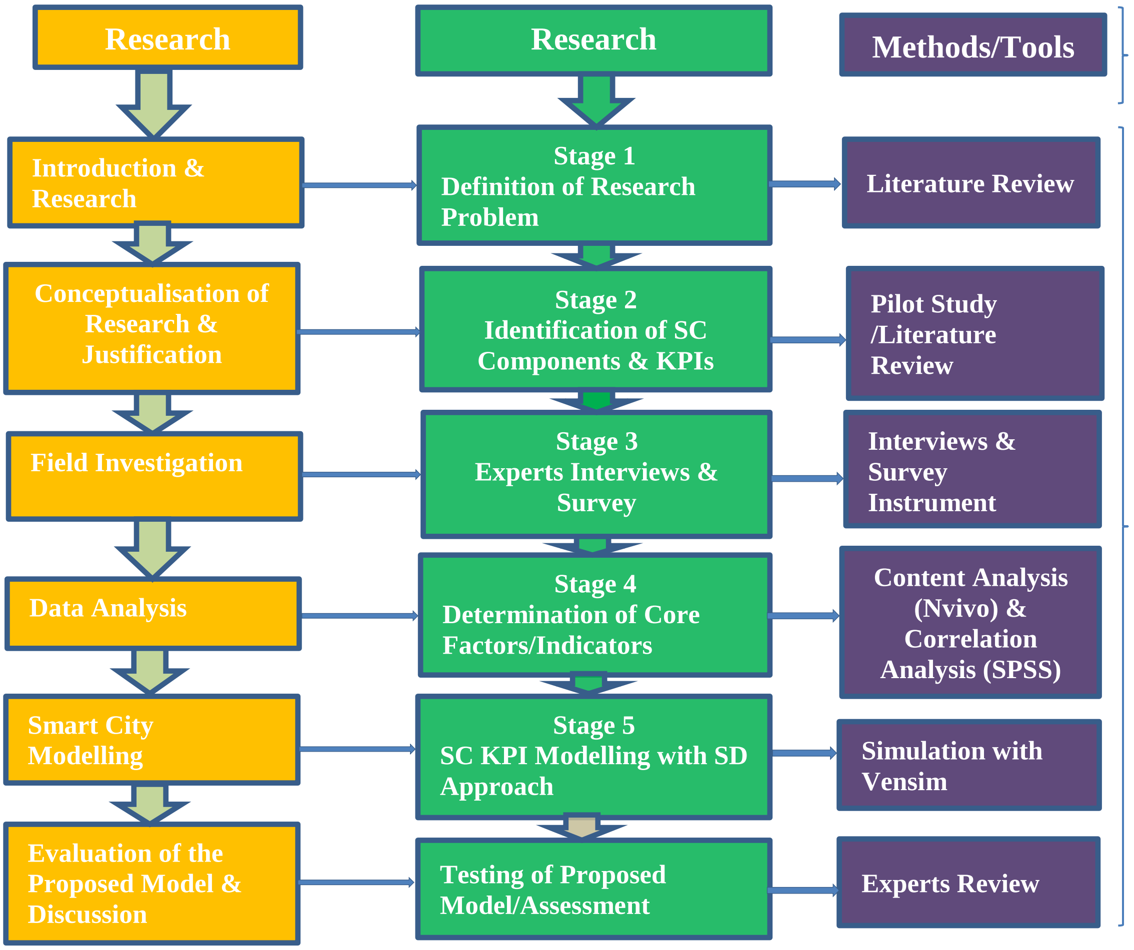


Figure 1-1: Thesis Structure and Methodological Processes of the Study

The above schematic structure of the research design provides a clear summary of the different stages of the study. The methodological steps are outlined in the following stages.

Stage 1: The preliminary stage focused on assessing current state of the art Smart City innovations to explore the key context of Smart City development, the existing frameworks, and how they are implemented in different city regions. A systematic literature review was undertaken to achieve this. Through this process, a clear definition of the Smart City concept amongst stakeholders was developed along with an understanding of their perception of the drivers for their Smart City vision. Moreover, the business models that helped to identify the knowledge gap in this field of study and the critical success factors were also classified. This helped in the selection of the case study locations. In addition to identifying and documenting the social and economic implications of Smart Cities within the context of social and technology innovation, this stage involved the conduct of systematic and in-depth literature analysis concerning the implications of social innovation, emerging technologies, proposed architecture, and the challenges that Smart City technologies potentially address.

Stage 2: In order to identify the core components and critical success factors of Smart Cities, a pilot study was undertaken through a discussion with professionals to confirm their understanding and agreement on the core components and the relevance of these measurement areas for KPIs in a Nigerian environment. An exploratory factor analysis was employed to assess how the factors that constitute the components cluster and to ensure that only relevant factors were retained for further analysis. Through this same process, a further review of the existing Smart City standards and frameworks was undertaken. The process helped in the design of the survey instrument and the interview guide for the field investigation.

Stage 3: This stage led to the collection of data through qualitative and qualitative means. The research philosophy section in Chapter 4 summarises the selected methods and justifications for this process.

Stage 4: The core factors and indicators of the KPIs were determined, firstly through the content analysis using Nvivo version 11, and secondly through the survey outcome analysis using SPSS version 23. The instruments were analysed using various data analysis techniques, which included descriptive statistics, a non-parametric test (Kruskal Wallis), and reliability tests. To assess and confirm the underlying relationships among the Smart City factors and indicators, Spearman's Correlation analysis was employed.

Stage 5: Based on the correlation analysis and a content analysis of the interviews with experts, the dynamic relationship among the factors and indicators was modelled using Vensim for System Dynamics. Thus, the interdependencies and interactions of the Smart City KPIs for assessing smartness were run with a simulation to understand their relationships. Moreover, tests were run, including stock and flow, to validate the model.

Stage 6: The proposed framework model was assessed by a review by experts, and validated as a proposed KPI model for a Smart City assessment framework.

1.8 Unit of Study and Analysis

It should be noted here that this research seeks to develop a framework to promote innovation in the socio-economic development in Smart Cities in the context of FCT-Abuja, Nigeria. Thus in this study, the main unit of study and analysis are the Smart City strategies and related initiatives currently implemented within the city of Boston, Abuja, and Manchester. Secondly, the top management staff within the organisations that are responsible for policy direction. Thirdly, the line-managers such as project managers, innovators, and consultants who contribute to the development and deployment of Smart City solutions across cases. A wide range of unit of analysis was necessary to gain better insights and analyzing the respondents perception on Smart City concept in considering holistic and embedded qualities of the case studies where individual organization investigated would be treated as one unit of analysis. This argument is supported by DePoy and Gitlin (2015) who argues that an evaluation of global units of assessment can be carried out for holistic case studies. Chapter 4 presents unit of analysis in details.

1.9 Novelty and Contribution to the Body of Knowledge

The discussion in the literature review will highlight existing research in this field of technological advancement. In view of the fact that modern cities across the globe are recognising the benefits of adopting emerging technologies to improve the quality of life for citizens through improved decision-making, developing an appropriate framework and innovative strategies for managing a sustainable Smart City represents a new research direction. There is currently no detailed research that analyses theory and practice with respect to building a sustainable Smart Cities framework using empirical evidence. Moreover, there are none that address the basic challenges of developing countries in terms of the relative disparities between wealthier and the poorer citizens across different economic regions, based the experiences and culture of these cities.

It is therefore evident that research is required to strengthen the previous efforts in this field in order to develop a better understanding and thus help to address key issues in innovation, emerging technologies and infrastructure in building Smart Cities in the context of cities in developing countries. This research will therefore add to the knowledge of Smart City development through examining the context of cities in developing countries, in particular

FCTA, whilst emphasising the need for empirical evidence aimed at introducing technologies to all cities.

1.10 Ethical Issues

The rights of those who may be affected by this study, in terms of the privacy and confidentiality of participants or respondents, will be duly considered as part of the researcher's responsibilities in maintaining professional honesty and integrity, especially when interpreting sensitive information. Thus, the rights to privacy, informed consent, and validation have been carefully considered when obtaining qualitative and quantitative primary data. In view of this, the ethical procedures of the University of Salford regarding research studies that involve human subjects were carefully followed and ethical approval obtained before the field work commenced (See Ethical Approval Attached as Appendix D).

1.11 A Guide and Structure of the Thesis

Overall, the thesis will provide a detailed study on social and technological innovation in Smart City deployment focusing on core components and challenges in the context of cities in developing countries and the KPI metrics for monitoring performances in Smart Cities. The guide and structure of the research are presented in the following chapters that reflect the research objectives:

- Chapter 1 provides an introduction with the aim and objectives of the study, the research problem, and the formulation of research questions that address the objectives.
- Chapter 2 presents a review of relevant literature on the concept the Smart City and its key context.
- Chapter 3 focuses on the implications of social innovation and emerging technologies in building sustainable Smart Cities.
- Chapter 4 is dedicated to a discussion on the research methodology.
- Chapter 5 discusses the standardisation of the Smart City and develops a conceptual framework for Smart City KPIs in order to assess the impact of 'smartness'.
- Chapter 6 presents the case study analysis and results.
- Chapter 7 presents the quantitative analysis of the survey data and the System Dynamics modelling.

- Chapter 8 discusses the results and presents the refined conceptual framework model for Smart Cities.
- Chapter 9 draws conclusions, recommendations and outlines the scope for future research.

1.12 Chapter Summary

This chapter has introduced the context and focus of the study with a review of the current understanding of the Smart City concept. The research aim and objectives as well as the research questions have been outlined. The chapter also noted that a mixed method approach was adopted to collect both qualitative and quantitative data, which was analysed using a combination of tools and techniques to derive meaningful results. The next chapter provides a review of relevant literature on Smart and Sustainable Cities and its contexts.

CHAPTER 2

2.1 The Smart City and its Key Context – A Review of Background Literature

This chapter reviews a wide range of relevant literature on Smart Cities. The chapter begins by establishing a general understanding of cities and their development. Since the Smart City concept is an emerging area, a literature review that examines current research is necessary to determine a generally accepted definition for the Smart City and to gain better understanding of the concept. Thus, various definitions from different perspectives in existing literature are analysed. In addition, the chapter identifies other theoretical foundations relating to Smart City characteristics/components, Smart City sustainability issues, and the drivers of Smart City innovation as outline in figure 2.1. It provides a summary which serves as guidelines for the primary data collection (survey/interview) and the empirical analysis. In this study, the word 'city' and 'cities' will be used interchangeably referring to the same entity depending on the context.

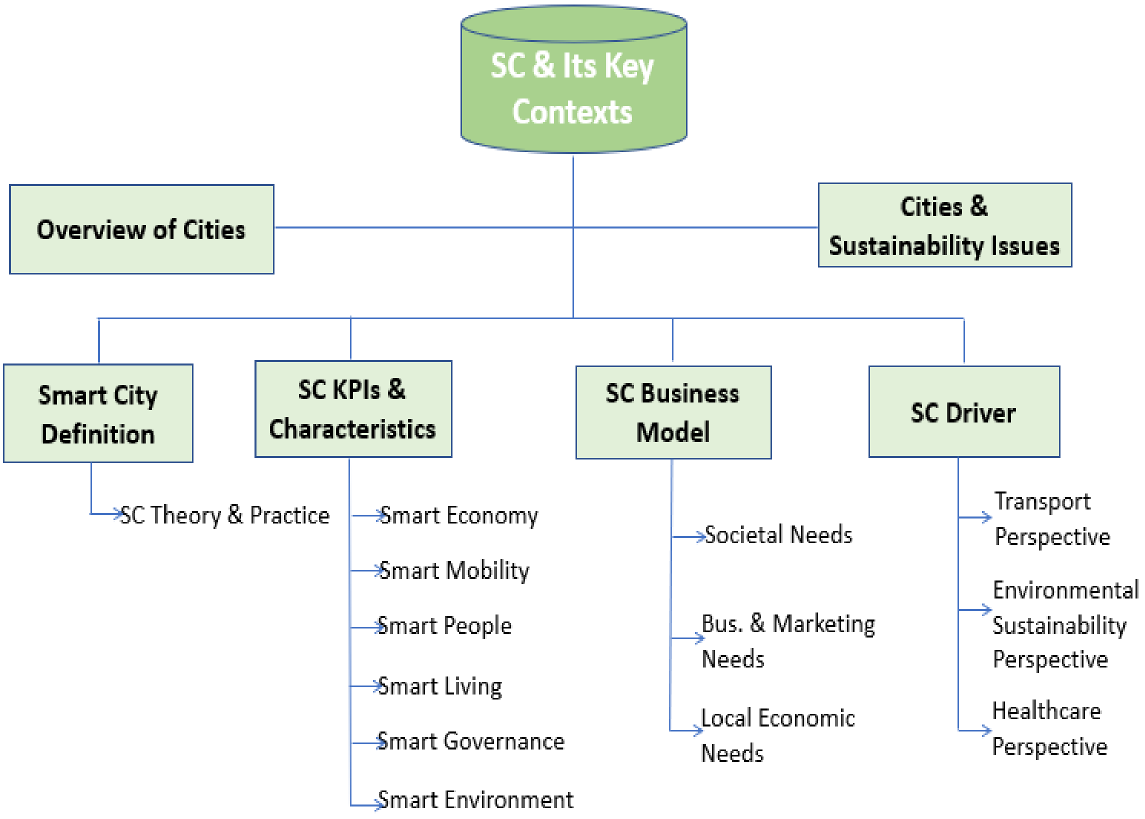


Figure 2-1: Outline of Smart City Literature Review and it Core Contexts

2.2 An Overview of Cities and Development

The origin of what is known today as a city is obscure, as it is difficult to trace its entire history in the same manner as it is difficult to weigh its future prospects. This supports the perception that no single definition can capture the true manifestation of the subject of the city nor describe all its transformations (Mumford, 1966). A city can be perceived as integrated systems, a social institution, and a determinant of social processes; however, in this study, it can be seen as an urban agglomeration where many services are needed or provided. In some instances, a city is referred to as a ‘geographic plexus’ highlighting its key attributes from the perspective of how it serves as an economic organisation; other descriptions include, a ‘theatre of social action’, an institutional process, and an aesthetical symbol of collective unity (Pile, 1999). From such perspectives, a city is seen as network of systems. Furthermore, Batty (2008) uses systems theory to explain a paradigm shift in the evolution of cities, describing them as complex systems whose structure merges from the bottom up rather than from the top down. As such, cities were regarded as features that were knotted together in sets of interactions.

Cities have witnessed an unprecedented level of development over the previous two centuries, or more precisely from 1750 and 1950 (Lampard, 1955). Although the existence of cities in different forms predated this period, the main movement of people and economic activities, especially amongst the regions that benefited from the Industrial Revolution, were more intensive during this time. In this phase of city evolution, many settlements in Europe and America significantly transformed from being simply regional hubs for trade to become vibrant centres of serious commercial activity in manufacturing and services (Hall & Raumlaner, 1998). For instance, London was the world’s greatest merchant city between 1570 and 1620, attracting a significant opportunities for wealth creation while also drawing talents from cities in other regions (Hall & Raumplaner, 1998). Moreover, Hall and Raumlaner state that, between 1870 and 1910, Vienna and Paris became affluent enjoying substantial growth in cultural expression, whilst, in the 1920s, Berlin was an extraordinarily creative city with a similar pattern of urbanisation. This pattern of development also spread across many cities in Europe, such as Athens and Florence (Hall & Raumlaner, 1998). However, during this period, cities were relatively small in size whilst, in contrast, cities in the current phase of urbanisation have become so big and complex that they now present real impediments to effective urban organisation. The development trend in cities is changing drastically with technological innovation introducing new waves of economic development.

Regardless of the development challenges they pose, through the publicity of international organisations that work with cities all over the world, cities have recently become seen as powerful tools for sustainable development. For instance, in the quest for sustainable development, the European Union identified cities as vehicles for sustainable development in view of the critical roles they play in the future of regions (Rotmans, van Asselt, & Vellinga, 2000). Interestingly, this development is encouraging competition amongst regions and between cities which reflects the increasing pervasiveness of the concept of competiveness in urban and regional economic strategies (Turok, 2004).

With cities gaining recognition as vehicles for driving sustainable development, a number of international organisations are focusing on their development through city-centric initiatives that drive growth in different regions across the globe (UN SDSN, 2012). In this regard, the United Nations [UN] identified 17 priority areas within its 2030 sustainable development goal entitled “Transforming our World” United Nations, (2015) . These 17 areas included: inclusivity, safety, resilience, and sustainability . Many of the UN departments (e.g. UNHABITAT) and other international agencies, corporations and NGOs are now collaborating with cities across the globe to achieve this target. For instance, the World Council on City Data (WCCD) published ISO 37120 as the first international standard on city indicators and quality of life (McCarney, 2015). Also, the Organisation of Economic Cooperation and Development (OECD), in partnership with major cities including Toronto, Montreal, Mexico City and Guanteng, have significantly contributed to the sustainable development of cities through the application of territorial reviews.

2.3 Cities and their Sustainability Issues

Increasing environmental problems and their related concerns have brought the issue of sustainability to the forefront of stakeholder discourse on Smart Cities. In order to address the issue of sustainability, stakeholders are now adopting creative, intelligent, and innovative solutions in a global effort towards sustainable city development. Given the economic and social challenges faced globally, advanced cities, especially those in Europe, are evolving strategies for the adoption of innovative approaches that can leverage the socio-economic development of urban areas (Komninos et al., 2013).

According to the United Nations' [UN] Department of Economic and Social Affairs (2014), Africa and Asia are taking the lead in the global trend for increasing urbanisation with a projection showing that Africa will attain 56% urbanisation by 2050, while Asia is expected to reach 64% in the same period. The UK's Department for Business and Innovation Skills (2013) further posited that 80% of the current global GDP is generated in cities, of which 50% was recorded from 380 cities in the developed economies of the world, especially in Europe and America. In its analysis, the report estimated a growth pattern that will shift to the East by 2025 with China contributing significantly to the upward trend of urbanisation through an unprecedented rise in its urban population. However, Saunders and Baeck (2015) posited that national governments, city planners and technology solution providers across the world are currently evolving strategies to address the challenges of mobility around cities, the provision of utilities, especially energy, and, most importantly, the safety of humans and the environment. In contrast, in its Smart solution for cities, Arup (2011) revealed that such areas are becoming overwhelmed as 50% of the current global population now reside in cities. According to Arup, this percentage of the human population generates 75% of the carbon emissions, which are now complicating the challenges of climate change as the demand for resource utilisation continues to increase.

To address such issues, Sauders and Baek (2015) state that China and India alone are currently planning about 300 Smart City pilot projects in addition to various other efforts. This is an indication that areas of the world are developing to a stage where most governments are now investing heavily in one form of Smart City project or another. For instance, the American Planning Association (2015) observes that city planners, engineers and other stakeholders are now being challenged to take responsibility for articulating clear-cut visions for cities. This is achieved through the collection and analysis of robust data to measure performances and through the identification of how plans will improve the standard of living in cities whilst also keeping planners up to date with the evolving elements of the city. At the regional level, especially in Africa and other developing countries, there is a need to build innovative ecosystems within the sub-regions for the effective sharing and distribution of resources; this is particularly relevant to the focus of this study and thus requires further investigation.

In addition, the globalisation of environmental problems has raised more awareness of the need to reconsider the manner in which the development and management of cities and the application of new technologies are undertaken in view of concerns regarding sustainability. Addressing sustainability issues in Smart City deployment will mean dealing with a number of challenges, such as strategic assessment to identify the required solutions, mitigating measures to manage the negative impacts of development, adopting the right approach (top-down or bottom-up), establishing competencies by bridging the skills gap between city administrators and solutions providers, and considering the issue of governance (Höjer & Wangel, 2015).

Rapid urbanisation in Africa (acknowledged by UN), to which Nigeria is a significant contributor, points to the fact that the region is also facing the challenges of environmental sustainability (e.g. climate change), resource depletion, social polarisation and a host of other negative impacts. These emerge from developments that do not consider appropriate measures to curtail negative impacts. Smart City research, such as the studies by Bătăgan (2011), Schaffers et al. (2011a), and Paroutis, Bennett, and Heracleous (2014) also support this view.

2.4 Towards a Generally Accepted Definition for Smart City

Smart Cities represent an emerging area of research that is gaining a lot of attention. A number of definitions have been proposed and one such notable explanation was given by Forrester (n.d., cited in Washburn & Sindhu, 2009, p.2) who defined a Smart City as, "the use of smart computing technologies to make the critical infrastructure components and services of a city – which include city administration, education, healthcare, public safety, real estate, transportation, and utilities – more intelligent, interconnected, and efficient". Similarly, IBM (2009), cited in (Dirks & Keeling, 2009) offered a definition from an industrial point of view;

> … a Smarter City uses technology to transform its core systems and optimize resources. At the highest levels of maturity, a Smarter City is knowledge-based system that provides real-time insights to stakeholders, as well as enabling decision-makers to proactively manage the city's subsystems. Effective information management is at the heart of this capability, and integration and analytics are seen as the key enablers.

In comparison, according to Gartner (2012), cited by Lee, Hancock & Hu, 2014),

> … a Smart City is based on intelligent exchange of information that flow between its many different subsystems. This flow of information is analyzed and translated into

> citizen and commercial services. The city will act on this information flow to make its wider ecosystem more resource-efficient and sustainable. The information exchange is based on a smart governance operating framework designed for cities sustainable

Lee et al. (2014) posited that the Smart City derives its definition from a combination of "information city, knowledge city, intelligent city, ubiquitous city, and digital city". Following a critical evaluation of the different characteristics of a Smart City, Lee et al. (2014) concluded that, "Smart Cities are envisioned as creating a better, more sustainable city, in which people's quality of life is higher, their environment more livable and their economic prospects stronger".

In addition, Harrisson (2011), cited in Chourabi et al., 2012) considered that a Smart City connects the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city. According to Batty et al. (2012), Smart Cities are simply "instruments for improving competitiveness in such a way that community and quality of life are enhanced". In an effort to come up with a standardised definition for Smart and Sustainable Cities, the International Telecommunications Union [ITU] (2014), analysed over 100 publications which offered a definition of a Smart Cities, and noted that these definitions revolved around 50 keywords that included: quality of life, ICT, technology, innovations, management, systems, integrate, and intelligent. The occurance of approxiately 726 of these keywords were analysed by ITU to measure or compare their importance on the subject matter.

Therefore, it is important to note that a wide range of definitions exist in the literature, which provide different labels for a city; these include including intelligent city, knowledge city, ubiquitous city, information city, technology city, wired city, creative city and digital city (Hollands, 2008; Nam and Pardo, 2011b). In all the label definitions, which some analysts referred to as 'cousins of the Smart City', the terms used are not totally different neither are the ideas clearly separate from what is essentially the same objective, namely urban development (Agbali, Arayici, & Trillo, 2017). The term Smart City therefore represents a convergence of many labels, as represented in Figure 2.2.

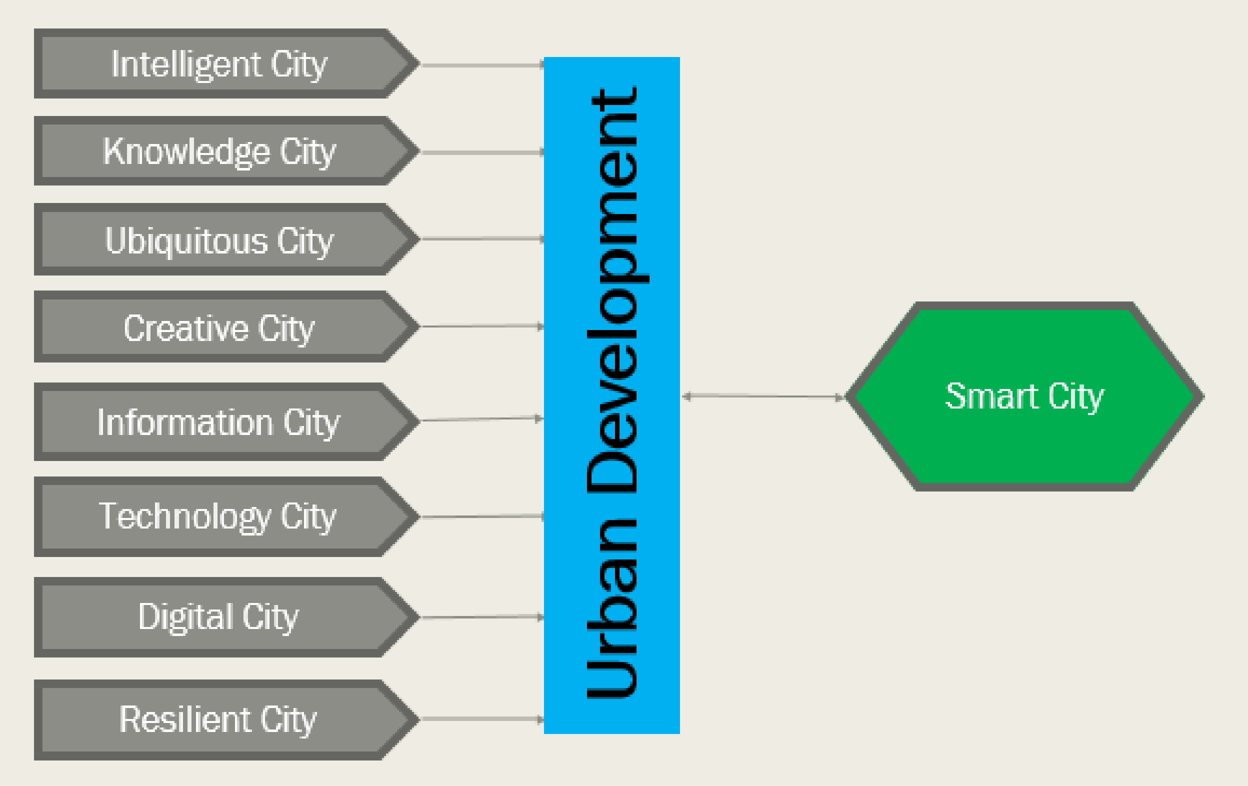


Figure 2-2: Convergence of Different City Labels in Smart City

In summary, the issue of improved services and quality of life are considered imperative in a Smart City. Thus, around the globe the Smart City concept has the central objective to improve citizens' social, political, cultural, and economic quality of life in today's densely populated cities, and to promote equal access, devoid of any form of exclusion, in terms of time and location. Hence, it is crucial for Smart Cities to create knowledge as well as transfer knowledge, social innovation and a host of other services by using emerging technologies, such as those in Cloud Computing, as a platform to solve the environmental, ecological, social, and sustainability problems that face the ever-expanding cities of today.

2.5 Smart City Characteristics and Key Performance Indicators

Urban scholarship from both industry and academia have acknowledged the lack of consensus and formality in the definition of a Smart City (Hollands, 2008; Lombardi, Giordano, Farouh, & Wael, 2012). In spite of the ambiguity in definitions, different perspectives of Smart City characteristics and components can be found in the literature. However, within their study, Giffinger et al. (2007) identified a number of Smart City characteristics and components which were classified into the following six major domains: Smart economy, Smart mobility, Smart environment, Smart people, Smart living, and Smart governance.

Various international organisations and renown scholars have approached the Smart City framework with different key performance indicators (KPI) models that propose to assess the impact of Smartness (Table 2.1). Among these organisations is the International Standardisation Orgainisation [ISO] which provided a broad-based model that captured 100 measurement areas. There were grouped into core and supporting indicators and proposed in its publication, “Sustainable Development of Communities Indicators for City Services and Quality of Life”. In a focus group technical report on Smart and Sustainable Cities, the International Telecommunications Union (2014) defined key performance indicators that established eight dimensions/categories of Smart City themes, which were based on existing literature. These were: environment and sustainability, economy and finance, quality of life and lifestyle, infrastructure and services, ict communication/intelligence/information, people-citizens-society, governance/management and administration, and mobility. The ITU framework aligns with the United Nations Habitat’s dimension for city prosperity which also established urban governance indicators relating to security, effectiveness, equity, participation, and accountability. IBM (2012) uses a three pillar framework that emphasises people, infrastructure, and planning and management. The three pillars were established with the following ten critical success factors: energy, government and administration, city planning and operation, education, smarter care, social programmes, water, buildings, public safety, and transportation.

Similarly, a number of frameworks with associated factors and indicators for measuring the performance of cities have been proposed. For instance, Giffinger and Gudrun (2010) proposed a KPI framework model in line with the six core characteristics highlighted in Giffinger et al. (2007). The six components were associated with 31 critical success factors and 74 indicators as areas of measurement. These six domains were referenced in a range of literature (Chourabi et al., 2012; Lee et al., 2014; Lombardi et al., 2012;).

Table 2.1: Smart City Benchmarking Tools and Frameworks

Source	**KPI Tool**	**Dimension**
Giffinger & Gurun, 2010	Smart City Ranking Framework	Economy, people, environment, governance, mobility, and living
UN Habitat, 2004	Urban Governance Indicators	Security, effectiveness, equity, participation, and accountability
ITU, (2014)	Smart Sustainable City: Technical Report	Economy/resources,ICT/communication/ intelligence/information, infrastructure,environment/sustainability, people/citizens/society,quality of life/lifestyle, governance/management/administration, mobility
IBM (n.d.)	Smarter Cities	Infrastructure, human, and planning & management
Palmisano, 2008	IBM A Smarter Planet: The Next Leadership Agenda	Smart healthcare, Smart power grids, Smart food systems, Smart weather, Smart water management, Smart financial systems, Smart oil field, and Smart telecommunications network
Nam & Pardo, 2011a	Conceptual Smart City Framework	Technology, people, and institution
Chourabi et al., 2012	Smart City Integrative Framework	People and communities, management and organisation, policy context, economy, natural environment, technology, built infrastructure, and governance
Lombardi, Giordano, & Yousef, 2012	Smart City Performance Modelling	Smart economy, Smart human capital, Smart environment, Smart governance, and Smart living
Cohen, 2012	Smart City Wheel	Smart economy, Smart people, Smart environment, Smart governance, Smart mobility, and Smart living
Lazaroiu, & Roscia, 2012	Model for Computing the Smart City Indices	Economy, people, environment, governance, mobility, and living
(Kourtit, Macharis, & Nijkamp, 2014)	Global City Performance Measurement Indicators	Environment, economy, R&D, culture interaction, livability, and accessibility.

Although in some instances more dimensions were added (Nam, 2011), the fundamental issues addressed by these frameworks were similar. Moreover, (L. G. Anthopoulos, 2015) conducted a review focused on resource, transportation, urban infrastructure, government, living and economy, and confirmed a six dimensional model with the additional dimension of coherence. Similarly, Neirotti, De Marco, Cagliano, Mangano & Scorrano (2014) also extended the six dimensional model with an added dimension of smart building. However, the model proposed by (J. H. Lee, Hancock, & Hu, 2014) introduced a new concept that focused on urban openess, service innovation, partnership formation, urban proactiveness, smart city infrastructure integration, and smart city governance. The factors associated with these six dimensions are summarised in the following sub-sections., whilst the dimensions are common reference points in most existing Smart City models.

2.5.1 Smart Economy

The competitiveness of cities is now measured in terms of innovative business models, employment, and sustainable growth using the factors of entrepreneurship, productivity, innovative spirit, the flexibility of doing business, economic image/trade mark, and so forth.

2.5.2 Smart Mobility

In an era when climate change has taken centre stage in the global development agenda, the Smartness of cities is expected to reduce traffic congestion through the easing of logistics in order to minimise carbon emissions around densely populated cities. In this domain, safe transport systems, local accessibility, international accessibility, and the availability of an ICT infrastructure that drives innovative transport systems are considered imperative factors in Smart City rankings (Giffinger et al., 2007).

2.5.3 Smart People

Developments in cities are centred on people as the major drivers of Smart initiatives; this is because people determine the failure and success of any initiative (Chourabi et al., 2012). The people component therefore requires creativity, education, and knowledge to drive the information economy in Smart Cities. In this domain, creativity, flexibility, the level of qualification (education), empathy in life-long learning, and social awareness are important factors that determine the smartness of the citizenry (Nam & Pardo, 2011a).

2.5.4 Smart Living

The ability of a city to offer the right solutions to the needs of the city dwellers, and the active management of public spaces to improve the attractiveness of a city are considered imperative (Neirotti et al., 2014). The satisfaction of citizens living in a city are important as this relates to improvements in quality of life, which are achieved through various factor-based initiatives, such as individual safety, social cohesion, quality health condition, housing quality, and life expectancy (including the promotion of cultural development and other welfare issues).

2.5.5 Smart Governance

The Smart City initiative requires innovative policies to achieve the use of tools in a Smart way (Nam & Pardo, 2014); thus, an effective institutional governance structure is imperative.

Governance is all-encompassing in that it cuts across all city services outlined in other components through the provision of a reliable infrastructure to deliver a clean environment, job creation, healthcare, and so forth. The key factors in this domain therefore include transport governance, participatory processes in decision-making, and social services since governance plays pivotal roles in coordinating initiatives.

2.5.6 Smart Environment

Lastly, the environment constitutes a critical component in the Smart City agenda as the issue of global warming has received substantial attention in the international development goals, moreover the elimination of poverty, and improvements in health and building security are also key considerations. Cities that aspire to Smartness are now focusing on strategies to reduce carbon emissions through initiatives such as Smart Grids and other innovations that support the capacity of the city's ecosystem (Tanguay et al., 2010). The key factors in this domain include: environmental protection, decreased environmental pollution, sustainable resource management, air quality, green space, and waste management.

In all, the conceptualisation of what constitutes a Smart City is still an ongoing debate as discussions amongst experts are yet to resolve the confusion between the basic components of a Smart City, its vision, and what many authors refer to as the main characteristics of a Smart City. Nevertheless, the aforementioned six main components have already been adopted for Smart City ranking, especially in the European Union [EU]. Chapter 5 further discusses the detail of Smart City standards, the framework on Smart City components, and the associated factors and indicators established from the literature and pilot study.

2.6 Setting the Stage for Smart City Research: Trend in Smart City Theories and Practice Scholarship Today

Innovative developments in technologies affect societies and cities, which have undergone significant changes in recent years. Given the compelling social and economic potential of the Smart City, many developed economies are embracing the concept regardless of the notion that a "Smart City is just a label or buzzy concept". The developed economies of the world, mainly in Europe, America and Asia, are taking advantage of the concept as a new approach to urban development and as a way of revitalising economic opportunities through concerted efforts to upgrade existing or emerging cities in order to firstly, meet the status of a knowledge-based city and secondly to strengthen their global competitiveness (Nam & Pardo al., 2011b).

In a critical analysis of the state of the art in Smart City development, Hollands (2008) posited that Smart Cities need to focus on people and the human capital aspect of city innovation in order to avoid issues that relate to inequalities which can arise as a result of a focus on technology. According to Hollands' study, for cities to attain Smartness, the challenges of the digital divide, widening inequalities and the potential for social polarisation must be addressed. Hollands emphasised the need to analyse the business interest of specific urban cases in that the entrepreneurial Smart City may cater for a small number of professionals as well as encourage capital flight. In a proposed framework designed for managers seeking to deliver effective Smart City projects, Lee et al. (2014) further identified gaps in terms of measuring how existing industries are influenced by Smart City initiatives as well as how start-ups and entrepreneurs can innovate with new 'green and smart firms'. The framework specifically emphasised the need for the comprehensive measurement or evaluation of how smart technologies are changing cities and how institutions and human factors impact on a Smart City. Using San Francisco in the USA and Seoul Metropolitan city in South Korea as case studies, and despite its limitations, the Lee et al. provided a conceptual framework for the conduct of case studies in building sustainable Smart Cities. The authors attempted to analyse the taxonomies of Smart City planning and development in six key dimensions and further sub-grouped Smart City practices into 17 sub-dimensions. Based on their findings, the framework was conceived as a point of reference to guide city planners in both developed and developing Smart Cities. In particular, the challenges of measuring the impacts of a city's smartness on entrepreneurial development and startup innovation are relevant to the focus of this study and require further research. To address the issue of sustainability, a Smart Cities framework needs to consider the concept of Public Private Partnership (PPP) with due consideration for local content in order to address the issues raised by Hollands.

Similarly, in a conceptual model for Smart City development, Nam and Pardo (2011a) suggest the need for a proper understanding of the socio-technical complexities that drive future cities. The study adopted a three-pronged approach to address the core components of a Smart City (i.e. technology, people, and institutions) and identified the need for a proper evaluation of the possible impacts of new technologies on human and traditional institutions in urban dynamics. In smarter ways to manage the many problems of cities, Chourabi et al. (2012) grouped the factors of Smart Cities into eight clusters: management, and organisation, technology, governance, policy, people and communities, the economy, built infrastructure and the natural environment. According to Chourabi et al., the primary objectives of a Smart City are to achieve environmental sustainability and to use technology to improve quality of life and livability. The study concerns the interaction of city factors and the different levels of impact. The two-way impacts of how factors influence one another were analysed in the context of outer and inner factors. Whilst these frameworks agreed on the need to address the gap in measuring how Smart Cities, or Smart Technologies, impact on cities, none of the studies addressed the disparities that exist between developed economies and the developing world in terms of the infrastructure that drives Smart Cities. Although it may not be realistic to develop a framework that will be suitable for all in view of the substantial gap between developed and developing economies (regarding infrastructure and specific environmental or regional challenges), it could be possible to adapt such a model if the basic issues are addressed.

Moreover, in a framework developed to guide planning, design, and engineering decisions, Appleyard et al. (2014) suggest that the relevance of livability should be considered when planning, designing, and engineering within the built environment circle. The study concerns the application of a livability concept in that the quality of life of an individual within a community needs to be pursued without denying the other individuals equal access to social and economic opportunities. Such a goal is critical to the focus of this study since the concept of the Smart City concerns the development of economic opportunities. According to Appleyard et al., the concept of livability is best understood as every individual living in a city having equal access to opportunities in the quest to improve their quality of life. The authors further evaluated a set of supporting and ethical principles as a guide for practitioners in the construction sector and prescribed how a community or place is considered livable with suggestions on mechanisms for measuring performance in the critical sectors of a city. Worthy of note, however, is the fact that the framework could not measure individual satisfaction against quality of life, which suggests the need for further study in the areas of social and economic opportunities. Similarly, in developing an information blueprint to create a Smart City using the Internet of Things (IoT), Jin, Gubbi, Marusic, and Palaniswami (2014) revealed that there is high demand by city administrators globally to ensure the provision of essential services that will improve the quality of life of city dwellers. In this framework, the systems for the live monitoring of cities and the decision-making processes of urban parameters were investigated. The lesson from this work is that few cities have adopted Smart Technologies for data collection and analytics to inform strategic decisions in real-time. The authors used the city of Melbourne as a case study adopting noise-mapping to experiment with the realisation of a Smart City through the IoT to meet the needs of urban habitants and a business sustainability model. The findings in this study placed a high premium on the quality of life as well as the technological impact on a city. Thus, the concept of knowledge management will be important in this study in view of the innovative challenges of technology concerning real-time data collection/analysis and in managing the policy innovations in city governance.

However, further emphasis needs to be placed on the critical roles of knowledge management in addressing the issues of enhanced social innovation and Smart specialisation in local economic development and entrepreneurial growth, and that these occur in a sustainable manner. It is essential to address the fundamental issues that new technologies, as drivers of development in the Smart City concept, could present to stakeholders, especially in developing countries. This poses particular threats for specific facets of a Smart City that could become vulnerable and thus require particularly close management, namely: resource depletion (due to serious contest for resources), greater energy consumption, increased gas emissions, and densely populated cities. Therefore, the concept of Public Private Partnership (PPP) potentially represents an ideal remedy if implemented with local content to address the sustainability issues that arise from the management and application of new technologies.

2.7 Smart City & Business Model

As described in the previous section, cities evolve as complex systems with an ecosystem that interacts to create values. In cities, therefore, the role of business models is to exploit common assets as well as to coordinate the value creation process in a vertical manner by ensuring that the actors involved profit from the outcome (Bankvall, Dubois & Lind, 2017) . Two business models have been proposed in-line with value chain associated with key Smart Cities drivers; these are related to safety, connected citizens, efficiency, the quality of life, economic growth, and the environmental improvement. For instance, Navid and Seyed (2016) proposed business models that applied qualitative and quantitative indices of energy with high a priority on the Smart City infrastructure. The model categorised the Smart City infrastructure into national, urban, and service infrastructure, and urban management.

In general, the application of a business model to Smart Cities aims to highlight the activity systems and explain the linkages amongst these activities in clear terms that include: which activities are performed, how are they performed, and who performs them (Datta, 2015). For example, according to Datta, Dholera Smart City based in Gujarat in India employed a business model for its urbanisation strategies and thus emerged as one of the most investor-friendly regions; this translated to improved annual growth rate of over 10% between 2004 and 2012.

2.7.1 Perspective of Societal Needs

To sustain the complex interactions amongst the city ecosystem, from citizen to citizen, business to business, and business to citizen, which includes services, and in order to enhance the well-being of the population, stakeholders need to address the social and economic challenges of the collaborative space as this can also encourage innovation and growth. Moreover, a sustainable environment with improved air quality and waste management systems that are adaptable to climate change must be addressed. Whilst, an improved quality of life and the introduction of modern industries that promote a greener environment, including long/short-term challenges, should similarly be considered.

2.7.2 Perspective of Business and Marketing Needs

As discussed in previous sections, a Smart City environment promotes social and technological innovations that can be sustained through the provision of smarter infrastructure that can respond to both business and societal needs. Hence, the city requires adaptive learning spaces to develop an adequate human capacity (Smarter People) in order to manage new business opportunities through responsive institutional arrangements (Nam & Pardo, 2011b). Chapter 4 further discusses these concepts in terms of Smart City KPI metrics for measurement and the need for a detailed Smart City standardisation.

2.7.3 Local Economic Perspective

The Smart City development is expected to impact positively on the economic growth of future cities. According to Neirotti et al. (2014), the local context factors will affect the development patterns of a Smart City. This means the geographical location, inequalities among the urban population, and other variables that are imperative in Smart City planning. Also, as Hollands

(2008) argues, the Smart City agenda in the global quest for the knowledge economy places a high premium on economic growth and competitiveness. Hence, the economic related issues of different urban regions need to be addressed.

Therefore, the concept of Smart specialisation plays an important role in local economic development (Neirotti et al., 2014). The European Union [EU] and many of the Organisation for Economic Co-operation and Development [OECD] countries (e.g. the United States of America and Canada) have adopted the strategy as a major driving force behind new innovation and regional policy reform. Thus, there are lessons to be learned in identifying the key factors that underpin the development gap between developed and developing countries, particularly with respect to the adoption of technology to promote growth. As such, finding ways to close gaps through accessing the potential of the knowledge ecology of cities in developing countries is essential as it will assist in identifying the relevant factors for consideration in Smart City efforts.

Essentially, the smart specialisation strategy aims to identify knowledge-based investments and innovations that are capable of driving development (Papa, 2013). The EU is, however, capitalising on this strategy to address new pressing challenges of cities and regions in the areas of sustainable resource and energy consumption, climate change, safety, and other health-related concerns. With this objective as the central focus, a number of EU cities are striving to attain the status of ‘smartness’ (Papa, 2013). Although these cities may have to contend with challenges associated with technological risks, the adoption of the ‘bottom up’ concept is gaining popularity in Smart City projects where citizens are expected to be at the centre of efforts to improve the life of cities. In this context, the smart specialisation vision will assist greatly in building sustainable economic growth. Such economic strategies in FCT-Abuja and other similar cities in developing countries, where national and regional governments are rushing to propose one form of Smart City project or another, may require further research to identify any hidden potential for development.

In general, sustained economic growth requires vibrant innovation and an entrepreneurial drive toward Smarter City initiatives; thus, stakeholders place entrepreneurship and innovation at the core of the Smart City construct to drive competitiveness (Kim, 2014). In Europe, a number of large cities are already proposing Smart City initiatives to try and attract new firms. For instance, in Amsterdam, Smart City initiatives integrate technology at all levels of the city’s sub-systems in order to drive local economic development as well as improve citizen participation/awareness through competitveness. The Amsterdam Smart City project focuses on two major goals, namely economic development and an improved quality of life for citizens (Renata, 2014). Similarly, the Barcelona Smart City initiative focuses on economic development, green infrastructures, and inclusiveness to promote innovation to achieve sustainable development (PWC, 2014). Developments in Smart City deployment, therefore, tend to suggest that the implementation of new technologies and approaches are critical sources of entrepreneurial development where creative and high-tech industries contribute to the attractive image of a city (Khraus, 2015).

Central to the goal of any city is efficiency and economic development; moreover, Leigh and Blakely (2013) posited that local economic development is continually evolving. On this premise, they argue that, although technology and innovation are essential components of the global response to development challenges (e.g. climate change), these factors cannot represent the sole solution. Hence local economic development requires entrepreneurial strategies to build a strong support network that focus on creating a culturally adaptive community and on, building an economic development strategy that is both knowledge-based and relevant to a number of issues regarding entrepreneurial and innovative development. Although the Smart City concept has substantial implications for virtually every sector of the city and national economy, this study mainly focuses on two key economic sectors, namely transport and health-care, when analysing the possible impacts of smart services on the selected cases.

2.8 Smart City Drivers and the Narrative

As previously discussed, the rapid growth of cities across the world create new economic opportunities and social benefits for citizens; however, at the same time, such growth in city populations introduce new challenges to service provisioning and infrastructure management (Washburn, 2010). In addition, at the core of the Smart City concept is service integration across city sub-systems for the optimisation and ability to offer new service possibilities to citizens (Ghanbari, Laya & Markendahl, 2017) . In this regard, Ghanbari et al. outlined the following five major building blocks that drive the Smart Cities concept:

i) Economic, social, and privacy implications,
ii) Developing e-government,
iii) Intelligent Transport Systems (ITS),

iv) Health & well-being, and
v) The digitally built environment.

Depending on the priority, or the challenges, of the city, its government and city administrators a focus on the Smart City drivers that are relevant to specific local development objectives is crucial. For instance, in Boston, mobility and waste management are major challenges; thus, environmental management and smart mobility (transportation) were identified as the driving forces of the Smart City programme, which is popularly known as GoBoston 2030 (City of Boston, 2014). Similarly, Chicago City focuses on four core Smart City drivers (i.e. transparency, accountability, analytics, and economic development) as strategies for a Smarter Chicago. Conversely, in Barcelona, traffic congestion, pollution and noise represent the most significant challenges (Arup, 2013); hence, the city focuses on relevant Smart City drivers to address such challenges.

In general, the core drivers of Smart Cities seek to address issues around environmental improvement (e.g. climate change and air quality), economic growth, cost efficiency, health and safety, quality of life, and so forth. This review focuses on key areas of innovative development in critical sectors, as citizen service clusters in order to identify the catalysts for the adoption of Smart City deployments. This entails addressing mobility challenges (i.e. transportation) and health & safety (health-care service delivery) amongst the core drivers in Smart City innovation. The imperative for this lies in the similarities between these sectors as most of these issues are addressed across cities that have adopted the Smart City concept.

2.8.1 Transport Perspective

In recent years, urban scholars have foregrounded the critical roles that infrastructure plays in advancing contemporary cities by examining how combined urban networks, for example freeways, ICTs, and other new technologies, have impacted on the urban environment, and especially on the movement of people, information, goods and services within and outside cities (Coutard, 2004). Practices in European and American cities suggest notable examples of service integration and systematic efforts to solve problems with congestion in cities; this has meant taking advantage of Mobile-to-Mobile (M2M) communications as well as the deployment of state of the art applications for parking facilities, real-time information on buses locations/arrival times, and last-mile information for timely decisions on driving routes (Kyriazis, Varvarigou, White, Rossi, & Cooper, 2013).

Transportation is a critical service for cities and one of the key components of service integration and day-to-day living (Kyriazis et al., 2013). Research findings suggests that 12% of the CO2 emissions that affect global warming are caused by transportation activities, which include metros, buses, trains, trams, and motorbikes (EU, 2011). According to Ashim (2013), the introduction of technologies to make city transport systems smarter is not a new phenomenon; Ashim cites the cases of cities in North America (e.g. Pennsylvania) that have introduced such initiatives to improve mobility around the urban environment. Through IBM's Smarter Cities Challenge, a number of US cities have also commenced programmes aimed at addressing mobility problems around the cities, although many are still at the experimental stage. Nevertheless, the impacts of these innovations are already visible in many urban centres. In Boston, for instance, the transport sector is the main focus of the GoBoston2030 initiative to reduce CO2 emissions (Boston City, 2015). With global warning posing a serious threat to liveability and the continuous increase in demand for city transport, there is a need for controlled transport systems to leverage the influence of new technologies; such development could form the core of Smarter City initiatives in different regions.

With advances in new technologies, such as RFID, sensor, and IoT, communication between devices have become simplified, which in effect, makes transport systems 'smarter' to optimise; this subsequently drives operations and improves the experiences of the traveller. Therefore, the concept of the Smart City needs to be understood in a cross-sector context to allow for spatial functionality. This is because data derived from the city's sub-systems, which are managed by technologies, shifts the utility of the space. Indeed, Kyriazis et al. (2013) proposed the need for eco-conscious public transport systems that will leverage IoT in a sustainable way in order to realise the full potential of these emerging areas.

2.8.2 Environmental Sustainability Perspective

One of the core objectives of the Smart City development is to improve the sustainability of urban environment with the aid of technologies (Ahvenniemi, Huovila, Pinto-Seppä & Airaksinen, 2017) . According to Lombardi et al. (2012), environmental sustainability and its issues are considered important drivers of Smart Cities and general urban development.

Caragliu et al. (2011), who re-echoed the assertion that environmental sustainability formed a major strategic component of Smart Cities, emphasised the need for cities to gurantee the safe and renewable use of their natural heritage. Moreover, Ahvenniemi et al. (2017) acknowledged that a number of Smart City studies focus mainly on technical and environmental aspects and this this gives impetus to the recommendation by Angelidou (2014) that Smart Cities should put technologies at the services of their inhabitants and not the other way round. Angelidou argues that human-centered approaches to the problems of urban environment are essential features of a Smart City.

The use-case examples of Smart City initiatives in environmental sustainability focuses mainly on emergencies, air quality, climate change, and waste management. For instance, in the Manchester Oxford Road 'Corridor', Manchester City Council, in collaboration with private partners and Research and Development [R&D] institutions, deployed Smart City technologies to monitor air quality in the form of a low-carbon urban laboratory that creates a recursive feedback loop intended to facilitate adaptive learning (Evans & Karvonen, 2014). The Manchester Smart City initiative in air quality monitoring is a typical example of a climate-change agenda that aims to reinvigorate the need to adopt new technologies/techniques for urban sustainability governance while stimulating economic growth. Moreover, Grossi and Pianezzi (2017) report that Genoa City in Europe is partnering Toshiba and Selex to deploy Smart City solutions to address the challenges of hydrological instability in order to reduce the potential for future emergencies in the area. In the area of waste management, North American cities, such as Boston, Seattle, Pittsburgh, and New York, are integrating the Smart City concept into the Open311 non-emergency digital platform for real-time urban maintenance services (Lee, Alvarez Felix, He, Offenhuber & Ratti, 2015) . In addition, these cities are also pushing the promotion of green initiatives to the next level through 'trash-tracking', which is a GIS-based smart innovation aimed at addressing the challenges of waste management and urban sustainability (Phithakkitnukoon, Wolf, Offenhuber, Lee, Biderman & Ratti, 2013) .

2.8.3 Health-Care Perspective

Health-care is one of the critical sectors of cities or national economies across the globe. Research on intelligent health-care systems in Smart Cities have proposed that remote health-care (smart and efficient) service provisions should represent a major component of a Smart City concept in order to improve the quality of life for an increasingly urban population

(Suman, 2015). However, a number of privacy and security-related issues have been raised with respect to the deployment of emerging technologies for mobile health (m-Health) and smart health (S-Health) in Smart Cities (Ding, 2016). Nevertheless, Ding further proposed the implementation of some effective information protection methods for m-Health to better ensure privacy and security in an efficient/sustainable manner. Furthermore, research into ubiquitous technologies (Alawharah, 2016) offer a cloud-based Publish/Subscribe framework to manage the complex applications for health-care and public safety in Smart Cities.

Given the growing potential of computing devices/new technologies to impact cities through the monitoring and real-time analysis of city data almost without human interference, new Smart Cities (e.g. Sondgo, Korea) testify to how emerging technologies are integrating into urban areas by building new opportunities (Kitchen, 2014b). Moreover, through a real-world implementation (pilot) in Bristol, research into healthy cities (Zhu, 2014) offers a means of deploying Ambience Assisted Living (AAL) to bridge the gap between the state of the art provision and the demand for the health-care services in Smart City regions. Additionally, with the IoT, communities are now connected in new ways, which potentially helps to form a smarter and happier environment that links atoms--humans to another human--or device to device (Maged et al., 2015). Harnessing the potential of the IoT therefore could benefit health-care delivery to improve individual well-being and the overall quality of life of the population.

2.9 Summary and Gaps in Literature

Most of the recent research into Smart Cities or urban scholarship has tended to focus on technological innovation (for instance, Townsend, 2013) and neglected the social side of the Smart City concept. Although Hollands (2008) emphasised the need to address widening inequities in technology driven cities to avoid the likelihood of raising the living standard of more wealthy professionals, at the expense of the poorer city dwellers, the economic and social aspects of Smart City developments are yet to receive such attention. Thus, gaps in literature and the preliminary challenges that require further attention are highlighted as follows:

i. There are critical challenges concerning the key infrastructure components (e.g. energy, transportation, water) that will drive Smart Cities initiatives in developing countries (Washburn et al., 2010)

ii. Measuring the impacts of a city’s ‘smartness’ on entrepreneurial development and startup innovation is relevant and remains a critical challenge that requires further research (Lee et al., 2014)
iii. Managing the risks associated with innovation and new technologies in Smart Cities due to poor planning could result in failures and poses critical challenges (Nam & Pardo, 2011b)
iv. The difficulty in measuring individual quality of life satisfaction in a city remains a challenge due to its complexity and the substantial resource requirement (Appleyard et al., 2014).

These gaps and challenges were the reference points in the methodology adopted in this study that intended to create new knowledge by proposing a framework to promote innovation in building sustainable Smart Cities in the context of Abuja. In Nigeria, like many other developing countries, no Smart City framework or guidelines exist. Despite this, FCT-Abuja and two other cities in Nigeria are already embarking on some pilot Smart City projects without the framework that were found in other cities with similar intentions; for instance, Manchester mainly uses BSI Smart City frameworks. This suggests the need to review both the state of the art and other appropriate efforts in this area. The next chapter discusses social innovation and the emerging technologies adopted in building sustainable Smart Cities.

CHAPTER 3

3.1 Social Innovation, Emerging Technologies, and the Implications for Sustainable Smart City Development

The previous chapter focused on a review of relevant literature on Smart Cities and its context. An overarching element of the Smart City discourse is social innovation, even though, as this study argues, it is often the least theorised component of the existing body of research. Also, literature on emerging technologies addresses how technological innovation builds sustainable cities although current research focuses closely on the construction of technological systems. Moreover, in view of the data requirements that reflect individual city experiences in different regions, there are also insufficient publications on ecological/spatial awareness and the architectural perspective. Research into the entrepreneurial city addresses the implications of governance but tends to lose sight of the need to deal with social and economic development issues based on empirical evidence. In addition, the dynamic and complex system of cities and the need for an appropriate System Dynamic approach has not been duly emphasised. These bodies of scholarship are discussed in this chapter to analyse and evaluate the implications of social innovation, emerging technologies, cloud computing, Big Data analytics, and the integrated architecture for a dynamic interaction platform to build sustainable Smart Cities as summarised in figure 3.1.

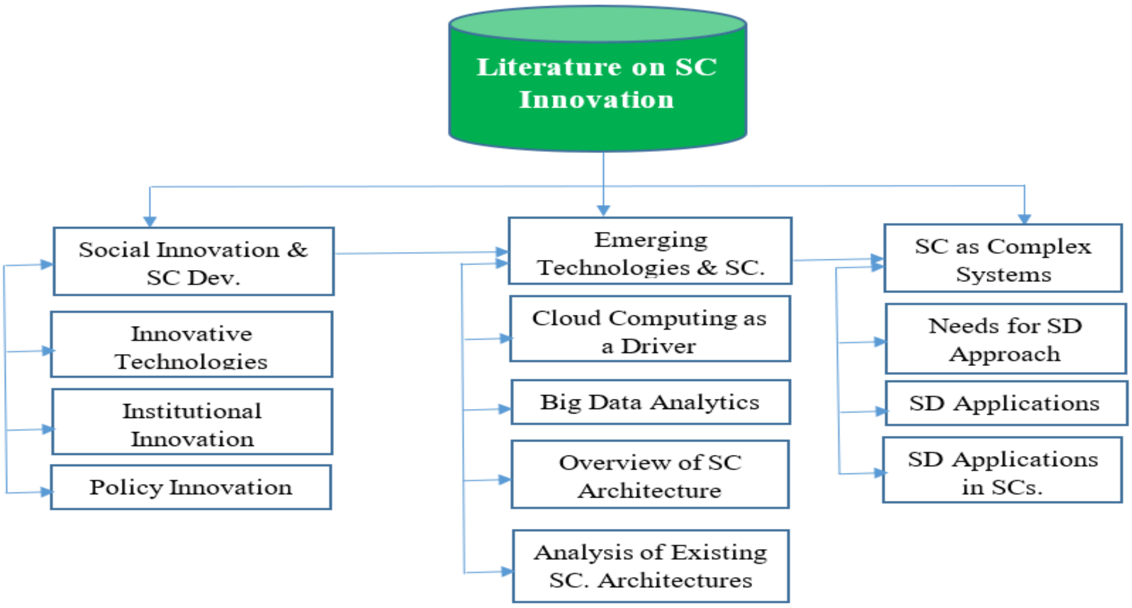


Figure 3-1 Outline of Smart City Literature Review on Social and Technology Innovations

3.2 Social Innovation and Smart City Development

According to Mulgan (2006), social innovation as a ‘new idea that works’ (meeting unmet social goals) relates to the Smart City concept and the current wave of its adoption in addressing the economic and social challenges of cities. According to Moretti (2015), “social innovation simply refers to a novel solution to a social problem that is more effective, efficient, and sustainable than existing solutions”. Moretti believes that, in order to deal with the challenges created by new possibilities and scenarios in the quest to satisfy the needs of the people, social innovation is inevitable in future cities. Furthermore, Manzini (2014) described social innovation as a new way of achieving socially recognised goals and the polarity favours a bottom-up approach where people and communities are involved. Thus, social innovation is a process of change, which has always been in existence (Manzini, 2014). In addition, the bottom-up approach, according to (Ratti & Townsend, 2011), involves exploring the sociability of cities through the growing array of smart mobile and personal devices in order to change the pattern of activities. Moreover, Mulgan, Tucker, Ali, and Sanders, (2007), argue that not much is known about social innovation in spite of the fact that it happens in all societies.

In cities, social innovation is expected to create a novel platform for interactions amongst organisations, enterprises, and individuals in order to deliver solutions, such as access to smart energy and water, education, healthcare, transportation, safety, and other services. However, among developing nations, there is a need to build an innovative ecosystem at the sub-regional level, as the effective sharing and distribution of energy and other resources, requires substantial attention. Although Nam and Pardo (2011b) posited the importance of innovation in the development of a Smart City, only a few published studies have discussed this concept. Calzada (2013b) revealed that the European Union [EU] has already adopted a critical social innovation concept in its Horizon 2020 regional strategy, e.g. Smart citizens or FabLabs, in the form of a bottom-up approach for Smart City development. According to the Calzada, social innovation strategies are also part of the EU’s urban governance strategies that aim to serve the interest of all stakeholders while incorporating social complexities in the process of decision-making at the regional level.

Social innovation plays a critical role in this study; this is because of the need to contextualise any attempt to address development challenges and incorporate social complexities in decision-making processes in cities. To effect this requires the participation of different agents (Calzada, 2013a). Moreover, Mulgan (2006) argues that the growing diversity of countries and cities form part of the challenges where social innovation deficits still exist. For instance, Mulgan, Tucker, Ali, and Sanders (2007) highlighted a number of issues relating to mobility, urban design, and climate change that require innovative ways of organisation in order to avoid unnecessary risks. In contrast, the different dimensions of social innovation, i.e. combination, cutting across, and compelling new social relationships, are now reflected in digital technologies that shape the diversity of research streams and lead to the development of Smart and integrated systems. This corresponds to IoT technologies, which introduce new types of spatial intelligence. Thus, to create and implement Smart Cities, social innovation is central to the entire process as it provides unique methods for integrating the systems for seamless participation as well as opportunities to improve the quality of life for citizens.

In view of such ubiquitous urban infrastructure deployment, this section further highlights the different perspectives of social innovation, i.e. innovative technologies, institutional arrangements and innovative policies, that are expected to drive future cities. These innovative developments will impact positively on the key components of city ‘smartness’ in terms of policy, technology, administration and governance, as summarised below:

3.2.1 Innovative Technologies

Innovative technologies have introduced higher institutional capacities and are currently being used to mobilise stakeholders (citizens, enterprises and research institutions) for participatory development initiatives (Schaffers et al., 2012), like general crowdsourcing, the crowdsourcing of sensored data, online collaboration, broadband for innovation, smart environment, and so forth. Moreover, according to Nam and Pardo (2011a), “technology is obviously a necessary condition for a Smart City, but citizens’ understanding of the concept is about the development of urban society for better quality of life”. In this context, innovation is regarded as a necessary ingredient at the infrastructure and process levels in order to realise a Smart City vision in any environment.

Furthermore, Schaffers et al. (2012) cited the Barcelona Smart City project as an initiative that effectively leverages innovative technologies to integrate ICT at all levels of its city infrastructure. In some cases, the innovation involved the full transformation of districts, like 22@Barcelona, which is now providing a platform for companies, institutions, universities, incubators, entrepreneurs, and residents, to interact and develop innovative solutions, either as products or services, in any field. Scaffers et al. revealed that the Barcelona Smart City project promotes innovation, access to opportunities, and information, both locally and internationally; moreover, the project also boasts over 400 research institutions as at 2012.

3.2.2 Institutional Arrangements and Innovations

Achieving the Smart City vision requires a rise above real-time operational difficulties (Kim, 2015). According to Marceau (2008), "innovations are made by people operating in organizations and firms but it has become clear that much of the impetus for innovation comes from the socio-economic and technical systems in which any firm or organization operates and innovates". In this regard, social innovation is considered imperative, either in terms of its organisation or in the regulatory system that facilitates the entire processes (e.g. the protection of intellectual property, capacity building, and other sundry issues) for sustainable development. Moreover, in citing the example of the South Korean U-City project, Kim (2015), stated the need for innovation in integration between public and private organisations (e.g. sharing data on security cameras between the police and other relevant agencies without any imediments or delays). Marceau (2008) also suggests that the people component entails diverse needs which require local innovation by decision makers to address them.

3.2.3 Policy Innovation

In the area of policy innovation, developed economies are already adopting the concept of social innovation in their quest to meet the needs of the citizens through collaborative strategies that enhance the capacity of people to become fully involved in the act of creating improved solutions (Moretti, 2015). The author cited the example of the "Collective Enhanced Environment for Social Task – CHEST", a Pan-European programme with the primary objective of developing digital based innovations with the potential for addressing societal challenges. The CHEST programme, which is already promoting the sharing of ideas, cuts across organisations and facilitates early stage business incubation, entrepreneurial development,and a host of other developments.

According to Gebhardt (2015), a, "Smart City will develop as an integrative approach comprising high technology intake, interdisciplinary knowledge creation, social innovation, capacity building, and political concept". Thus, countries are now introducing strategies for urban innovation, and observatory systems that seek to promote “Third Generation Innovation Environments”. Barcelona and Singapore are already collaborating in developing strategies that link stakeholder interests and serve as a test laboratory for the exchange of ideas in real time (Marceau, 2008).

Planning a Smart City project requires the proposal of some innovative solutions to address urban problems; these can represent new strategies for building knowledge economies, especially in large cities. In view of this, knowledge management is a major factor in the successful innovation of the fast changing business environment today as it provides an enabling environment for organisations and cities generally to leverage the availability of rich knowledge in evolving new technologies that are changing our societies. Nevertheless, an innovation highway, according to Carneiro (2000), depends on the knowledge evolution. Organisations and stakeholders in Smart Cities therefore need a platform to develop a viable and strategic knowledge system in order to enhance the production of new products and processes that drive ever-expanding cities. Thus, knowledge management provides a supporting role in the transformation of one form of knowledge to another in a creative manner.

In Smart City development, stakeholders need adequate information and the ability to analyse, evaluate and use such information for timely decision-making. In this regard, the organisations and key stakeholders in a Smart City need to strategically adopt knowledge management processes based on the available information and innovative solutions. Basically, adopting the principles of knowledge management and innovation conerns how organisations/stakeholders use emerging technologies to improve communication in a sustainable manner to achieve individual and organisational goals (Du Plessis, 2007). The findings of the study by Carrillo et al. (2008) on rising knowledge cities supports this principle, suggesting that knowledge-based urban development can encourage a vision or strategies that promote the transformation of cities into knowledge-based spaces with knowledge-based economies. It therefore necessary to strengthen such innovation systems in order to produce ‘new knowledge’ to fulfill a city’s economic development goals. However, challenges exist in recognising local institutions (businesses) as strategic partners in local innovation systems and thus involved in the planning of policies and strategies to develop knowledge networks where ideas can be experimented; this challenge is yet to be addressed in research.

The concern of this study is both to develop a Smart City framework that will serve as a model for the Abuja city region, but also to use the Smart City as a platform to trace the hidden correlation between social, technological, and economic development in innovative cities. Therefore, the Smart City initiatives that will be considered in this study do not solely concern technological innovation. These initiatives will be carefully analysed and, more importantly, the study will argue that social innovation is more important in Smart City deployment in making cities more competitive and productive.

3.3 Emerging Technologies and Smart City Deployment

Ubiquitous technologies have changed economic systems through affecting a growth in the power of knowledge. Thus, innovation is expected to remain the key factor of technological advancement in relation to the development of societies and knowledge distribution. New technologies are gradually becoming integrated into virtually every facet of the activities in cities resulting in streams of available data (Bell, 2009). Emerging technologies have greatly simplified real-time data collection through the IoT and Internet Connection Devices (ICD), such as RFID, sensors, cameras and smart phones. Furthermore, current estimates suggest that the IoT evolution could increase internet connectivity to about 50 billion devices by the year 2020 (Thoma, Fedon, Jara, & Bocchi, 2015) The ‘super connected world’ described by Thoma et al. has introduced innovative technologies that are now capable of assisting in the integration of cities’ subsystems and in simplifying decision-making processes.

Research into ubiquitous technologies, such as that by Soriano, Lizcano, Cañas, Reyes, and Hierro (2007), posited that a good number of Web 2.0 technology platforms are now in place providing enterprises with different specialisations and capabilities for the collective generation, sharing, and processing of information and business knowledge. However, Soriano et al. pointed out that the technologies have drawbacks with respect to collaboration as they slow down the pace of innovation. Therefore, it is imperative to conduct a thorough investigation to determine the most appropriate use of such technologies. This view is similar to that raised by N. Sultan (2013) who adds the dimension of emerging knowledge management products offering cloud and social networking functionalities. Sultan states that small and medium enterprises (SMEs) will likely benefit from innovations in Cloud Computing and Web 2.0 given that it is cheaper to invest in these platforms. These studies show that research targeting economic sectors with similar characteristics, as in the case of Smart Cities, could be improved in the future, especially when considering security and other salient issues on innovative platforms which attract Smart City stakeholders.

3.3.1 Cloud Computing as the Driver of Innovation for Smart City Deployment

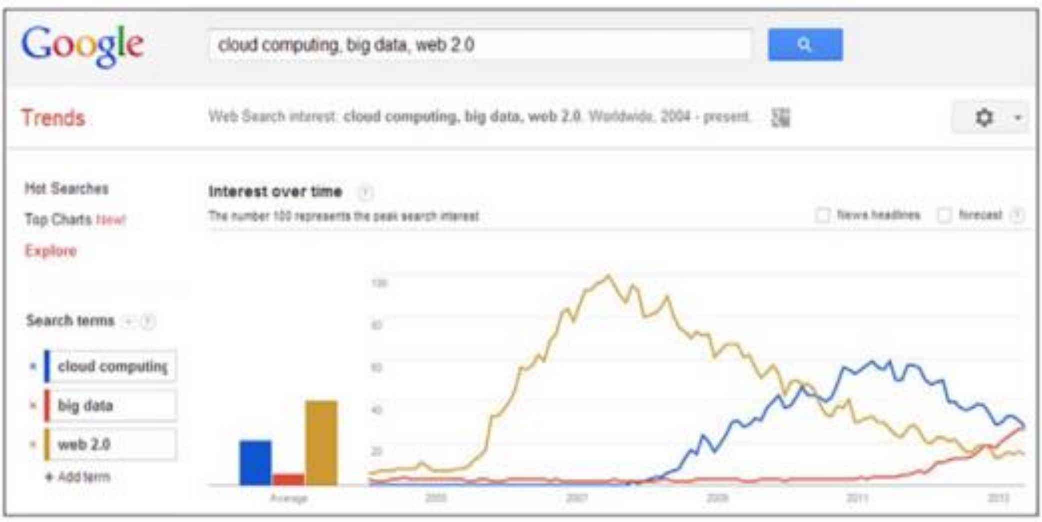
The convergence of Cloud Computing and the Internet of Things (Schootman et al.) for the realisation of a ubiquitous communication vision is critical to the focus of this research. For instance, Suciu et al. (2013) analysed the suitability of Cloud Computing and the IoT for Smart City deployment in the context of an open sensor network and a decentralised cloud-based platform. This work proposed a conceptual interoperable framework that integrates the characteristics of Cloud Computing and IoT for a Smart City service middleware platform. According to Suciu et al. (2013), the integration of emerging technologies for the realistic development of a Smart City should be conducted in a highly distributed environment with support for real-time Big Data management. However, the suitability and testing of this model in core Smart City services (e.g. via a Smart Grid), and especially in an emerging environment, requires critical investigation.

Similarly, Mitton, Papavassiliou, Puliafito, and Trivedi (2012) posited that the realisation of any envisioned Smarter City will depend largely on the critical role of sensor networks and the capabilities of the future internet. Mitton et al. (2012) believe that Smart Cities will deploy smarter sensor devices (with higher processing powers and other capabilities) to capture, analyse, and manage sensitive data, such as that concerning security, traffic, the monitoring and management of water gage, pollution-related information, etc. The study, therefore, proposes a new architecture that will allow cloud sensors and actuators to be dynamically provisioned as services through the platform of the IoT. The previous studies mentioned point to the possibilities from a plethora of tools and techniques for managing smart innovations; however, advancing these services for real-time data filtering in a specific Smart City is yet to be tested. Indeed Suciu et al. (2013) emphasise that the suitability of Cloud Computing and the IoT for Smart City deployment requires further research.

3.3.2 Big Data Analytics and Smart City Evolution

Big Data is defined by the Mckinsey Global Institute (Hu, Wen, Chua, & Li, 2014) as datasets whose size is beyond the ability of typical database management software tools to capture, store, manage and analyse within a reasonable time period. Leveraging the opportunities in Big Data analytics within data intensive technologies which can be deployed for future cities will ease the processes of making the right information available to the right user at the right time. Such a development would have a substantial influence on how cities are instrumental in driving innovation and creativity in entrepreneurial development. According to Kitchen (2013), the evolution of Big Data enables the real-time analysis of city life and introduces a new form of urban governance while providing an enabling environment for the running of transparent cities that will be more efficient, sustainable and competitive.

Concerns have emerged about Big Data analytics in the context of knowledge management and innovation in Smart Cities; however, the development trends in this area suggest that this represent a new research direction. For instance, Townsend (2013) viewed this emerging trend (Smart City and Big Data) as technocratic in nature. However, there is a fear of technological lock-in on the grounds that the promotion of a Smart City and various Smart City solutions are heavily driven by technological experts (principally by vendors, such as IBM and CISCO) rather than city governments. On the other hand, Batty (2013), suggests that Big Data has the potential to provide an understanding of how city sub-systems function and are managed, to the extent that, “Big Data will become a source of information about every time horizon”. Kitchin (2014) further posited that many city governments now use real-time analytics to manage regulatory and other functions within a city in key sectors like security, transportation, the environment and surveillance systems. Figure 3.1 demonstrates the rise of Web 2.0 Cloud Computing and Big Data from 2004 to 2013, which indicates that the future cities will benefit immensely from technologies for real-time analytics. The implications of these developments are unknown and thus require more investigation in order to evaluate their adoption (and level of awareness) in both developed and developing economies.



cloud computing, big data, web 2.0

Figure 3-2 The rise of Web 2.0 Cloud Computing and Big Data from 2004 to 2013

(**Source:** Batty, 2013)

It is envisaged that the challenges of complex data collection/capture (especially in real-time), storage, query, and analysis required in future city environments will require serious attention. This will particularly concern: volume (terabytes and petabytes of data); velocity (datasets in batches and in real-time); variety (the heterogeneity of data – structured, semi-structured and unstructured); veracity (trust in and the integrity of the data), and value (how much value can be derived from such data). The emergence of Big Data tools and their associated technologies provide rich and diverse research opportunities in knowledge management which can help to provide solutions to some pressing urban challenges. Such solutions could potentially be more realistic as most Smart City projects/efforts are virtually at the experimental level.

Innovative solutions in social media and crowdsourcing appear to offer excellent opportunities for a wide range of applications in the critical aspects of city services, such as health, education, transportation, and professional services. Crowdsourcing is noted for its high accuracy and thus can be used as ‘a base-map for other social media data’ that are useful in geo-location and mobility management (Batty et al., 2012). With the integration of people and systems through the concept of the ‘web of everything’, emerging technologies are empowering citizen participation via interaction with key actors, thereby promoting territorial proximities and providing opportunities for social and economic development. Thoma et al. (2015) provided a use-case scenario of a human-centric system of integration for different services, such as the Smart Santander initiative in Spain.

3.4 Viewing Smart City Architectures as Basic Component of Technological Innovation

Recent research in Smart City development has dwelt heavily on the technologies and architectures of Smart City, on which divergent views have been presented. Hence, different Smart City architectures exist in the literature but, to date, no generally-accepted architecture has been adopted (Wenge, Zhang, Dave, Chao, & Hao, 2014) which suggests that this key aspect of the Smart City concept is still evolving. Smart City architectures are designed from the different perspectives of technological knowledge and aim to address the sustainability challenges of future cities by building efficiency and effectiveness into the sub-systems of cities. A significant number of service oriented architectures (SOA), event driven architectures (EDA), Internet of Things (IoT) architectures, and Internet of Everything (EoT) architectures are proposed while, in many cases, authors have suggested a combination of different technologies (Schootman et al.). However, many of the proposed architectures are not that different from the traditional enterprise architectures adopted to solve urban development challenges (Mulligan & Olsson, 2013). This section briefly discussed Smart City architectures analysed within the literature with a view to identifying a potential research direction (see for instance, Figure 3.2).

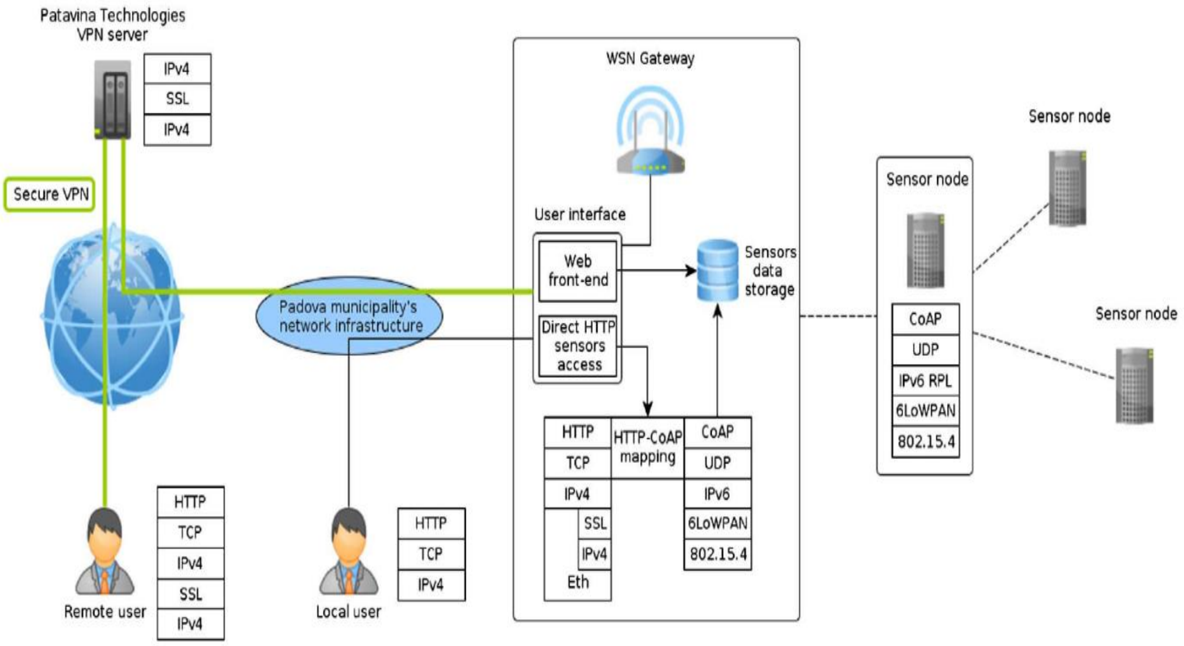


Figure 3-3 System Architecture of Padova Smart City

(**Source**: Zanella, Bui, Castellani, Vangelistra & Zorzi,.2014)

3.4.1 SOA-based Architectures

From the perspective of Service Oriented Architecture (SOA), some authors have proposed Smart City architecture to address the flexibility and scalability requirements of managing heterogeneous data in Smart City technologies. In this context, L. Anthopoulos and Fitsilis (2010) have proposed an enterprise architecture to strengthen the organisation and technical evolution of Smart Cities. Anthopoulos and Fitsilis presented a layered architecture with sustainability components to deliver multiple applications and services within urban areas. Andreini, Crisciani, Cicconetti, and Mambrini (2011) also proposed a Smart City architecture based on SOA for the efficient orchestration of different components in a re-usable manner. Recognising the importance of scalability, Andreini et al. suggested the use of a Distributed Hash Table (DHT) protocol by applying the concept of geo-localisation to the IoT for easy access to services.

Although these architectures were proposed as effective solutions (in some cases with use-case scenarios), service-oriented architectures are prone to the challenges of archival and dirty/unified data (Xiong, Zheng, & Li, 2014). As future cities are expected to be data-driven, these challenges limit the effectiveness of architecture built with a deep emphasis on SOA that do not integrate more technologies.

3.4.2 EDA-based Architectures

A number of architectures have also been developed based on Event Driven Architecture (EDA) in order to manage changes in Smart City systems. Filipponi et al. (2010) proposed an EDA-based architecture that was enabled by Smart Objects for Intelligent Applications (SOFIA–infrastructure) to enhance communication as well as detect abnormal events using sensors. The architecture was designed with an Interoperability Open Platform (IOP) to ease the integration of heterogeneous sensors and sub-systems in managing spatial development. Filipponi et al. (2010) further divided the architecture into a Semantic Information Broker (SIB) and a Knowledge Processor (KP) as the main components for data storage and access. Wan, Li, Zou, and Zhou (2012) introduced the concept of the IoT with sensor networks to EDA in order to maximise the efficiency of services in SC through the management and cooperation of machine-to-machine (M2M) components. According to Wan et al., the M2M Smart City architecture was introduced to manage mission-critical wireless messages that are capable of playing an important role in critical services, such as smart grids, public safety, intelligent transport, and energy management. Nevertheless, EDA architecture again has limitations because of the higher semantics of heterogeneous events.

3.4.3 IoT-based Architectures

From a different perspective, over recent years developments in technologies and innovation for Smart City deployment have shifted their focus to the Internet of Things (Schootman et al.). Many industry players and academics are vigorously pursuing research topics that will contribute significantly to the adoption of the IoT for sustainable Smart City development. The IoT represents a computing paradigm that enables every physical object or heterogeneous device with virtual components to produce and, at the same time consume, services. The IoT has been described as a convergence of radio frequency identification (RFID) with Cloud Computing (internet), sensor technologies, and Smart objects (Singh, Tripathi, & Jara, 2014). In this area, a number of novel architectures for Smart City deployment based on the IoT (for instance, Distefano, Merlino & Puliafito, 2013; Schaffers et al., 2011) have been proposed with different perspectives in addressing the technical challenges in Smart City.

One of the most interesting IoT architectures, which was proposed by Zanella, Bui, Castellani, Vangelista, and Zorzi (2014), was validated with a use-case in Padova Smart City. The proposed architecture was based on an urban IoT system with a proof-of-concept deployment covering different areas, such as waste management, air quality monitoring, energy consumption, traffic congestion, and Smart parking. Although Zanella et al. (2014) concluded that the enabling technologies for the realisation of IoT solutions in a Smart City have reached maturity, the impact of noise on humidity and temperature measurements (based on this small scale implementation), requires further investigation. IoT architecture, like other previously discussed architecture, has drawbacks in terms of data security and privacy (Roman, Najera, & Lopez, 2011). In the IoT, everything becomes virtual ‘anywhere, anything, anytime’, hence, there is need for the integration of more technologies.

3.4.4 IoE-based Architectures

Finally, to uncover new information, enable fast communications and decision-making, and automate connections, the Internet of Everything (IoE) has emerged as part of the Smart City discourse. It is perceived as a technology that will overcome the challenges of the IoT in connecting people, processes, data and things with the same objective of improving the livability of cities. IDC Government Insights (2013) summarises the implications of the IoE in a Smart City (architecture) of the future based on the IoE technologies via Big Data and analytics, social media, mobility and Cloud Computing; this provides the foundation to address future development challenges in cities (Clarke, 2013). Similarly, Jara, Ladid, and Gómez-Skarmeta (2013) proposed the full integration of internet protocol (IPv6) technologies into the IoT architecture in order to realise the IoE potential for Smart Cities. Jara et al. (2013) presented an architecture to leverage connectivity and reliability for the support for heterogeneity, security and mobility in IPv6 interactions. Jara et al. proposed the Internet of Everything as the means to enhance the potential of IoT applications in eHealth/mHealth as well as Smart Cities. However, it is important to note that the IoE still exploits the internet infrastructure and network connectivity in order to transport or communicate with every object through innovative management systems.

3.4.5 Towards an Integrated Architecture for Smart Cities

Emerging technologies and innovative solutions for managing new challenges that confront urban development goals in Smart Cities will, undoubtedly, require the comprehensive integration of diverse techniques, perspectives, and knowledge for sustainability. Research findings in this field have shown a development trend in which Smart City architectures are evolving towards the integration of different technologies in order to achieve a heterogeneous architecture to handle the emerging challenges of Smart Cities and the future perspective of the IoE (Kyriazopoulou, 2015). Authors, such as (Wenge et al., 2014), have contributed significantly to the idea of integrating more than one technology in order to handle the new challenges of Smart Cities through a layered architecture. For instance, their architecture addresses data management issues through the support service layer that integrates cloud computing and data technologies in the form of the Internet of Things (Schootman et al., 2016).

The work of Rong et al. (2014) suggests that data should be gathered, analysed, stored and kept secure. Their proposed architecture recognises that traditional data management systems can no longer cope with the challenges of the data intensive requirements of future cities. New technologies that generate Big Data are characterised by their heavy volume (running into petabytes) and variety (coming from various sources) in terms of their applications, and the IoT devices' data outputs, which are heterogeneous (namely, structured and unstructured, including semi-structured). Above all, they have velocity (streaming data), as described in the previous section. As depicted in Figure 3.3, such multi-layered architecture emphasises the relevance of data integration from heterogeneous sources as the key feature of Smart Cities. The data acquisition layer in this scenario captures data from different sources, such as sensors, RFIDs, and so forth. As shown from the data acquisition layer to the upper-most application layer (Event-Driven), the architecture depicts the comprehensive integration of SOA, EDA and the IoT capabilities necessary for the fusion of data from different objects, particularly cloud platforms and visualisation technologies.

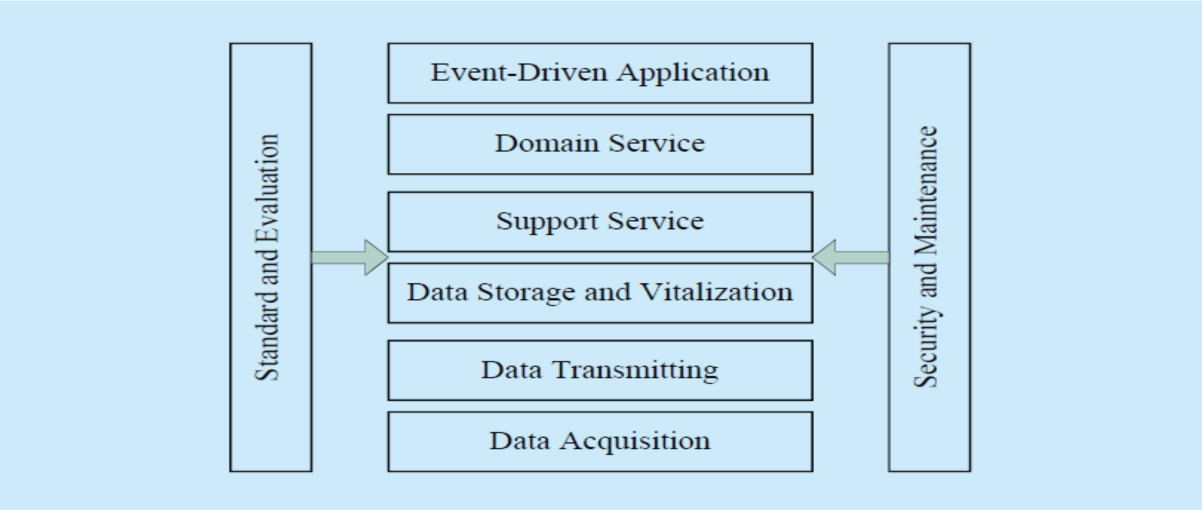


Figure 3-4 Data Oriented Smart City Architecture

(**Source:** (Wenge et al., 2014)

Although ease of administration (as depicted in the simple layered architecture), standards, and security (in terms of data vitalisation, transmission, and sensorship) were considered, the critical success factor of the proposed architecture was the comprehensive integration of technologies that address issues such as the creation of cross-domain solutions to handle real-time Big Data analytics. This considers the new challenges of real-time Big Data analytics and the emergence of IoE; this was due to the sensor systems that are desirable in generating further insights. The importance of this has been echoed in the work of Kitchin (2014), which revealed that city administrators across the globe are now using real-time analytics in regulatory functions as well as in the management of some aspects of cities' performances. Furthermore, a data vitalisation layer for managing incoming data from sensors can be useful in pushing analytics' results back to different actors in the city (users) through smart devices by using SOA techniques to give stakeholders real-time access to information for timely decision-making.

3.5 Smart City as a Complex and Dynamic System

In their work on modelling the performance of Smart Cities, Lombardi et al. (2012) (who are planners and environmental evaluators), argued that a city is a complex system and this complexity is the result of some unpredictable interactions. According to Lombardi et al., the complex system of cities exhibits unpredictable behaviours in which, when certain actions are taken, they are capable of generating feedback. Furthermore, according to Dodgson and Gann (2011), complexity increases with diversity and requires approaches that are adaptive and collaborative in nature. In addition, the complex system of a city is a valuable image when related to the evolution of information systems (Harrison & Donnelly, 2011). Assessing the performance of Smart Cities, therefore, requires a complex model that can address the core components of cities for effective decision-making.

Exploring the systems approach described in different sources, (for example, Dodgson & Gann, 2011; Harrison & Donnelly, 2011), requires an assessment of the performance of cities, which can be achieved effectively through modelling the core sub-systems of a city in order to simplify the complex systems of the Smart City innovation. Interestingly, systems science scholars, such as Sterman (2000), recommended modelling as a means of simplifying complex processes and as a way of making responses quicker and more effective. Sterman suggested modelling as a complement to other tools rather than as a substitute. Therefore, because cities are organic in the way they evolve with time, a System Dynamic approach is suitable in assessing their innovation ecosystems in order to provide guidance for planners, policy makers, and innovators on appropriate courses of action in all efforts to make cities more liveable and sustainable.

3.5.1 The Need for System Dynamics Approach in Smart Cities

System Dynamics relates to research on system information feedback and represents an approach for solving the problems inherent in systems. In this scenario, the complexity of a city as a set of systems relates to the clarity of the level of interaction among the city sub-systems over time. According to Vafa-Arani, Jahani, Dashti, Heydari and Moazen (2014), System Dynamics ,is one the best tools for modelling socio-economic problems with complex characteristics. Thus, System Dynamics is a methodology and mathematical modelling approach that aims to discover the behaviour of complex systems over time. Therefore, in

System Dynamics, the structure of a system concerns the relationships that exist among the system components, which, in this case, has direct implications for the causal relationships among the core components of Smart Cities and represents a major concern for this study.

As emphasised in the previous section, cities and the current wave of Smart City innovation are both complex and dynamic in nature. As Chao and Zishan (2013) in their System Dynamics model for the evolution of a passenger transportation structure in Shanghai city argued, relying solely on qualitative and quantitative research methods to analyse or solve problems carries certain limitations. Thus, there is a need for a System Dynamics approach that is built on an effective combination of both quantitative and qualitative methods. In addition, one of the key objectives of Smart City innovation is to 'de-risk' investments (Smart & Cooperation, 2014). Thus, a System Dynamics approach aims to simplify reality by requiring effective solutions with clear-cut baselines to create transparency and quantify the metrics of all actions, which is also fit to study the dynamism of the core factors of Smart Cities.

3.5.2 System Dynamics and it Applications

In recent years, the System Dynamic method has been applied to different fields for policy analysis and design. Moreover, a System Dynamics approach has been widely applied in different fields to gain a better understanding of systems that are dynamic, complex, and interact with nonlinear variables (Xu & Coors, 2012). According to Xu and Coors, the System Dynamics methodology has been applied in telecommunications, software engineering, energy and power production systems, performance evaluation, and policy analysis. System Dynamics is thus growing at an exponential rate and spreading to many areas as people appreciate its ability to represent real-world situations (. However, according to Sterman (2000), the System Dynamics methodology was originally developed in the 1950s to assist industry leaders in improving their understanding of the behaviour of complex social systems, especially in an industrial context. As noted by Forrester (1961), System Dynamics developed from system thinking as a modelling method and represents an aspect of systems theory that deals with a method for understanding the dynamism of complex systems.

According to Sterman (2000), System Dynamics, can be applied to any dynamic system. Sterman cited use-cases in corporate strategy formulations, healthcare related policies, and the automobile industry where the approach has been successfully applied. According to Fiksel

(2006), in developing strategies for economic growth, environmental sustainability, and a host of other challenges, the System Dynamic approach has been adopted by researchers to comprehend a holistic view of policies and development.

In the built environment, urban dynamics represented the first modelling work produced by the earliest system scientists at MIT; this provoked strong emotional reactions (Forrester (1995). In addressing environmental problems, the System Dynamics method was applied to ecological problems. For instance, Park and Kim (2016) used the approach in modelling the implementation of the management policy of a water supply system. They analysed the effect of investment on water quality improvements for a city region in Busam, South Korea and concluded that the model helped to quantify the benefits of investment in efficient waste-water treatment in the upstream sector of the city. In this study, System Dynamics principles were adopted to assess and interpret the causal relationships that existed among the core components of Smart Cities.

3.5.3 Application of System Dynamics Approach in Smart Cities

The application of the System Dynamics methodology to address the complex problems of cities is no longer new. For instance, Tsolakis and Anthopoulos (2015) used this methodology in their integrated framework for an eco-city to assess sustainability in order to assist policy makers and urban planners with the development of effective policies to monitor and assess the sustainability performance of eco-cities. Their holistic System Dynamics methodological framework used case study data generated from a multi-method approach in Hsmichu city, Taiwan and Tiamjin city in China. Similarly Chao and Zishan (2013), in proposing a Shanghai passenger transportation structure evolution model, applied the System Dynamics approach based on transportation survey data to validate their proposed model of a passenger transportation structure.

In environmental sustainability, which is at the core of Smart City innovation (Saysel, Barlas, & Yenigün, 2002), employed a System Dynamics methodology for the experimental analysis of long-term environmental sustainability in order to inform policy analysis. They addressed a range of issues related to regional agricultural projects and water resource development but the analysis focused on the totality of environmental, social, and economic related issues. In addition, Chen, Ho, and Jan (2006) applied System Dynamics to analyse the causal relationships of air pollution problems resulting from transportation, and the complex system of urban development. The proposed sustainable urban development model for assessing air purification policies for Taipei city was based on System Dynamics modelling.

The cited examples suggest that the main focus of System Dynamics is to understand how system components interact, how the changes in one component impacts on other components, and how it affects the entire system (Peter, 1990). The interactions in System Dynamics are based on three building blocks (modes) of positive feedback (reinforcing loops), negative feedback (balancing loops), and delay (negative feedback with delay). Other more complex patterns of behaviour, according to Sterman (2000), arise due to nonlinear interactions amongst these structures. Although System Dynamic models can be qualitative (conceptualisation) or quantitative, system scientists have argued that quantified simulation models are always superior to qualitative models (Coyle, 2009). This is founded on the argument that qualitative models tend to mainly create cause-effects diagrams, whilst quantitative models are devoted to simulation. Neverthless, both qualitative and quantitative data collection for System Dynamics can be adopted interviews, survey, focus groups, experiments, and observations (Luna-Reyes & Andersen, 2003). In this study, a variety of these data collection approaches were employed during the field investigation.

3.6 Chapter Summary

This study aims to propose a Smart City framework with a KPI model to assess the impacts of socio-technological innovation on the social and economic development of cities in the context of FCT-Abuja, Nigeria. It intends to address this by investigating current developments across different city regions. The study is systematic and comprehensive in that it links together the ongoing social and technological innovations on the grounds that this exemplifies the concept as it has emerged from the literature discussed in this chapter. In specific terms, the study has explored the implications of innovation and the introduction of new technologies within the context of Smart Cities.

The findings from this review and analysis suggest that emerging technologies, such as Wireless Sensor Networks (MSN), vehicular networking and machine-to-machine communications (M2M), will play a critical role in the Smart City agenda, moving governance and the management of city sub-systems gradually towards the utilisation of Big Data analytics.

Furthermore, Big Data analytics will leverage cloud computing to provide unlimited computing and storage infrastructures to cope with the huge amounts of data that emerge from a Smart City. The analysis will run both predictive and prescriptive data mining on the extracted data. Such analysis is already helping the real-time monitoring of high traffic volume routes in order to facilitate traffic flow as well as assist law enforcement agencies around the globe, notably in crime management.

In the area of architecture, a plethora of Smart City architectures exist in the literature, presented from different perspectives, such as SOA, EDA, the IoT, and the IoE. Based on the number of published studies, the IoT-based architecture dominates the recommended Smart City architectures and represents many use-case implementations. A few of the proposed architectures adopt the integration of further architectures in order to cope with the service requirements of future cities. The most interesting part of the analysis is the new challenges posed by the emergence of the new Internet of Everything (IoE). From these research findings, it is suggested that many of the proposed Smart City architectures did not envisage the arrival of the IoE where virtually everything and every process can communicate, thereby automatically generating high volumes of Big Data from which extensive insights can be gained through real-time analytics.

Cities and their characteristics are described as complex systems, and this complexity is due to their unpredictable interrelations (Lombardi et al., 2012). Therefore, these interrelationships that form the sub-systems of cities need to be treated as dynamic systems. In doing so, they can be modelled to address the behaviour of the entire system over time in order to enable better conceptualisation and insight. Thus, the application of a System Dynamics approach based on soft system thinking is considered suitable for the modelling of Smart City KPIs.

In all, Smart City literature has emphasised the functionality of Smart urbanism for the digital infrastructure by focusing closely on the implications of harnessing new digital opportunities to achieve ‘Smartness’. While this is important, the underlying rationale for harnessing these emerging areas through empirical evidence that engage the core-knowledge-rich-stakeholders and networks of Smart City policy making is often under examined. This research will bridge some of the gaps by sharing empirical results from the Abuja case study with lessons and experience from the Boston and Manchester case studies, as outlined in Chapter 1.

CHAPTER 4

4.1 Research Methodology and Paradigm

Whilst the previous chapters have signposted the problem under investigation, this chapter presents a comprehensive description of the research methodology and paradigm adopted in the conduct of this study. The chapter also discusses issues relating to validity and reliability and adopts a triangulated approach to bridge any possible gap. As clarified in the previous chapters, this study seeks to address the research aim and objectives outlined in the introductory section by adopting an appropriate research philosophy, approach and strategies to analyse the current developments in Smart Cities with a view to contributing to knowledge in this field. According to Ruddock (2008), a methodology must provide a set of principles that serve as guides in all facets of research work; indeed, the research methodology is a term used to refer to the theory of how research should be conducted. Thus, the basic research elements for this study are discussed in the following sections.

4.2 Methodological Framework

The research methodology provides detailed processes of the study with emphasis on the step-by-step developments, research tools/techniques, and procedures followed. It provides the framework that guides the data collection and analysis in this study. The research methodology can be understood to represent the procedural framework that guides the design and conduct of a research study (Denscombe, 2014). A systematic research methodology is therefore established on several interrelated elements which include the research approach, philosophy, strategy, and methods.

A number of methodological models have been proposed to represent the distinct hierarchical levels of decision-making for research framework design processes. For instance, Cotty (1998) proposed a four-dimensional framework design incorporating the elements of: epistemology, theoretical perspective, methodology and method. Crotty asserted that the researcher’s initial stance towards the nature of knowledge determines the particular theoretical perspectives adopted, specifically in terms of objectivism, post-positivism, or interpretivism. Similarly, Creswell (2009), proposed a model based on Crotty's four elements, although. Creswell's model mainly emphasises qualitative, quantitative, and mixed methods.

In a nested approach, Kagiolou, Cooper, Aouad and Sexton (2000) proposed a research framework model that defines three research philosophies, the research approach, and research techniques (see Figure 4.1). The nested model is hierarchical in nature and emphasises the research processes from a wider, knowledge-based perspective to the narrower element of specific data collection methods. Here, the research philosophies are regarded as the first elements for definition in a research methodology in that it guides further research techniques.

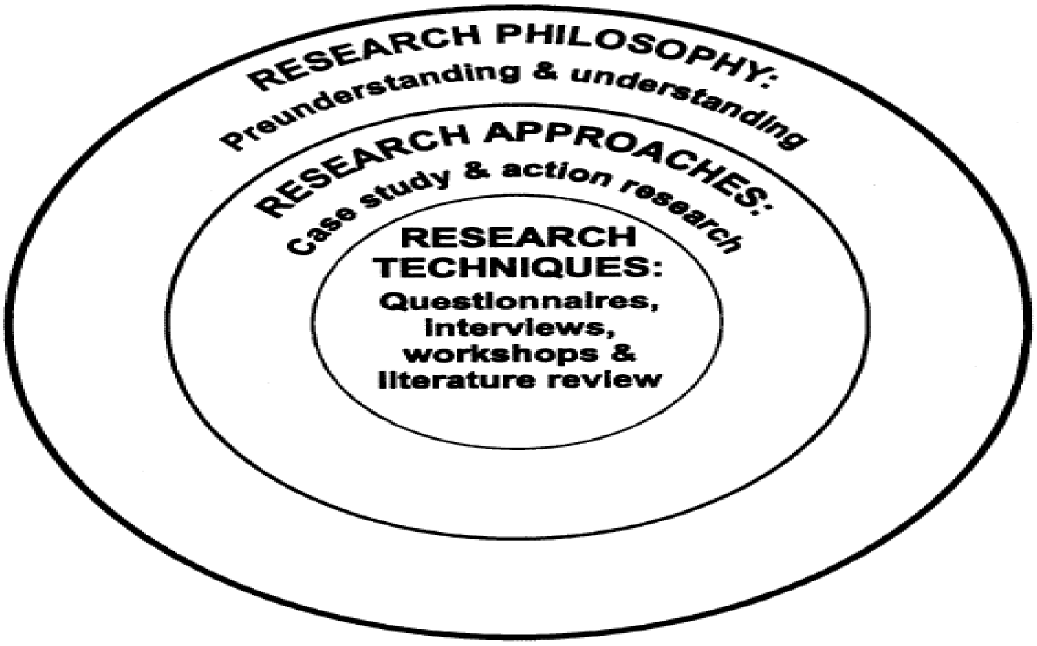


Figure 4-1: The Nested Approach of the Research Framework Model.

(Source: (Kagioglou, Cooper, Aouad, & Sexton, 2000)

Lastly, Saunders, Thornhill and Lewis (2009) proposed a six-layered model of a research methodology framework known as 'Research Onion' in which every research process was considered as a phase in a typical journey from the outer layer through several stages to the centre (see Figure 4.2).

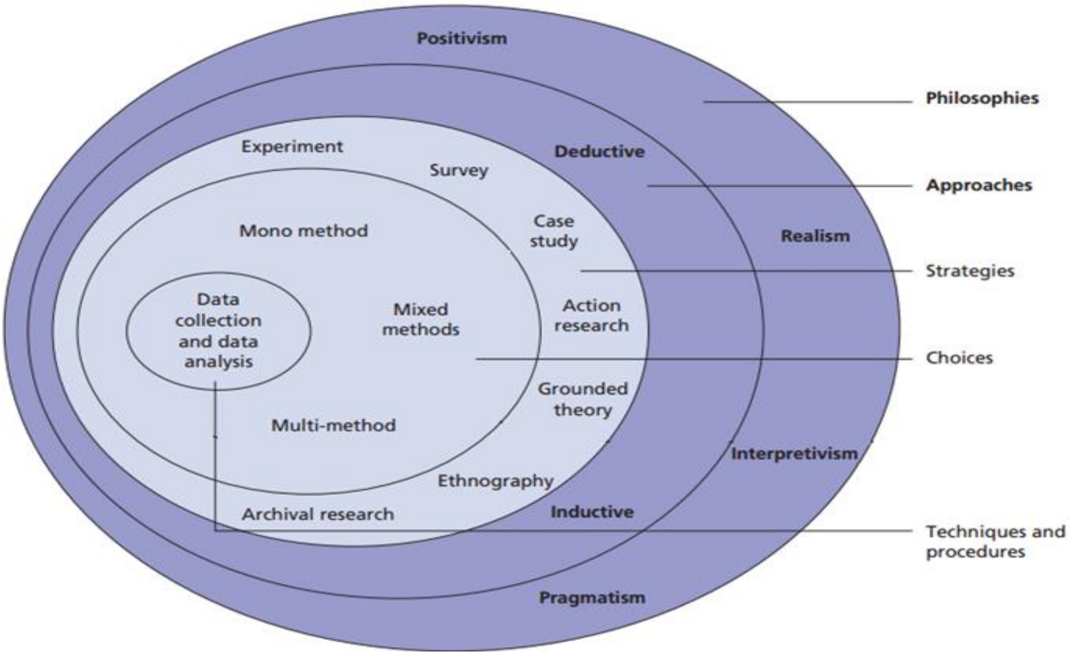


Figure 4-2: The Research Onion: The Layered Approach of a Research Framework Model.

(**Source:** (M. N. Saunders, 2011)

In comparison, both the nested model and the Research Onion provide researchers with a similar understanding of the mechanisms of a research methodology. For instance, the outer ring/layer in both models identified research philosophy as the first element for definition in a research methodology, and this is based on the ontology, epistemology, and axiology of the study. In comparison, the inner layers of the two models relate to research techniques. Basically, the two framework models only differ in the research approach where the nested model tends to combine two layers. Thus, this study finds the Research Onion more suitable for conducting this study because of the clarity it offers as a guide for a systematic research approach. The interrelated elements are discussed with the choices adopted for this research.

4.3 Research Paradigm/ Research Philosophy

Research paradigms serve as guide to researchers on the questions for selection in terms of data collection, analysis, and the interpretation processes. A research paradigm, according to (M. Saunders, Lewis, & Thornhill, 2009), refers to the world view that guides the investigation not only in terms of choices of method but also in relation to the fundamentals of ontology and epistemology as the basic belief systems. Collis and Hussey (2014) define a paradigm as a framework that guides how research should be conducted; it is based on people's philosophies and their assumptions about the world and the nature of knowledge. Guba and Lincoln (1994) further suggest that adopting a paradigm most appropriate to a particular study is of utmost importance, and the question of research method is of secondary importance, from both ontological or epistemological perspectives. In reality, the philosophical nature of the study that underpins the research paradigm is usually specified by the tenets of the ontological, epistemological, and axiological beliefs.

The two main research paradigms traditionally discussed in a research methodology are positivism and interpretivism. Henderson (2011) made a strong case for post-positivism as the third primary paradigm; this is particularly relevant for research designs that use post-positivist qualitative data, and helps to move positivism from a narrow perspective into a broader way of examining real-world problems. However, research designs relating to such methods are rarely described in such a manner. Consequently, in this study the discussion on the paradigm continuum focuses on the two traditional paradigms of positivism and interpretivism. The next section discusses the philosophical underpinnings and the combination of factors that determined how this research was positioned on the paradigm continuum.

4.4 Research Philosophy

Philosophical assumptions provide guidance in a description of the underling process to be followed to complete the research. In other words, a research philosophy can be described as the ‘conceptual means’ of investigating a research study. According to Collis (2014), a research philosophy is described as set of beliefs or the study of the important nature of knowledge which includes reality and existence. Philosophical assumptions, therefore, assist in identifying an appropriate methodology for adoption. Although some authors discussed complementary assumptions - rhetorical assumption - the three distinct philosophical and interrelated assumptions that tend to be discussed are ontology, epistemology, and axiology (Collis, 2014; Saunders et al., 2009).

A good understanding of research philosophy is essential in order for a researcher to clarify the appropriate research design (Easterby-Smith et al. 2008). According to Denscombe (2007), philosophical assumptions guide the implicit or explicit inquiry in a research study. Thus, ontology is mainly concerned with what knowledge is and the assumptions of reality, whilst epistemology primarily defines ‘how we know reality’ and how knowledge should be acquired and accepted. Axiology, on the other hand, is mainly focused on the value system. These assumptions and their relevance to this study are discussed in the subsequent sections.

4.4.1 Ontology

WordWeb Dictionary (n.d) refers to ontology as “a branch of metaphysics dealing with the nature of being”. Ontology is the philosophical assumption that deals with the question of what constitutes knowledge or nature of reality (Blaikie, 2010). In other words, it is about whether reality is whether multiple or singular (Creswell, 2015). According to Saunders et al. (2009) ontology raises questions concerning the researcher’s assumptions about how the world operates as well as the researcher’s level of commitment to particular views. Gray (2009) described ontology as the study of being, namely the nature of existence, and this ontological assumption embodies an understanding of ‘what is’. Nevertheless, there are two divergent views or assumptions from the ontological stance; these are viewed as polar opposites and are called objectivism and constructivism-subjectivism (Saunders et al. 2009).

4.4.1.1 Objectivism

From the perspective of objectivism, social phenomena and their meanings exist independently of social actors (Saunders et al. 2009). Gray (2009) posits that objectivists believe that things exist as meaningful entities independently of consciousness. This implies that the objects have a single (objective) truth and meaning where the goal of research is to ascertain such ‘objective’ truth and meaning (Crotty, 2003).

4.4.1.2 Constructivism (Subjectivism)

Constructivism-subjectivism, on the other hand, is an ontological belief that social phenomena are created through the perception and resultant actions of social actors (M. P. L. a. A. T. Saunders, 2009). Thus, some theorists believe that subjects construct their own meaning in diverse ways and that the meaning is not discovered but rather constructed (Gray, 2009). Remenyi (2003) stressed that social constructivism sees reality as socially constructed. Both Gray and Remenyi also suggest that this perspective is based on studying the details of a situation to comprehend its particular reality, or, in other words, to know its specific underlying truth.

Based on the objectives of this study (discussed in Chapter 1), this research encompasses interviews and surveys with experts to quantify the embedded knowledge, experiences, and the perceptions of the Smart City stakeholders who are directly involved in Smart City innovation. Smart City initiatives are being accomplished by social actors who are in constant interaction with varying degrees of understanding. In addition, research on Smart City innovation involves the study of complex interaction between people and processes, which means that the ontological stance of this study lies in constructivism, in that it aims to gain an understanding of the real-world relating to changes in the urban environment. Table 4.1 and Figure 4.3 provides more detail on the ontological assumption for this study.

4.4.2 Axiology

Axiology is a philosophical assumption that concerns judgements about values (Collins & Hussey, 2005). Saunders (2007) posited that axiology has two opposing assumptions in that a decision has to be made if it is value-free and unbiased, or value-laden and biased. Pathirage (2008) also stressed that axiology makes known the assumptions concerning a value system. Generally, people have different perspectives on what constitute the truth, and this is based on their specific beliefs and experiences.

Based on the nature of this study, the Smart City stakeholders, which included urban planners, academics, ICT professionals, transport experts, and security professionals, who were involved in the study were not free from bias. In addition, the study was multidisciplinary in nature with different opinions from a range of experts, and this affected the research techniques adopted and the ways in which the results were interpreted. Thus, the study cannot be completely value-free. However, the assumptions only suggested the directions from which to seek answers, rather than a description of what to seek in itself. Therefore, the axiological stance for this study leans more towards value-laden than value-free.

4.4.3 Epistemology

Epistemology refers to an examination of the relationship between the researcher and the subject or entity being researched. Epistemology is therefore concerned with the question of what, and how we know that what we know exists. According to Crotty (2003), the epistemology provides the philosophical grounds for the researcher to decide on ‘what kinds of knowledge are possible’, and how the researcher can ensure that the adequacy and legitimacy of such knowledge is taken into account. Williams, Roberts and McIntosh (2012) posited that the epistemology is concerned with the following questions: what are the sources of knowledge; what are the limitations of knowledge, and what are the essentials and adequate conditions of knowledge. The philosophical stance of epistemology also has two divergent viewpoints with positivism at one end of the continuum and interpretivism at the other (Collis & Hussey, 2009; Saunders et al., 2009). .

The epistemological assumption of positivism is grounded on the belief that scientific knowledge is the only valid form of knowledge (Burns, 1997). Crotty (2003) states that positivism concerns empiricism and places value on evidence discovered from experiments. The underlying basis for positivism assumes that any such research is conducted in a value-free manner. However, as Saunders et al. (2009) argued, complete freedom from the researcher's values may not be practically possible noting that the 'feelings' of a researcher are part of data collection process. The second epistemological assumption is interpretivism, which advocates the need for a proper understanding by the researchers of the distinction between humans in their roles as social actors. This emphasises the difference between research undertaken involving human beings rather than inanimate objects (Saunders et al., 2009). According to Saunders et al. (2009), the heritage of interpretivism stems from phenomenology and symbolic interactionism. Phenomenology, on the one hand, refers to the way that humans make sense of the world around them, whilst symbolic interactionism, on the other hand, relates to the continuous process through which humans interpret the social world, which includes the actions of others and the reason for the interpretation in order to adjust our own meaning and actions. An interpretivist approach appreciates secondary data for its significant value, and this is especially pertinent to the concluding phase of the research (Johnson et al., 2013).

The third assumption is known as pragmatism and provides the mid-point between positivist and interpretivist ideologies. Pragmatism employs a combination of qualitative and quantitative research paradigms to conduct research into complex human activities; as such, it is considered most suitable for investigating phenomena that involve both numerical and non-numerical datasets (Kral et al., 2012). According to (Fidel, 2008), pragmatism is appropriate for studies that are multifaceted in nature in that it enables a researcher to capture inferences drawn from qualitative and quantitative methodologies in a single research design to explore critical issues in diverse ways. Pragmatism draws on the strengths of both positivism and interpretivism, which helps to avoid the paradigm war between two opposing ideologies (Masadeh, 2012).

Based on the focus of this study and the nature of the research questions outlined in Chapter 1, the epistemological basis of this study lies in the middle ground of pragmatism. Studying Smart City innovation relates to how new technologies are being introduced to cities, the impacts of innovation on people, the environment, and entrepreneurial growth generally, which renders the study multifaceted in nature. This study therefore adopts a pragmatic research paradigm as the middle position of the two extremes in order to enrich the outcome of this study, as indicated in Table 4.1 and Figure 4.3.

Table 4.1: Critical Choices in Research Methodology

Areas of Consideration	Choices	Adopted Choice
Ontology	i. Objectivism ii. Constructivism	Constructivism
Epistemology	i. Positivism ii. Interpretivism iii. Pragmatism	Pragmatism
Axiology	i. Value Free ii. Value Laden	Value Laden
Research Approach (Reasoning)	i. Induction ii. Deduction iii. Abduction	Abduction
Research Strategy	i. Experiment ii. Case Study iii. Survey iv. Action Research v. Ethnography vi. Grounded Theory vii. Archival viii. Phenomenology	i. Case Study with ii. Survey
Research Methods	i. Qualitative ii. Quantitative iii. Mixed Method	Mixed Methods
Rationale for Case Study	i. Generality ii. Triangulation iii. Facilitation iv. Complementarity v. Aid Interpretation vi. Study Different Aspects	Triangulation
Data Collection Methods	i. Interviews ii. Survey Questionnaires iii. Focus Group (Pilot Study) iv. Direct Observation v. Archival Retrieval/Documentation	i. Focus Group (Pilot Study) ii. Interviews iii. Survey Questionnaires
Type of Case Study Design	i. Exploratory ii. Explanatory iii. Multiple-case iv. Descriptive v. Collective vi. Instrumental vii. Intrinsic	Multiple-case
Data Analysis Techniques	i. Qualitative ii. Quantitative	Thematic Analysis i. Correlation Analysis ii. Kruskal-Wallis Test ii. Reliability Test.

4.4.4 Summary of Philosophical Stand

Having highlighted the philosophical assumptions and the different viewpoints, the compromise on how to investigate Smart City evolution from the perspective of a city in a developing country tends towards the constructivist ‘naturalistic inquiry’ than the objectivist. Thus, the axiological basis lies in a value-laden than a value-free perspective in that “the researcher is part of what is being researched--value bound” (Saunders 2009). In terms of its ontological basis, this study adopts constructivism, whilst the epistemological position is interpretivist. Thus, the study will benefit from the experiences of other researchers in this field by focusing on the interpretation of situations in Smart City development and the realities behind these interpretations. Figure 4.3 outlines a summary of the research methodology for this study.

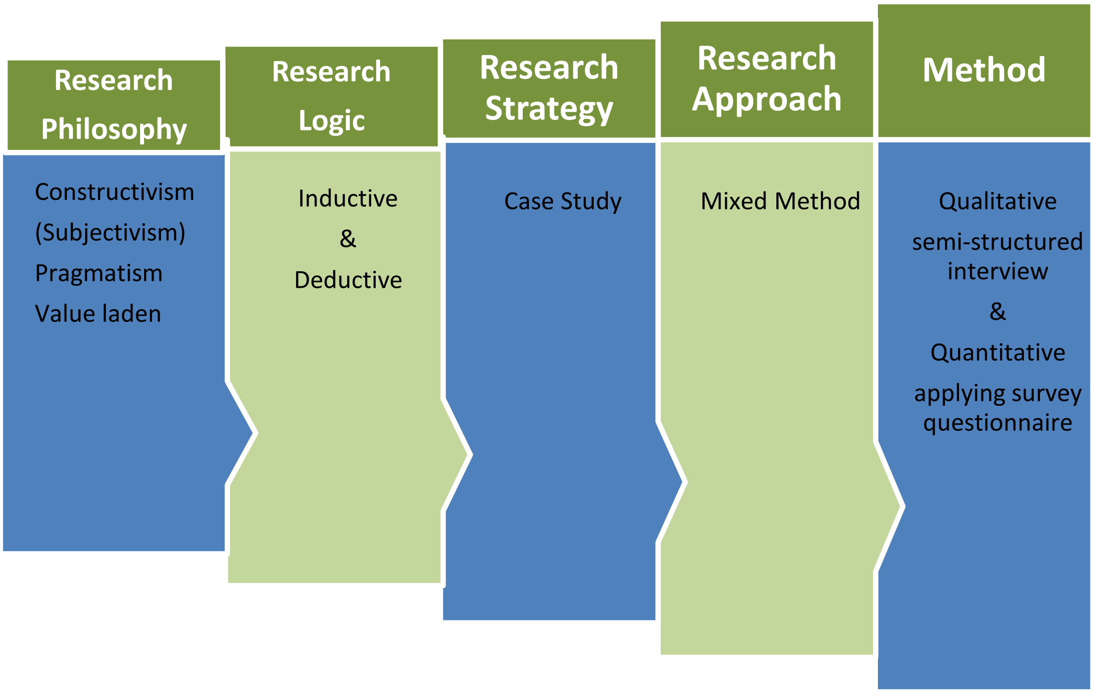


Figure 4-3: Summary of Research Methodology

4.5 Research Approach

In order to gain a better insight into the phenomena under investigation, a research approach is developed, which is concerned with the selection of appropriate research methods to address the research question/s. In other words, the research approach can be considered a significant component of a research framework for the collection and analysis of the data required for a study. However, the logics (reasoning) informs the choice of research approach to enable researchers make better decision about a research design (Sarantakos, 2013). Although, according to Blaikie (2010), there are seven research reasons, only three of the seven cognitive reasoning approaches tend to be used, namely inductive, deductive, and abductive. While the inductive approach is mainly concerned with developing theory from the observation of empirical reality, moving from theory to empirical investigation, the deductive approach seeks to enquire into the identified problems through the testing of theories – this theoretical structure is developed and then tested by empirical observation.

Inductive reasoning, on one hand, is generally an enquiry to understand social or human problems from different perspectives (Yin, 1994). It usually involves the investigation into an area with less theory in order to develop theory. Through the inductive process, behaviour in relation to a certain phenomenon or facts can be observed for a period of time on the basis of which generalisation about the development can be made. On the other hand, the deductive approach moves from a general principle to a specific case; it is used extensively in literature reviews from a global perspective. The deductive research approach is top-down in that it moves from the general to the specific. In contrast, the inductive approach starts from the specific and moves to the general (bottom-up). In addition, while the inductive approach is mainly concerned with theory-building, the deductive approach is concerned with theory-testing. According to Anderson (2013), the theory generated through an inductive process can be further developed through deductive empirical testing. The two approaches to reasoning are therefore somewhat complementary and cyclical in nature, as illustrated in Figure 4.4.

The third cognitive reasoning approach is abductive; this combines both inductive and deductive logics and carries some flexibility. Abductive reasoning, according to Walton (2004), is presumptive in nature. It proceeds with the construction of hypothesis (a provisional guess) which may give way later in the process when more evidence is gathered, particularly from experiments. Abduction is both a presumptive and plausible form of reasoning which goes backward from a given conclusion to search for the premises upon which this conclusion was drawn. According to Walton (2004), this form of reasoning is common in forensic analysis and it is believed to be important at the discovery stage of scientific research hypothesis formulation and testing.

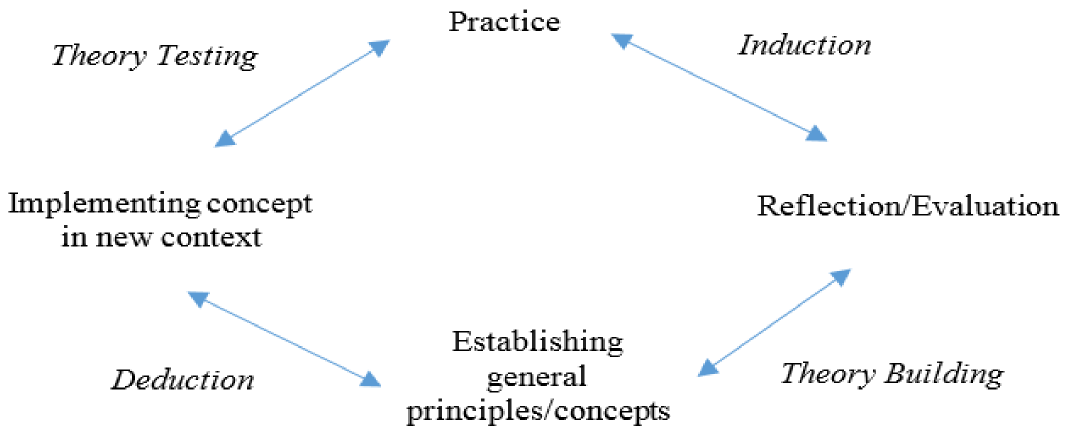


Figure 4-4: Inductive and Deductive Reasoning

(**Source**: Anderson, 2009)

In view of the nature of this study, the logic leans towards inductive reasoning although a combination of deductive and inductive reasoning was adopted to address the research questions and the identified problems. Adoption of the two different approaches will enhance the reliability of this study. According to M. P. L. a. A. T. Saunders (2009), the combination of inductive and deductive reasoning in a single piece of research is advantageous in minimising some inherent risks; for example, prolonged time in the case of a purely inductive approach and the non-return of questionnaire as in the case of a purely deductive approach. Similarly, D. Gray (2009) suggests that a researcher can turn the data collection process into a concept, models, and theories; an inductive approach can then be tested through experiments, whilst a mixed method helps in the design of studies.

In this study, both inductive and deductive reasoning (abductive) were employed, beginning with the literature review and the observation of Smart City developments to identify specific problems that could being addressed through Smart City technologies and innovation; this latter stage was achieved by talking to professionals. The different definitions and perspectives obtained are compared amongst the different city regions to formulate hypotheses, collect and analyse primary data, and develop theories to subsequently draw conclusions on how innovation in Smart City deployments can be modelled for an impact assessment.

4.6 Research Strategy

A research strategy refers to the overall direction within which the researcher conducts a particular piece of research, and includes the entire processes followed to acomplish the task (Remenyi, 2003). According to Saunders et al. (2009), there is no better strategy than another; instead, it they argue that it is more appropriate to consider whether the research strategy adopted will helpto answer the research questions and meet the objectives. Thus, in chosing the research strategy, there is need to consider the amount of time available for the research, the existing knowledge in the field and the philosophical underpinnings of the study. Saunders et al. (2009) suggested that a research strategy could include experiments, surveys, case studies, action research, grounded theory, ethnography, and archival research. Similarly, Yin (2014) posited that a research strategy includes experiment, surveys, archival analysis, history, and case studies. For this study three relevant situations were identified for the adoption of different strategies, and this was based on the following conditions:

i) The form of the research question/s
ii) The level of control (of the researcher) over behavioural events, and
iii) The extent of focus on contemporary (historical) events.

Furthermore, the strategies are not mutually exclusive as more than one can be combined - case study and survey - to achieve the goal of the research (Saunders et al., 2009). As Robson and McCartan (2016) also suggest, the setting of the study and type of research questions are two determinants of any methodology.

4.6.1 Adopted Strategy for This Study (Mixed)

Based on the philosophical assumptions, the proposed research approach and the logical reasoning for this study, a case study stratey alongside a survey method were chosen; thus, the study adopted non ‘mutually exclusive’ approaches. The two strategies and the rationale for their adoption are discussed in the subsequent sub-sections alongside the alternative research strategies and a summary of why they were not considered appropriate for this study.

4.6.2 Case Study

In this research, the case study approach will be adopted in order to triangulate multiple sources of data. Using a case study approach (Saunders et al., 2009) allows a researcher to triangulate multiple sources of data because it allows for the use of different data collection techniques within one study. Yin (2014), describes a case study as a distinctive form of empirical inquiry. He therefore defines a case study as an empirical inquiry with an in-depth and real-world contextual investigation of a contemporary phenomenon, which is particularly applicable when the boundaries between the phenomenon and context are blurred. According to Yin, a case study inquiry relies on evidence from multiple sources (triangulation), which guides the data collection and analysis through the benefits derived. This occurs prior to the development of the theoretical proposition and addresses any technical requirements for situations where there are more variables of interest.

It is in view of the above factors that this study adopts both case study and survey strategies; this is due to the multi-disciplinary nature of the Smart City concept. The combined strategies were employed in a multiple case study to gain a deeper understanding of experts' opinions from the three cities investigated. The case study strategy is also considered appropriate for an in-depth analysis of the multifaceted and multi-dimensional nature of technologies and the innovative characteristics of Smart Cities.

Such research is also classified into different types of case study, which include: single, multiple, explanatory, intrinsic, instrumental, collective, exploratory, and descriptive. However, a multiple case study approach was adopted because it permits the extensive discovery of data to better enable theoretical development and the reproduction of outcomes across cases (Creswell, 2013). In addition, a multiple case study approach is widely used to analyse data within and across different situations (Yin, 2013). It is also important to use multiple case studies to avoid criticisms and draw-backs relating to the generalisability in single case study (Sultan, Woods & Koo, 2011).

4.6.3 Case Selection

In case study research, the selection of appropriate cases is critical. Therefore, a case for study must be selected based on its critical need, uniqueness and other criteria, such as its potential to be revelatory and provide a notable example (Bryman, 2008). For this research, the multiple case studies of Boston, Abuja, and Manchester were selected for logical deduction. The cases are considered most suitable to enable the researcher cover a cross-section of issues relating to the Smart City concept and the possible impact on social and economic development.

CASE-1 (Boston City): The City of Boston has launched a long-term Smart City strategy named “GoBoston 2030” (now Imagine Boston 2030) comprising a number of strategic goals and targets. The key objective is to transform the city into a mobility innovation laboratory focusing on: People - Teaching Hospital for Transportation, Places - Radically Programmable City, and Things - Data (Boston, 2015). In particular, Boston is involved in a number of initiatives such as setting up platforms for innovation ecosystems through the innovation hubs/districts as well as encouraging Public-Private Partnership (PPP) through collaborating with key industry players (e.g. Verizon) to transform the city into a smart and healthy competitive environment. Boston was rated one of the six cities world-wide that have made huge investment towards Smart City projects (Bis, 2013).

CASE-2 (FCT-Abuja City): Abuja was selected as a case study because the focus of this study is primarily on how Nigeria can take advantage of the Smart City concept for sustainable development. In addition, FCT-Abuja recently launched a vibrant campaign for smart growth (G. Jiriko, D. G. JY, & S. Wapwera, 2015). Although the Abuja Smart City initiative is still at the foundational stage, FCT-Abuja, is embarking on ambitious smart transformation projects and programmes aimed at transforming the Nigerian capital city into a smart and sustainable city. The city has commenced the implementation of laudable projects towards the realisation of its Smart City vision, which include Abuja’s first eco-city project in Apo, the modernisation and expansion of its road infrastructure, and the provision of spatial data imagery for the city under the Abuja Geographic Information Systems (AGIS), (Jiriko et al., 2015). Other projects include the Abuja Light Rail System, Bus Rapid Transport (BRT), modern a health-care infrastructure, and so forth.

CASE-3 (Manchester City): Similarly, Manchester has advanced its Smart City developments since the launch of the Manchester Digital Strategy in 2008. A recent European Union report portrayed Manchester city as one of the Smart City demonstrators in the European region. In a recent assessment, Manchester was ranked the fifth most successful Smart City among 240 European Union [EU] cities (CentreforCities, 2014). A description of the three cases investigated is presented in Chapter 6.

For this research, Boston and Manchester (cases 1 and 3) are used as motivating case studies for lesson-drawing while Abuja (case-2) is the primary case study and the main-focus of the research. The selection of Boston and Manchester as motivating case studies were informed by the needs of this research. Although the primary focus of this study is not to dwell on comparative analysis, it is important to understand how Smart City policies are implemented in similar or different fashions; thus, it will be beneficial to study wealthier and poorer cities with different histories as well as a range of locations (Robinson, 2011). According to Rose (1991, 1993), lesson drawing starts with checking for programmes in operation elsewhere; however, it is expected to end with the prospective evaluation of the future when, or if, an already implemented programme is transferred elsewhere. As summarised in literature, cities tends to have unique challenges but, within the context of lesson drawing, nations tend to have much in common across cities or national boundaries (Richard, 1991).

4.6.4 Survey Strategy

A survey as a research strategy provides a quantitative-numeric-description of the trends, attitudes, or opinions of a population by studying a sample of that population (Creswell, 2009). It allows the researcher to collect, collate, and analyse quantitative data in a quantitative manner using descriptive and/or inferential statistics. According to Saunders (2012), a survey strategy is usually associated with a deductive approach and is popular because it allows for the collection of a large amount of data which is often obtained through the administration of a questionnaire. Thus, it is important to sample the opinions of an enlarged Smart City stakeholder in FCT-Abuja for this study to gather the different views of individuals who are involved in the Smart City initiatives.

4.6.5 Alternative Research Strategies

A number of research strategies have been proposed to help researchers accomplish the aim and objectives of a particular study. As technologies have helped the handling of complex analysis, researchers now have several options for procedures to conduct research, especially in the social sciences (Creswell, 2009). These alternative strategies and the reasons for not chosing them are discussed in the following sub-sections.

1. Experimental Strategy: Experiments include ‘true experiments’ with the random assignment of subjects to treatment conditions, and ‘quasi-experiments’ that use non-randomised design (Keppel et al., 1992). An experimental strategy is therefore concerned with the manipulation of an independent variable to observe the behaviours of dependent variables (Collis & Hussey, 2009). Thus, an experimental strategy uses control testing and manipulation to understand casual processes. Usually, experimental research is adopted to assess hypotheses about cause and effect reactions. The need for a control renders the experimental strategy unsuitable for this study because the research has no control over the phenomena under consideration.

2. Ethnography: In an ethnographic strategy, the researcher studies an intact cultural group in a natural setting for a prolonged period of time to collect observational and interview data (Creswell, 2007). According to Saunders et al. (2009), ethnography is deeply rooted in an inductive approach and originated from the field of anthropology. However, this strategy "describe(s) and explain(s) the social world the research subject inhabit(s) in the way in which they would describe and explain it", which is time consuming (Saunders et al., 2009). Thus, this strategy cannot be applicable in this study as the research is time-bound.

3. Grounded Theory: In grounded theory, according to Creswell (2007), the researcher derives a general abstract theory of a process or interaction grounded in the views of the participants. Grounded theory therefore emphasises development and the building of theory using a combination of both inductive and deductive approaches (Saunders et al., 2009). The application of grounded theory is not considered in this study because it seeks to develop theory from the systematic examination of a phenomenon while this study explores real life situations through the existing knowledge and experiences of the core Smart City stakeholders.

4. Action Research: An action research strategy is also known as 'learning by doing' and involves a continuous and interrelated process of planning, acting, observing, and reflecting (Anderson, 2005). Action research, according to Saunders et al. (2009), emphasises the involvement of practitioners in the research; moreover, it emphasises the iterative nature of the process diagnosis, it has implications beyond the immediate project, and it stresses the importance of co-learning. Moreover, it is important to note that an action research strategy has befitting attributes in combining both data gathering and the facilitation of change. In spite of its strength in fostering change and diagnosis, this strategy was not considered suitable for this study because the level of commitment and involvement of the practitioners required from the Smart City stakeholders is not realistic for the duration of the study.

In the same manner, phenomenology and other research strategies, including ‘archival research’ and ‘direct observation’, were considered but rejected because of associated draw-backs . A phenomenological strategy, for instance, involves the study of a small number of subjects through extensive and prolonged engagement in order to develop patterns and relationships of meanings (Moustakas, 1994). Thus, a phenomenological strategy was rejected because of the fundamental and situational dilemmas that may arise, since the cases investigated differ significantly in both culture and orientation (Shi, 2013).

4.6.6 Research Choices

The research choices are described with different terminologies by different authors. For instance, Tashakkori and Teddlie (2010) referred to multiple methods as ‘research design’. In comparison, Saunders et al. (2009) denoted the ways in which researchers choose to combine quantitative and qualitative techniques and procedures for the collection and analysis of data as ‘research choices’. Similarly, Creswell (2009) identified qualitative, quantitative, and mixed methods as the three research approaches. In this regard, Saunders et al. (2009) in a hierarchical structure, classified two basic choices of mono method and multiple methods. Furthermore, the multiple method choice is further classified into: firstly, multi-method which encompasses multi-method quantitative studies and multi-method qualitative studies, and secondly mixed-method, which is also grouped into mixed-method research and mixed-model research.

As Tashakkori and Teddlie (2010) suggested, a combination of various methods can be useful in exploring research questions in order to evaluate the extent to which the findings of the research study can be trusted, as well as the inferences drawn from such a study. Similarly, Creswell (2007) proposed a mixed method approach to enable researchers to collect, analyse, and integrate qualitative and quantitative data into a single piece of research. This method of combining procedures and techniques for the collection and analysis of data from different sources and the integration to enrich the outcome of the research findings was determined to be most appropriate for this study.

4.6.7 Time Horizon

Another component of the research onion is the time horizon. The time horizon is mainly concerned with the completion of the research study. In this area, Saunders et al. (2009) identified two perspectives, namely cross-sectional and longitudinal. While time is predetermined in a cross-sectional study, a longitudinal study is not necessarily time constrained. A cross-sectional study is based on a ‘snapshot’ that is taken at a particular time, whilst a longitudinal study is more akin to a diary or series of ‘snapshots’ and an image of actions over a given period of time. The appropriate time horizon for this study is cross-sectional since it is an academic programme expected to be completed within a given period of time.

4.7 Unit of analysis

This section summarises the unit of analysis of the phenomenon under investigation. According to Trochim, Donnelly, and Arora (2015), one of the most important considerations in a research study is the unit of analysis. Thus, the social entity about which information is sought, hypothesis are designed, and inferences are drawn is the unit of analysis (Blanchard, Engle, Howley, Whicker, & Nagler, 2016). In this study, the unit of analysis are the Smart City organisations/initiatives across the selected cases investigated. Because of the dynamic nature of Smart City development, it is imperative to analyse the embedded knowledge of the key stakeholders who are involved in Smart City deployment, from senior management in both the public and private sector through to mid-level managers who have unlimited access to relevant information. In this regard, the study requires an understanding and analysis of the evolving Smart City concept, its critical success factors, key performance indicators, and the identified challenges, which are based on existing initiatives.

The initial units of analysis within this study are:

a) Senior management of key Smart City stakeholder organisations
b) Managers of key industry practitioners
c) Managers and team-leaders in innovation hubs

The strategies for participant recruitment and data collection will be explored further and discussed in subsequent sections of this chapter and Chapter 6.

4.8 Research Method

Research methods involve the techniques for gathering evidence or various ways of proceeding in collecting information. It includes the approaches used in the collection of data upon which inferences are drawn. In summary, research methods are the systematic means by which data are gathered and analysed. According to Saunders et al. (2009), a research method should provide detail on how to achieve the research objectives. Basically, it considers the data collection method, data analysis methods, sampling techniques, and ethical issues.

4.8.1 Quantitative and Qualitative Approach

Quantitative research (approach) involves the use of methods, such as questionnaires or structured interviews through surveys, to generate statistics. A quantitative approach is mainly concerned with quantitative data, whilst qualitative research is mainly concerned with qualitative data. A qualitative approach seeks to develop an understanding of the subject matter to formulate theories that explaining the phenomenon under investigation.

A mixed method approach is adopted in this study, which employs a qualitative method integrated with quantitative method; this provides a triangulated approach to strengthen the validity of the outcome. The choice of mixed method will help, through providing collective strength, in better understanding the problems in this field as well as uncovering the variables not apparent in literature (Creswell, 2015; Vicki, 2008) .

4.8.2 Data Collection Method

Data collection methods in this scenario refer to the various means or specific tools by which data can be collected and analysed. Yin (2014) suggests six different sources of evidence in case study research strategy that are relevant to this study, from which two were considered useful. They six sources are: interviews, documents, participant-observations, direct observation, physical artefacts, and archival records. In this study, systematic and organised procedures were employed to collect data from primary and secondary sources through the use of face-to-face interview, retrieval from relevant documents, and a survey component (Tsolakis & Anthopoulos, 2015). Professionals in Smart City projects in public and private organisations and academia (covering city administrators, IT professionals, and planners) were interviewed.

To access multiple sources of evidence, this study adopts a triangulation approach in order to achieve a high quality of data. According to (Brewer & Hunter, 2006), triangulation involves the use of more than one approach in the research process to enhance the quality of research findings. In this regard, Denzin (1970) suggests four types of triangulation, namely: methodological triangulation – using more than one method to collect data; theoretical triangulation – using more than one theoretical perspectives to interpret data; investigator triangulation – using more than one researcher to collect data; and data triangulation - using different sampling strategies to collect data. This study employs three of the four types (all except the investigator triangulation because the research design did not accommodate multiple researchers).

4.8.2.1 Sampling Approach

The piloting phase and focus group (expert) interviews provided a useful platform to carefully obtain information about the FCT-Abuja Smart City programme as well as to determine the population size for inclusion in the study. However, it is imperative to estimate the number of participants/respondents required to obtain the information needed to achieve the core objectives of the study. In this regard, Walliman (2010) revealed that probability sampling is suitable for qualitative research while a non-probability sampling strategy is considered most appropriate for quantitative research. During the pilot phase/focus group exercise, a list of the collaborating agencies for the Abuja Smart City initiative was obtained through the office of the co-ordinator. Based on the list, the population size for the interviews and the survey respondents were drawn, which were: six organisations with two Federal Government MDAs, two universities, two professional bodies and one not-for-profit organisation.

The selection of interviewees during the field investigation in CASE-1 and CASE-3 employed purposeful sampling and a snow balling technique to select key individuals for interview. During this phase, documents such as GoBoston 2030 and the Transport for Greater Manchester Committee Report, were also purposefully selected for review. Although the Abuja Smart City initiative is still in its infancy, the following documents were reviewed,: Integrated Abuja Transport Master Plan; Abuja Geographic Information Systems (AGIS); Abuja: The Dream; Conception and the Product, Abuja: The Making of a New Capital City for Nigeria; and Committee Report on the Creation of a New Federal Capital Territory.

In CASE-2, a combination of probability and non-probability sampling techniques were adopted because of the mixed method design. It is important to note that the face-to-face interviews targeted senior executives of organisations collaborating with FCTA on the Smart City initiative. In this case, a non-probabilistic sampling strategy was suitable since these senior executives are well-known individuals. However, a probabilistic sampling strategy was employed to draw the survey participants for the survey component because the study relied on the stakeholder organisations to obtain a comprehensive list of participants - in this situation, the researcher had limited control (J. Collis & Hussey, 2013)Dawson, 2011; Yin, 2009).

4.8.2.2 Focus Group Interview/Pilot Study

In considering the design of the survey, Naoum (2013) posited that lessons drawn from feedback in a pilot study helps the researcher to refine and check the instrument (questionnaire) before the main data collection exercise. Hence, in an effort to produce an all-inclusive survey instrument for the study, a pilot study was carried out in Abuja to check the initial design; this was achieved through a focus group exercise. The focus group pilot phase started in Abuja on 4th July 2016 and was concluded 20th July 2016. The city was selected for the pilot because it also formed the main focus of this study. In addition, FCT-Abuja recently launched a campaign concerning Smart growth (G. Jiriko et al., 2015). Moreover, in recognition of its transformational efforts, FCT-Abuja was named as one of the 16 candidate cities selected by the IBM Council Global Partner to benefit from the ‘IBM Smarter Cities Challenge 2014’ (IBM, 2014). The Smarter City Challenge is a special grant for municipalities with a contribution of technologies and talents from IBM; only three cities qualified from Africa. Abuja city was selected alongside the city of Durban in South Africa and Mombasa County in Kenya; this initiative represented the continuation of IBM’s Smarter Cities Challenge collaboration around the world (IBM, 2014).

In an effort to identify core indicators that are already being used as reference for Smart City impact assessment, current data on Smart City development and the key performance indicators for cities were sourced from academic journals, reports from research institutions, and white papers by international/regional organisations. The intention was to first generate a comprehensive list of factors/indicators based on existing ‘Smart City wheels’ and ISO-37120 resilient city standard for measuring the Smartness of a city. The second step was to subject these priority themes to focus group analysis in order to validate and refine the indicators with the purpose of analysing them using Smart City stakeholders in Abuja (the ISO-37120 list of indicators is attached as Appendix A).

In recognising the challenges of the infrastructure deficit that exists amongst the cities in developing countries, this research integrates data from different sources for the proposed KPI for Smart Cities, and validates these data through ranking the Smart City core components through a focus group, which was drawn from ICT industry, academia, and inidivuals involved in urban development, which was dominated by FCT Administration. To articulate the focus, the study received valid feedback from the stakeholders based on the core objectives of the research. In doing so, a number of changes to the existing Smart City core components were made for ease of analysis and to address the perceived interrelationship. Meanwhile, the factors/indicators were streamlined in line with the priority dimensions; for instance, the need for a Smart Infrastructure was prioritised as a core component of a Smart City among the three categories of stakeholder in Abuja; this contrasted with the Smart economy emphasised in existing models. The details of the pilot study are presented in Chapter 5.

The focus group interview adopted an aspect of Q-methodology to elicit information from ‘knowledge-rich’ stakeholders in a more scientific manner in order to minimise any researcher bias (Stephenson, 1953). In this procedure, the interviews were targeted at the senior executives in core stakeholder organisations after which they were asked to nominate experienced officers below senior management who were conversant with the Abuja Smart City initiative to participate in the ranking session. Prior to this, the key elements of the ISO-37120 resilient city standard and the Smart City wheels retrieved from academic journals, industry reports, and standards were listed. This resulted in 29 components for consideration with the senior executives, whilst at the end of the interview phase, the list of components was reduced to 18 and transformed into statements for stakeholders to rank in line with their perception as well as the priority Smart City themes relevant to the focus of the Abuja Smart City programme. In summary, 105 experts representing seven Smart City stakeholder organisations from the ICT industry (in public/private sector, professional bodies, and NGOs), academia, and urban planners from the FCT Administration participated in the comprehensive ranking exercise.

4.8.2.3 Interviews

Stakeholder interviews were part of the major data collection techniques used in this research and designed to collect valid and reliable data that were relevant to the focus of this study. In general, different types of interview are used by researchers for data collection, which includes structured, semi-structured, and unstructured. In this study, a semi-structured (face-face) interview was adopted in order to undertake extensive probing of the issues as well achieve effective engagement to obtain in-depth information from stakeholders. A copy of the semi-structured interview guide is attached as Appendix B.

Saunders et al. (2009) argued that interviews, as a technique for data collection, lack a standardised approach which potentially suggests a lack of rigour and reliability in the findings. Similarly, (D. E. Gray, 2013) criticised interviews as being time-consuming, and difficult to code, and analyse especially when a large number of participants (interviewees) are involved. In contrast, (Qu & Dumay, 2011) described interviews as a powerful means of discovering new knowledge as well as capturing the embedded knowledge of experts in the field of research, which may not be feasible through other techniques, such as questionnaires.

Consequently, a total of 22 interviews were conducted across cases with core Smart City stakeholders. These individuals were drawn from urban planning, academia, and ICT industry. CASE-1 involved a total of ten participants, CASE-2 involved seven participants while CASE-3 involved five participants. The summary of the participants' profiles and demographics are shown in Table 4.2.

Table 4.2: Interview Participants' Profiles and Demographics.

CASE-1	**Position**	**Sector**	**Qualification**	**Experience (in years)**
MOB	Cabinet Head/Member	Urban Planning	PhD.	15
MSB	Manager	Information Technology	BSc.	11
SLB	Innovation Coordinator	Academia	PhD	12
SCB	Senior Lecturer	Academia	Professor	9
ICB	Executive Director	Urban Planning	MSc.	13
DHB	Director	Urban Planning	BSc.	7
UFB	Director	Academia	Professor	17
UMB	Director	Information Technology	BSc.	6
MHB	Executive Director/CEO	Urban Planning	MSc.	5
NMB	Founder/CEO	Urban Planning	MSc.	7
CASE-2				
CCA	MD/CEO	Urban Planning	MSc.	11
FNA	Ass. Chief	Information Technology	PhD.	14
FCA	Coordinator/CEO	Urban Planning/Transport	MSc	27
SCA	National Coordinator	Transportation	MSc.	17
AUA	Senior Lecturer/Director	Academia	Professor	21
SCA	Executive Director	Information Technology	BSc.	17
AGA	Director/CEO	Information Technology	PhD.	9
CASE-3				
CHM	Director/Senior Lecturer	Academia	PhD.	4
IPM	Director	Information Technology	MSc.	27
CCM	Senior Policy Officer	Urban Planning	MA	20
ODM	Founder/CEO	Information Technology	MSc	7
TFM	HOD	Urban Planning	MA	11

Archival/Review of Documents

Yin (2009) and Dawson (2009) expressed the need for caution regarding the credibility and authenticity of document retrieval for research purposes. Furthermore, Yin suggested that, when documents are carefully selected, valid documentary evidence and sources are crucial to improve the quality of the research. In this case, valid documents are regarded as supplementary sources of data to support both interviews and the data generated through a questionnaire.

In this study, the following relevant documents, amongst others, were reviewed as soft/secondary sources of data: the Integrated Abuja Transport Master Plan, AGIS, Abuja Master Plan 1975, GoBoston 2030, The Making of a New Federal Capital City for Nigeria (2nd Edition), the Abuja Handbook 1998, Abuja: The Dream, Conception and the Product – A Review of the Abuja Master Plan. In addition, online sources from official websites and the Internet were reviewed to source qualitative and quantitative data.

4.8.2.4 Survey Instrument (Questionnaire) and its Development

In data collection, many researchers generally employ a questionnaire instrument to elicit information in different fields of study. Saunders et al. (2009) revealed that a questionnaire is one of the most commonly used data collection techniques compared to other forms/techniques. The adoption of a questionnaire in this case gives the researcher a good grounding for taking control of the data collection exercise in order to obtain results that will be credible in representing the population under study (Saunders et al., 2009).

In designing the questionnaire, different measurement scales were considered which included: nominal, interval, ratio, and ordinal. In order to provide coherent answers to the research questions in this study, ordinal scales of measurement were used which were designing by ranking and based on the priority and level of agreement in an ordered sequence. Thus, a five-point Likert scale was adopted – the number was selected in order to provide a convenient mid-point option. Although a Likert scale can also adopt four, seven, nine, and 11-points (Dawes, 2012), this study adopts the five because of its tendency to reduce bias (Brace, 2008).

During the design phase of the survey instrument, it was imperative to ensure that the overall aim and objectives of the study were duly considered in order to generate data that effectively addressed the research questions. Hence, the relevant issues raised during the literature review on Smart City development, Smart City KPI measurement metrics, and other information relevant to the core components of Smart Cities under consideration were considered in the choice of questions.

4.8.2.5 Survey Instrument (Questionnaire) and its Layout

The survey instrument was structured into four main sections labelled A, B, C, and D. Each section was further divided into specific questions in a simple design to ensure the accuracy of the responses, its timeliness, and the usefulness of the responses from the respondents. Further detail regarding the content of these sections is provided as follows;

Section A - General Information and Respondent Profile: Section A consisted of four questions about the general background information of the respondents. Question one requested information about respondent’s educational qualification. Question two enquired about the respondent’s level of experience in the sector. Question three enquired about the respondent’s organisation and sector, while question four asked the respondents to indicate their areas of specialisation.

Section B – Confirmation of the Core Components of Smart Cities: Section B consisted of three questions about the core components of Smart Cities established from the pilot study. Question one requested that respondents confirmed whether the three the core components were important to their Smart City objectives. Question two gave the opportunity for respondents who disagreed to give their reasons, while question three asked respondents to rank the core components according to the importance and priority.

Section C - Identifying Core Factors for the Classification of Smart City Core Indicators to Measure the Impacts of Smart Cities: Section C consisted of three questions about the factors of the core components of Smart Cities. Question one asked the respondents to rank the factors of the Smart Infrastructure on a scale of 1-5 based on their perceived priorities. Question two asked the respondents to rank the factors of Smart Institution on a scale of 1-5 based on their perceived priority factors, while question three asked the respondents to rank the factors for Smart People on a scale of 1-5 based on their perceived priority factors.

Section D - Identifying Core Indicators for Measuring Impacts of Smart Cities: Section D also consisted of three questions about the indicators of the core components of Smart Cities. Question one asked the respondents to rank the indicators of Smart Infrastructure on a scale of 1-5 based on their perceived priority factors. Question two asked the respondents to rank the indicators of a Smart Institution on a scale of 1-5 based on their perceived priority factors, while question three asked the respondents to rank the Smart People indicators on a scale of 1-5 based on their perceived priority factors.

The last segment of the survey instrument requested that respondents make general comments about the relevance of the research and the Smart City innovation generally. A copy of the survey instrument is attached as Appendix C.

4.8.2.6 Survey Instrument (Questionnaire) and Its Administration

As discussed above, the study adopted a focus group platform to pre-test the validity and the likely reliability of the data for collection with the draft survey instrument. As Sarantakos (2012) suggests, the conduct of a pilot study to test an instrument – in this case a survey – helps to ensure the reliability, effectiveness, and validity for which the research is intended. The testing helped to refine the instrument in terms of keeping the language simple and clear to avoid ambiguity and the need for error correction. It also helped to reduce the time required to complete the questionnaire to the barest minimum.

The refined version of the instrument and the covering letter were directly hand delivered to respondents in Abuja within a period of five weeks. Efforts were also made to deliver a number of the questionnaires through email addresses to improve the response rate but the email channel did not yield the desired results as respondents kept complaining of unstable Internet access throughout the duration of the survey. At the end of the five week exercise, a total of 139 survey instruments were delivered to respondents of which 107 completed survey instruments were retrieved successfully giving a response rate of 76.98%. According to the participants contacted as follow-up mechanism, a poor Internet service was responsible for the low response experienced from the mailing option. Chapter 7 presents the outcome of the survey component and its detailed analysis.

4.8.3 Data Analysis Method

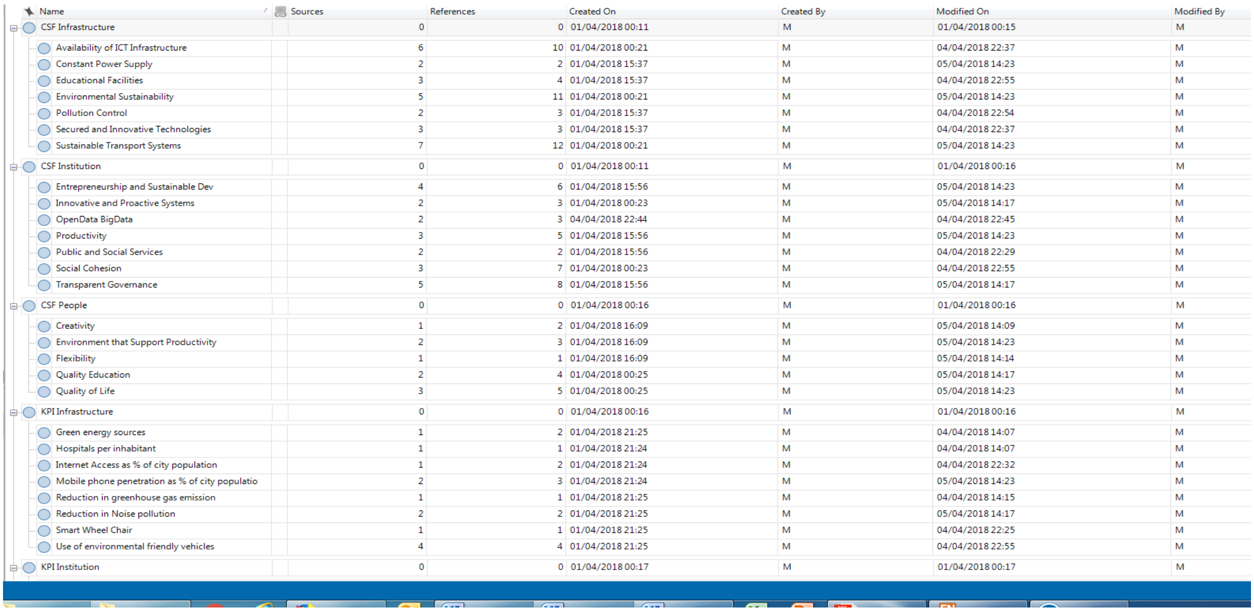
This section presents a description of the procedures employed to analyse the data obtained from the face-to-face interviews and the survey. The section is structured into two main sub-sections covering the qualitative data analysis and the quantitative data analysis. The study aims to identify meaningful findings from the different types of data retrieved in order to draw intelligent conclusions. Yin (2009) identifies the appropriateness of content analysis for case study data from different sources, such as text transcripts of surveys. Content analysis was used to analyse the qualitative data generated from the field, while the quantitative data was analysed with the aid of SPSS (structured and unstructured) to compare empirical patterns and to conduct statistical tests using the Kruskal-Wallis test and correlation analysis.

4.8.3.1 Qualitative Data Analysis

To obtain qualitative data from face-to-face interviews, thematic and content analysis techniques were used. Yin (2009) and Dowson (2011) suggested that data must be produced in a format that can be easily analysed. In view of this, the interviews (which were audio-recorded) and notes taken during the interactions were transcribed accordingly. During this phase, the outcomes of the interviews were carefully transformed into textual form in order to commence the data analysis. The process can be cumbersome and requires the careful guidance of the researcher to ensure the validity of the transcribed data. According to Corden and Sainsbury (2006), interview transcriptions give the researcher an opportunity to gain a better understanding of the interview data.

Coding and Information Categorisation: In the qualitative data analysis process, the coding of the textual version of the interviews is important in extracting the data. The categorisation of information, or indexing of data, is an important aspect of the qualitative data analysis especially when labelling and grouping variables. Hence, after the transcription of the interviews, the texts were carefully coded in order to organise the data for the content analysis and interpretation. Again, to allow for the sentence-to-sentence examination of the transcribed interviews, an open coding approach was adopted. In this study, a thematic analysis method was used to analyse the data from the interviews, as shown in Figure 4.5.

In general, the development of a framework for qualitative data analysis focuses on high quality data in order to extract the textual representation of the interview responses (data) for the initial findings before any further interpretation. Chapter 6 presents the breakdown of the data from the face-to-face interviews and the further analysis of the field investigation.



Name	Sources	References	Created On	Created By	Modified On	Modified By
CSF Infrastructure	0	0	01/04/2018 00:11	M	01/04/2018 00:15	M
Availability of ICT Infrastructure	6	10	01/04/2018 00:21	M	04/04/2018 22:37	M
Constant Power Supply	2	2	01/04/2018 15:37	M	05/04/2018 14:23	M
Educational Facilities	3	4	01/04/2018 15:37	M	04/04/2018 22:55	M
Environmental Sustainability	5	11	01/04/2018 00:21	M	05/04/2018 14:23	M
Pollution Control	2	3	01/04/2018 15:37	M	04/04/2018 22:54	M
Secured and Innovative Technologies	3	3	01/04/2018 15:37	M	04/04/2018 22:37	M
Sustainable Transport Systems	7	12	01/04/2018 00:21	M	05/04/2018 14:23	M
CSF Institution	0	0	01/04/2018 00:11	M	01/04/2018 00:16	M
Entrepreneurship and Sustainable Dev	4	6	01/04/2018 15:56	M	05/04/2018 14:23	M
Innovative and Proactive Systems	2	3	01/04/2018 00:23	M	05/04/2018 14:17	M
OpenData BigData	2	3	04/04/2018 22:44	M	04/04/2018 22:45	M
Productivity	3	5	01/04/2018 15:56	M	05/04/2018 14:23	M
Public and Social Services	2	2	01/04/2018 15:56	M	04/04/2018 22:29	M
Social Cohesion	3	7	01/04/2018 00:23	M	04/04/2018 22:55	M
Transparent Governance	5	8	01/04/2018 15:56	M	05/04/2018 14:17	M
CSF People	0	0	01/04/2018 00:16	M	01/04/2018 00:16	M
Creativity	1	2	01/04/2018 16:09	M	05/04/2018 14:09	M
Environment that Support Productivity	2	3	01/04/2018 16:09	M	05/04/2018 14:23	M
Flexibility	1	1	01/04/2018 16:09	M	05/04/2018 14:14	M
Quality Education	2	4	01/04/2018 00:25	M	05/04/2018 14:17	M
Quality of Life	3	5	01/04/2018 00:25	M	05/04/2018 14:23	M
KPI Infrastructure	0	0	01/04/2018 00:16	M	01/04/2018 00:16	M
Green energy sources	1	2	01/04/2018 21:25	M	04/04/2018 14:07	M
Hospitals per inhabitant	1	1	01/04/2018 21:24	M	04/04/2018 14:07	M
Internet Access as % of city population	1	2	01/04/2018 21:24	M	04/04/2018 22:32	M
Mobile phone penetration as % of city populatio	2	3	01/04/2018 21:24	M	05/04/2018 14:23	M
Reduction in greenhouse gas emission	1	1	01/04/2018 21:25	M	04/04/2018 14:15	M
Reduction in Noise pollution	2	2	01/04/2018 21:25	M	05/04/2018 14:17	M
Smart Wheel Chair	1	1	01/04/2018 21:25	M	04/04/2018 22:25	M
Use of environmental friendly vehicles	4	4	01/04/2018 21:25	M	04/04/2018 22:55	M
KPI Institution	0	0	01/04/2018 00:17	M	01/04/2018 00:17	M

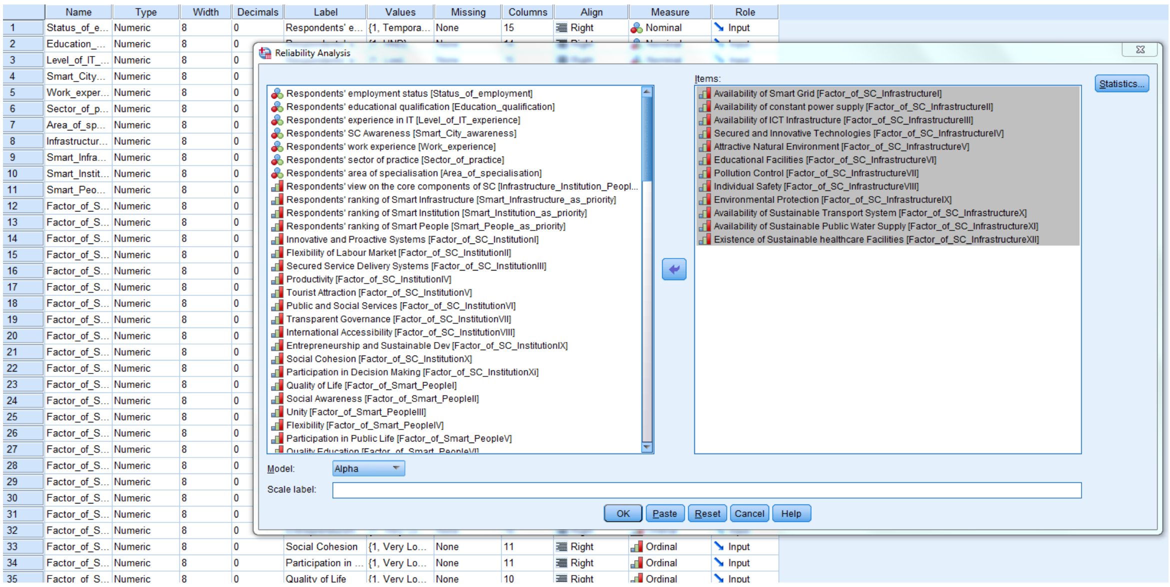
Figure 4-5: Coding of the Face-to-Face Interview Transcripts

4.8.3.2 Quantitative Data Analysis Framework

Quantitative data analysis is another critical stage of the research. According to Saunders et al. (2009), analytical methods offer researchers a better perspective from which to determine the answers to their research questions. An important task, however, is to identify the data type and appropriate method for analysis. In this regard, Sarantakos (2013) suggests the following six critical steps to ensure that the data analysis tasks are undertaken in a logical manner:

i) Data preparation which includes cleaning and editing to avoid errors and omission
ii) Data entering in preparation for the analysis
iii) Data presentation using tables and graphs
iv) Statistical analysis of the data for inferential purposes
v) Data summarisation and an explanation of the findings, and
vi) The drawing of conclusions based on the results of the analysis.

In this study, the data from the survey instrument were analysed using SPSS version 23. In order to examine the relationship among the core factors and indicators of the Smart City components, the Spearman's Rank Order Correlation (rho) was employed as statistical tool for the correlation analysis. In addition, the Kruskal-Wallis test was carried out to determine if there were any disparities among the scores of the different groups of participants (in terms of the area of specialisation and educational qualification) in their answers to the questions. The test was deemed necessary to assess the difference between the groups of participants in this study and to provide answers to some of the research questions. The Kruskal-Wallis H test is a non-parametric alternative to the one-way between groups analysis of variance. Prior to this, the reliability of the data collected was also tested using Cronbach's Alpha, which was based on standardised items, as shown in Figure 4.6.



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	Status_of_e...	Numeric	8	0	Respondents' e...	{1, Tempora...	None	15	Right	Nominal	Input
2	Education_...	Numeric	8	0							
3	Level_of_IT_...	Numeric	8	0							
4	Smart_City...	Numeric	8	0							
5	Work_exper...	Numeric	8	0							
6	Sector_of_p...	Numeric	8	0							
7	Area_of_sp...	Numeric	8	0							
8	Infrastructur...	Numeric	8	0							
9	Smart_Infra...	Numeric	8	0							
10	Smart_Instit...	Numeric	8	0							
11	Smart_Peo...	Numeric	8	0							
12	Factor_of_S...	Numeric	8	0							
13	Factor_of_S...	Numeric	8	0							
14	Factor_of_S...	Numeric	8	0							
15	Factor_of_S...	Numeric	8	0							
16	Factor_of_S...	Numeric	8	0							
17	Factor_of_S...	Numeric	8	0							
18	Factor_of_S...	Numeric	8	0							
19	Factor_of_S...	Numeric	8	0							
20	Factor_of_S...	Numeric	8	0							
21	Factor_of_S...	Numeric	8	0							
22	Factor_of_S...	Numeric	8	0							
23	Factor_of_S...	Numeric	8	0							
24	Factor_of_S...	Numeric	8	0							
25	Factor_of_S...	Numeric	8	0							
26	Factor_of_S...	Numeric	8	0							
27	Factor_of_S...	Numeric	8	0							
28	Factor_of_S...	Numeric	8	0							
29	Factor_of_S...	Numeric	8	0							
30	Factor_of_S...	Numeric	8	0							
31	Factor_of_S...	Numeric	8	0							
32	Factor_of_S...	Numeric	8	0							
33	Factor_of_S...	Numeric	8	0	Social Cohesion	{1, Very Lo...	None	11	Right	Ordinal	Input
34	Factor_of_S...	Numeric	8	0	Participation in ...	{1, Very Lo...	None	11	Right	Ordinal	Input
35	Factor_of_S...	Numeric	8	0	Quality of Life	{1, Very Lo...	None	10	Right	Ordinal	Input

Reliability Analysis

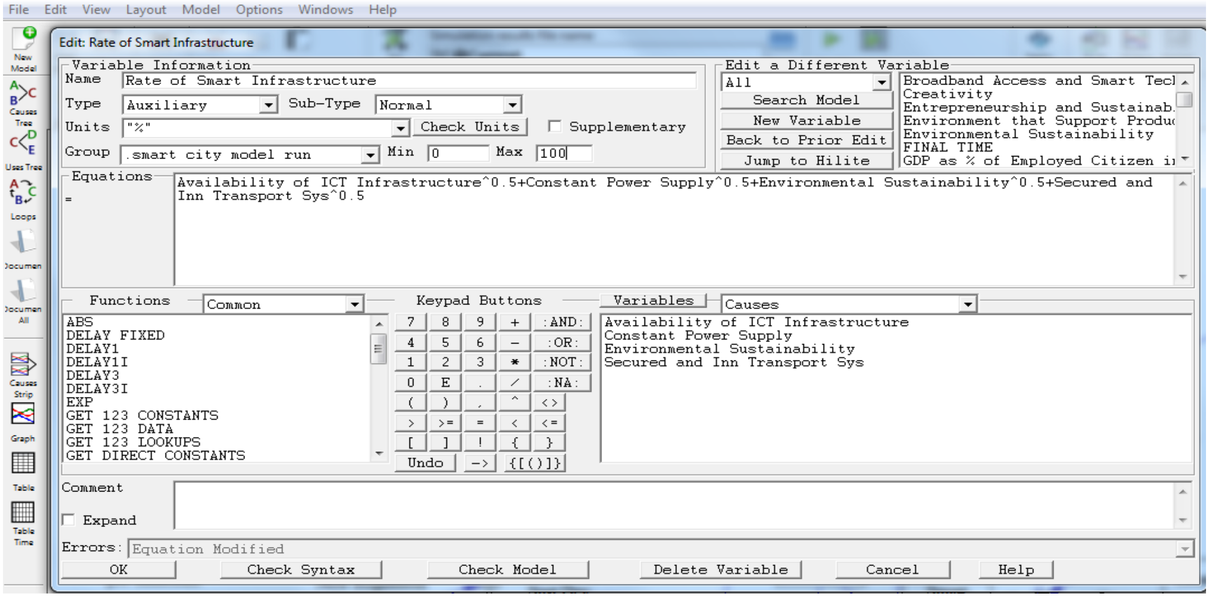
Respondents' employment status [Status_of_employment]
Respondents' educational qualification [Education_qualification]
Respondents' experience in IT [Level_of_IT_experience]
Respondents' SC Awareness [Smart_City_awareness]
Respondents' work experience [Work_experience]
Respondents' sector of practice [Sector_of_practice]
Respondents' area of specialisation [Area_of_specialisation]
Respondents' view on the core components of SC [Infrastructure_Institution_Peopl...
Respondents' ranking of Smart Infrastructure [Smart_Infrastructure_as_priority]
Respondents' ranking of Smart Institution [Smart_Institution_as_priority]
Respondents' ranking of Smart People [Smart_People_as_priority]
Innovative and Proactive Systems [Factor_of_SC_InstitutionI]
Flexibility of Labour Market [Factor_of_SC_InstitutionII]
Secured Service Delivery Systems [Factor_of_SC_InstitutionIII]
Productivity [Factor_of_SC_InstitutionIV]
Tourist Attraction [Factor_of_SC_InstitutionV]
Public and Social Services [Factor_of_SC_InstitutionVI]
Transparent Governance [Factor_of_SC_InstitutionVII]
International Accessibility [Factor_of_SC_InstitutionVIII]
Entrepreneurship and Sustainable Dev [Factor_of_SC_InstitutionIX]
Social Cohesion [Factor_of_SC_InstitutionX]
Participation in Decision Making [Factor_of_SC_InstitutionXi]
Quality of Life [Factor_of_Smart_PeopleI]
Social Awareness [Factor_of_Smart_PeopleII]
Unity [Factor_of_Smart_PeopleIII]
Flexibility [Factor_of_Smart_PeopleIV]
Participation in Public Life [Factor_of_Smart_PeopleV]

Items:
Availability of Smart Grid [Factor_of_SC_InfrastructureI]
Availability of constant power supply [Factor_of_SC_InfrastructureII]
Availability of ICT Infrastructure [Factor_of_SC_InfrastructureIII]
Secured and Innovative Technologies [Factor_of_SC_InfrastructureIV]
Attractive Natural Environment [Factor_of_SC_InfrastructureV]
Educational Facilities [Factor_of_SC_InfrastructureVI]
Pollution Control [Factor_of_SC_InfrastructureVII]
Individual Safety [Factor_of_SC_InfrastructureVIII]
Environmental Protection [Factor_of_SC_InfrastructureIX]
Availability of Sustainable Transport System [Factor_of_SC_InfrastructureX]
Availability of Sustainable Public Water Supply [Factor_of_SC_InfrastructureXI]
Existence of Sustainable healthcare Facilities [Factor_of_SC_InfrastructureXII]

Model: Alpha

Scale label:

Figure 4-6: Reliability and Consistency Test Using SPSS



Edit: Rate of Smart Infrastructure

Variable Information
Name: Rate of Smart Infrastructure
Type: Auxiliary
Sub-Type: Normal
Units: "%"
☐ Supplementary
Group: .smart city model run
Min: 0
Max: 100

Edit a Different Variable: All
Broadband Access and Smart Tecl
Creativity
Entrepreneurship and Sustainab.
Environment that Support Produ
Environmental Sustainability
FINAL TIME
GDP as % of Employed Citizen i

Equations =
Availability of ICT Infrastructure^0.5+Constant Power Supply^0.5+Environmental Sustainability^0.5+Secured and Inn Transport Sys^0.5

Functions: Common
ABS
DELAY FIXED
DELAY1
DELAY1I
DELAY3
DELAY3I
EXP
GET 123 CONSTANTS
GET 123 DATA
GET 123 LOOKUPS
GET DIRECT CONSTANTS

Variables: Causes
Availability of ICT Infrastructure
Constant Power Supply
Environmental Sustainability
Secured and Inn Transport Sys

Comment:

☐ Expand

Errors: Equation Modified

Figure 4-7: Vensim Window Showing System Dynamics Equation for the Model.

The last stage of the analysis employed a System Dynamics simulation to model the summarised Smart City KPIs in order to evaluate the causal relationship among the core components (Figure 4.7). Chapter 7 presents the detailed analysis of the simulations, the reliability test, the non-parametric Kruskal-Wallis H test, and the result of the Spearman's Rank Order C orrelation (rho) analysis.

4.8.4 Research Question and Hypotheses

The problem statement discussed in Chapter 1 formed the basis for outlining the research questions which led to the hypotheses of the study. The research questions therefore give the direction for the study and the framework for the research focus. The focus in this case relates to how data should be collected and analysed including the sampling strategies.

4.9 Research Process

This research adopts a systematic process to collect information through semi-structured interviews and a structured survey instrument, which was designed with closed-ended questions. Data were gathered from the Smart City stakeholders at different levels, as previously described, and the systematic process is outlined in Figure 4.8 in accordance with the aim and objectives of the study.

As shown in Figure 4.8, the first phase involved a comprehensive review of relevant Smart City literature, which provided the foundation for the study. Afterwards, the research aim and objectives were further established from the systematic review which helped in defining the research questions for the study. Furthermore, a conceptual framework was developed based on the theories established in the literature, and the pilot study was held to refine the focus of the instrument. The research process flow diagram presents the different stages of research activity and outlines the tools and techniques employed including the overlaps at each stage of the study. The detailed process and the different stages are summarised in three phases, as follows.

Phase-1: Exploratory

i. The first stage involved the identification of the research problem, the formulation of the research aim, objectives, and research questions (as articulated in Chapter 1), and a discussion on the contribution to knowledge. It was important at this stage to define the need (i.e. ‘what’, ‘why’, and for ‘whom’) and the purpose of the research.

ii. The second stage provided a critical review of relevant literature relating to Smart Cities and it contexts. This included the identification of Smart City core factors and indicators, and the identification of the gap in literature that needed to be filled. The review was part of the research activities required to fulfil the first two objectives, as stated in Chapter 1 to justify the need for this research.

iii. The third stage expanded the scope of the relevant literature to cover issues relating to Big Data, social innovation, proposed Smart City architectures, and the role of emerging technologies in building sustainable Smart Cities. This enabled the researcher to obtain a deeper understanding of the topic areas that denote the unit of analysis in Smart City research. This stage of the exploration provided extensive knowledge on the subject matter.

Phase-2: Data Collection and Analysis

i. Considered at this stage were the decisions on the case study and assessment criteria and an evaluation was conducted to establish key issues concerning Smart City factors and indicators. The in-depth literature review discussed in the first phase was used to develop the conceptual framework for this study. The conceptual framework served as a guide to fulfil the aim and objectives of the study. Again, the decisions on the data collection method, the development of the instrument, the data collection and its analysis was taken into consideration.

ii. Since case study research combines a variety of data collection methods, document analysis will be considered where resources or time constraints may not allow for the holistic coverage for an in-depth investigation with interview and surveys.

iii. At this stage, the use of qualitative and quantitative techniques to analyse the qualitative and quantitative data on Smart City indicators focusing mainly on infrastructure, institution and the people component were employed.

iv. Having established the values for the component variables, the research sought to model the summarisation of the Smart City KPIs in the context of Abuja using the System Dynamics approach.

Phase-3: Framework Development

i. The discussion of the results through ‘explanation building’ which formed a major component of the hypothesis and process, were considered at this stage.

ii. An assessment of the causal relationships among the core components of Smart Cities was carried out using Vensim PLE for Windows version 6.4b. At this stage, a review of the System Dynamics literature and the administration of a structured questionnaire helped to determine the appropriate variables of the impact indicators.

iii. Using feedback from experts, the reliability of the Smart City model for the core components of Smart Infrastructure, Smart Institution, and Smart People were modified.

iv. The modification of the conceptual framework using the findings from the different stages of the analysis was undertaken. The development of the final Smart City framework relied on experts from urban planning, the ICT industry, and academia to validate the proposed framework model.

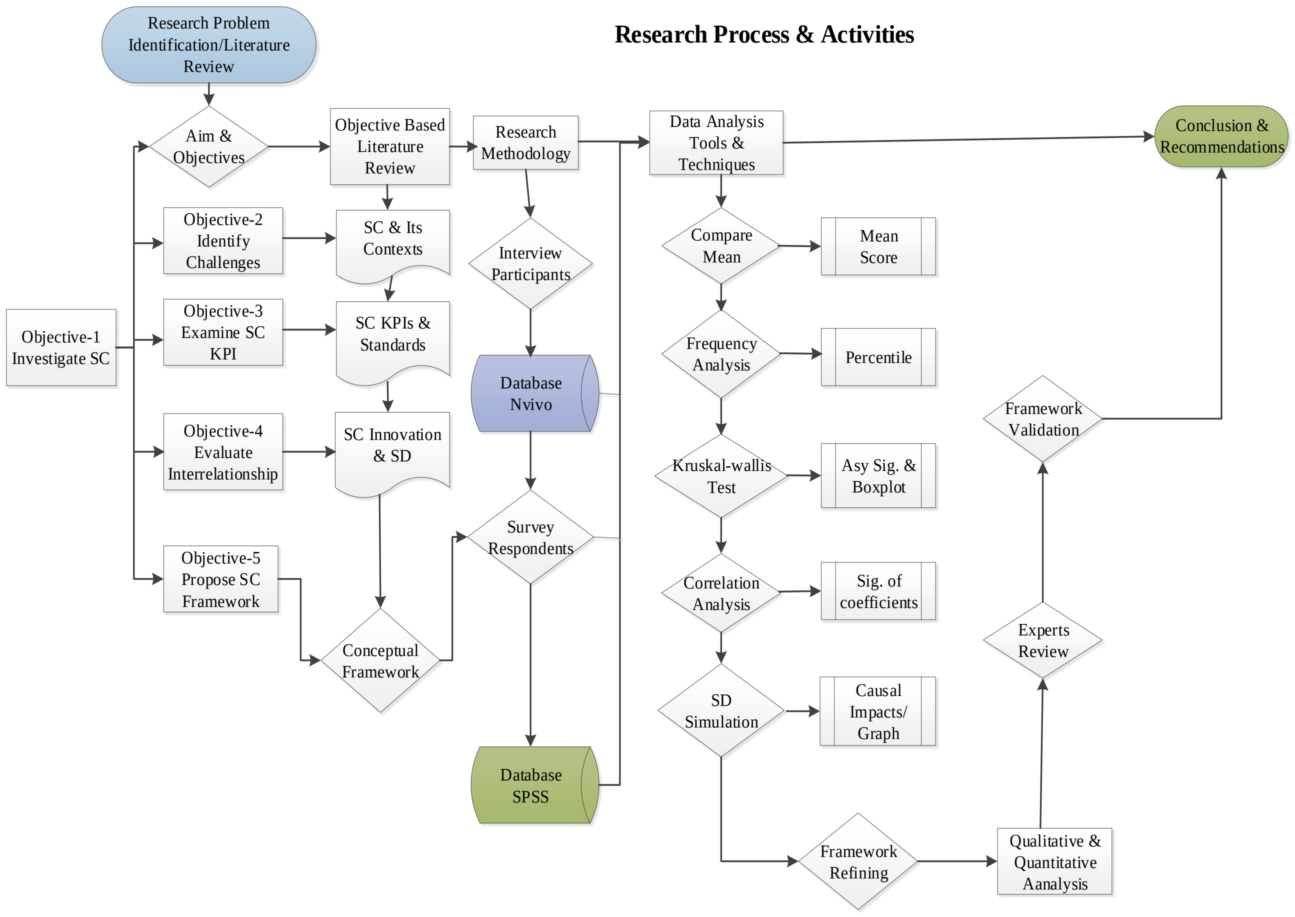


Figure 4-8: Research Design and Process

4.10 Ethical Consideration

One of the basic requirements for the conduct of research is the need for informed consent, the right of privacy, and professional honesty. Research ethics, according to Dawson (2011), relates to the appropriateness of behaviour and concerns the rights of subjects or those who may be affected by the research. In this study, the protection of the research subjects' privacy and confidentiality is part of the ethical responsibilities of the researcher. Hence, when the research is fully complete, all sensitive information and identifiable data will be deleted.

The ethical procedures for this research comply substantially with the University of Salford's ethical policies on research involving human subjects. The researcher strictly adhered to the ethical principles to ensure that the informed consent of participants was sought in line with the policies. No invasion of privacy arose as all the participants involved in this study were given detailed information about the purpose of this study before participating. Above all, the researcher ensured that there was no bias to the views and contributions of the participants while their views did not in any way constitute a risk to them. In the process, all the participants filled out the consent form as evidence of their consent to participate and were informed of their right to withdraw at any stage at which point all their data would be deleted. A sample of the signed consent form and ethical approval letter is attached in Appendix D.

4.11 Chapter Summary

This chapter presented the research methodology followed to achieve the aim and objectives for this study. The chapter provided a detailed account of the philosophical position, research strategy, research method, and research approach adopted for this study. Furthermore, the qualitative/qualitative tools and techniques used to collect and analyse data in providing answers to the research questions were also discussed. In addition, the chapter summarised the schematic diagram of the research processes from the literature review to the field investigation stages as well as the analysis/framework development stages, which include the correlation analysis and System Dynamics simulation to model the Smart City KPIs.

CHAPTER 5

5.1 Towards a Conceptual Framework for Smart Cities Impacts Assessment

The goal of this chapter is to discuss the Smart City standardisation and analyse the Key Performance Indicators (KPIs) in order to establish the metrics for monitoring the impacts of Smartness in cities. The KPIs will form the theoretical bases for a comprehensive analysis in subsequent chapters. The chapter first presents the results of the pilot study conducted in the primary case study (FCTA), which lays the foundation of the study and obtains a better understanding of the critical issues that drive smart innovation in FCTA. Using the proposed Smart City wheels published in academic/industry journals and the ISO 37120 Sustainable Development of Communities -Indicators for City Services and Quality of Life, three theoretical bases were identified from prior research and the interviews with experts. Based on the information from experts, a simple and adoptable model of measurement was developed in which the Smart City dimensions/characteristics were grouped into three distinct components: Smart infrastructure, Smart institutions, and Smart people. The chapter concludes with the presentation of the conceptual Smart City framework model and further details on the core indicators.

5.2 Pilot Study and Results

Following the successful completion of the preliminary expert ranking exercise in July, the focus group survey was expanded to consult more participants from the Nigeria Smart City group located within Abuja; this aimed to ensure adequate sampling. The Smart Cities core components included in the expert ranking exercise were selected based on the principles of representativeness, objectivity, comparability, and the ease of data collection. Additional inputs from the expanded expert survey were needed to carry out a comprehensive analysis in order to establish the core components of Smart Cities. The imperative of the analysis was to address the issue of prioritisation in order to provide the basis for a structured approach to align a coherent and effective Smart Cities initiative in view of the existing divergent Smart Cities definitions amongst stakeholders. Using the comprehensive list of experts from the stakeholder organisations and the participant list of the Nigeria Smart Cities forum held in Abuja (July, 2016), a total of 129 experts were contacted to endorse the instrument. At the end of the exercise, a total of 107 instruments were retrieved from the stakeholders out of which six instruments were defective due to incomplete respondent entries. In summary: 56 participants representing 55.4% of the respondents were BSc holders; nine participants representing 8.9% were HND holders; 28 representing 27.7% had an MSc degree, and 8 representing 7.9% had a PhD in a relevant field. The profile of the respondents are summarised in Table 5.1:

Table 5.1: Profile of Respondents

Edu_qualification

		Value	Count	Percent
Standard Attributes	Label	Respondents Educational Qualification		
Valid Values	1	HND	9	8.9%
	2	BSc	56	55.4%
	3	MSc	28	27.7%
	4	PhD	8	7.9%

Furthermore, a detailed analysis of the respondent profiles revealed that 52.5% of the respondents were IT experts, 7.9% were specialists in urban planning, 15.8% were transport experts, 9.9% were security experts, and 13.9% were professionals in health-care (see Table 5.2 for more detail).

Table 5.2: Summary of Respondent Areas of Specialisation

Area of Specialisation

		Value	Count	Percent
Standard Attributes	Label	Respondents Area of Specialisation		
Valid Values	1	IT Expert	53	52.5%
	2	Urban Planner	8	7.9%
	3	Transport Expert	16	15.8%
	4	Security Expert	10	9.9%
	5	Healthcare Professional	14	13.9%

In all, 84.2% of the total respondents who participated in the pilot survey had a permanent employment status, while 15.8% were in temporary employment. In the area of Smart City awareness, 12.9% of the respondents indicated that their level of awareness was high, another 34.7% indicated that they had a moderate (medium) general awareness of the Smart City while

52.5% indicated a low level of awareness. The low level of awareness could be ascribed to the level of stakeholder engagement in public sector led initiatives in Nigeria, which calls into question the sensitisation efforts of policy makers. It is also important to note that 5.0% of the respondents had 21-25 years experience in their respective organisations. Interestingly, only 2.0% had between 16-20 years, 39.6% had 11-15 years, and 35.6% had 6-10 years experience; meanwhile, 17.8% had between 0-5 years of experience in their current organisation.

5.3 Exploratory Factor Analysis for Smart Cities Core Components

The previous sections summarised respondents' demographic information, whilst their different views on Smart City core components were analysed using descriptive statistics. This section presents the results of the exploratory factor analysis employed to determine the strength of the groups and the correlations between each variable that constitute the components of a Smart City; this is based on the feedback from interviews with experts and the literature review. In this context, the factor analytics procedures in the IBM SPSS 23 statistical software program was used to establish a refined and coherent grouping of the core components of Smart Cities, which is part of the objectives of this study. In doing so, a number of criteria need to be fulfilled before a factor analysis can be successfully employed.

One of the important criteria is the scaling of the variables; this survey instrument adopted a five-point Likert scale. Likert scales produce data that can be assumed to be internally scaled; they also communicate interval properties to the respondents (Koed Madsen, 1989). Moreover, the sample size for a factor analysis must be considerably large; indeed, research findings (Jullie Pallant, 2005) suggest that correlation coefficients obtained on variables from small samples may not generalise as much as those obtained from larger samples. Tabachnick and Fidell (2013) suggested a sample size of at least 300 for a factor analysis. However, they conceded after further review that a smaller sample size of 150 cases can be sufficient if solutions have several high loading marker variables above .80. In contrast, other researchers advocate the significance of the ratio of respondents to items (variable) and not the overall sample size. In this regard, (Nunnally & Bernstein, 1978) recommend a sample size ratio of 10 – 1, which means 10 cases (respondents) for each item that needs to be factor analysed. Indeed, as more research has been conducted on the topic, this position was further reduced to a 5 – 1 ratio, which has been widely used for factor analyses (Tabachnick & Fidell, 2013). Again, the sample of 105 for this study also fulfilled these criteria.

5.3.1 Reliability Test for Smart City Core Components

In order to establish the reliability of the focus group survey instrument and the data used in this study, Cronbach's Alpha was used to test the internal consistency of the dataset that constituted the sample. This measure was deemed necessary to enable the researcher to study the properties of the measurement scales. In other words, the reliability test allows the researcher to determine the degree to which a set of items that make up the scale cluster determine whether they measure a single unidimensional latent construct (Field (2013) Julie Pallant (2013). Chapter 7 presents a detailed discussion of reliability test.

Based on the Smart Cities characteristics, the components identified from the literature review and the feedback from the interviews with experts across the three cases, 12 factors emerged for a Smart City infrastructure and these were used to develop the survey instrument for this study. These factors were ranked on a five-point Likert scale defining the level of importance to respondents; this ranged from one, which represented very low, to five, which represented very high. In this study, the data collected from respondents were keyed into SPSS version 23. After the data cleaning and editing, Cronbach's Alpha was run successfully, and the results are shown in Tables 5.3 and 5.4.

Table 5.3: Reliability Statistics - Smart City Core Components

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.913	0.914	19

As shown in the Table 5.3, the Cronbach's Alpha coefficient for the infrastructure factors is 0.913. This indicates that the internal consistency of the data collected for this survey is within the acceptable limit. In addition, and with the exception of SCOMP2, SCOMP11, and SCOMP16, the item-total statistical correlation values for the majority of the items in Table 5.4 were greater than the 0.3 threshold, which represents a satisfactory outcome.

In Table 5.4, SCOMP1 represents effective urban planning; SCOMP2 - the Deployment of smart living solution; SCOMP3 - Promoting the idea of smart environment visibly interwoven;

SCOMP4 - Facilitating learning and improving smart education; SCOMP5 - Building intelligent assets for future infrastructure; SCOMP6 - Providing bespoke assistance for health and safety; SCOMP7 - Building context-sensitive institutions for unified social, political and economic considerations with richer e-approach; SCOMP8 - Deploying intelligent transportation for innovative services; SCOMP9 - Deploying solid waste management systems (e.g. GIS) to improve city ecosystems; SCOMP10 - Building smart energy ecosystems to maximise efficiency, reduce costs and CO2 emissions; SCOMP11 - Developing skilled human capacity with innovative ideas (highly intelligent people); SCOMP12 - Deploying technologies to support better planning and decision-making (governance system); SCOMP13 - Deploying robust telecoms & innovative communications systems; SCOMP14 - Building cost-effective homes (Shelter); SCOMP15 – the Provision of independent/Internet based facilities (finance) to benefit citizens; SCOMP16 - Creating space for enhanced interactions (recreation) amongst citizens; SCOMP17 - Deploying waste water management solutions for efficiency, sustainability, and to maintain a high quality of life; SCOMP18 - Improving infrastructure for water system & sanitation, and SCOMP19 - Deploying intelligent infrastructure for fire service & emergency response.

Table 5.4: Item Total Statistics - Smart City Core Components

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SCOMP1	77.92	111.734	0.525		0.909
SCOMP2	78.29	116.247	0.171		0.919
SCOMP3	77.83	104.101	0.816		0.902
SCOMP4	77.90	112.650	0.474		0.911
SCOMP5	77.82	103.868	0.829		0.901
SCOMP6	77.92	113.794	0.404		0.912
SCOMP7	77.91	112.482	0.477		0.910
SCOMP8	77.83	103.841	0.831		0.901
SCOMP9	77.95	106.848	0.595		0.908
SCOMP10	77.85	104.868	0.775		0.903
SCOMP11	78.27	116.238	0.174		0.919
SCOMP12	77.92	112.374	0.476		0.910
SCOMP13	77.84	105.755	0.786		0.903
SCOMP14	78.24	106.283	0.543		0.910
SCOMP15	77.94	112.796	0.452		0.911
SCOMP16	78.28	116.242	0.170		0.919
SCOMP17	77.87	103.793	0.806		0.902
SCOMP18	77.88	104.306	0.789		0.902
SCOMP19	77.88	103.626	0.816		0.902

Having met the preliminary conditions described above, the next step was to verify the suitability of the data for a factor analysis by checking the Kaiser-Meyer-Oklim (KMO) Measure of Sampling Adequacy and Bartlett’s Test of Sphericity. The KMO and Bartlett’s Test of Sphericity are generally acknowledged as the most appropriate methods to determine the suitability of data for factor analysis (Stewart, 1981). Although Jullie Pallant (2005) recommends a KMO value of 0.6 for Sampling Adequacy and a Bartlett's Test of Sphericity of .000 (i.e. .05 or less), a KMO value of 0.5 or higher was recommended by other researchers (Field, 2000). In this study, the 19 Smart City components (established from the literature review and pilot study) were analysed to streamline the core components of Smart Cities. Table 5.5 is the summary of the KMO and Bartlett's test.

Table 5.5: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.886
Bartlett's Test of Sphericity	Approx. Chi-Square	4061.589
	df	171
	Sig.	0.000

In the focus group analysis, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) value is .886, which is above the minimum requirement of .6 (Pallant, 2005); furthermore, the Bartlett's Test of Sphericity value is significant at 0.000. Thus, it can be concluded that the data for this study is suitable for a factor analysis. By the Kaiser criterion, as described above, any interest is only in components that have an Eigenvalue of 1 or more. Again, it is imperative to examine the total variance explained in order to determine the number of components that represents the group of Smart City components. Here, the factor results from the Principal Component Analysis were carefully studied. As noted by Pallant (2005), an Eigenvalue of 1.0 and above is recommended as the benchmark for decisions regarding the number of components for extraction for further analysis.

As outlined in the Total Variance Explained table (Table 5.6), there is a need to determine how many components meet this criterion. Thus, in this exploratory focus group analysis, only three components recorded Eigenvalues of more than one (1) (i.e. factor 1 8.790, factor 2 5.344, and factor 3 2.980) respectively; this accounted for 90.069% of the cumulative variance. Thus, the three components were used for further analysis.

Table 5.6: Total Variance Explained for Smart City Components

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	8.790	46.262	46.262	8.790	46.262	46.262	8.557
2	5.344	28.125	74.387	5.344	28.125	74.387	5.894
3	2.980	15.682	90.069	2.980	15.682	90.069	2.983
4	0.620	3.265	93.335				
5	0.433	2.280	95.615				
6	0.201	1.059	96.674				
7	0.151	0.797	97.470				
8	0.126	0.661	98.131				
9	0.078	0.411	98.541				
10	0.066	0.347	98.889				
11	0.054	0.282	99.171				
12	0.046	0.242	99.412				
13	0.033	0.173	99.585				
14	0.024	0.126	99.712				
15	0.023	0.119	99.831				
16	0.012	0.062	99.893				
17	0.010	0.051	99.943				
18	0.007	0.036	99.979				
19	0.004	0.021	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

It is also important to examine the Scree Plot as often, in using the Kaiser criterion, a researcher may find too many factors extracted (Pallant, 2005). Pallant (2005) further suggests the retention of only the factors above the elbow shape of the Scree Plot.

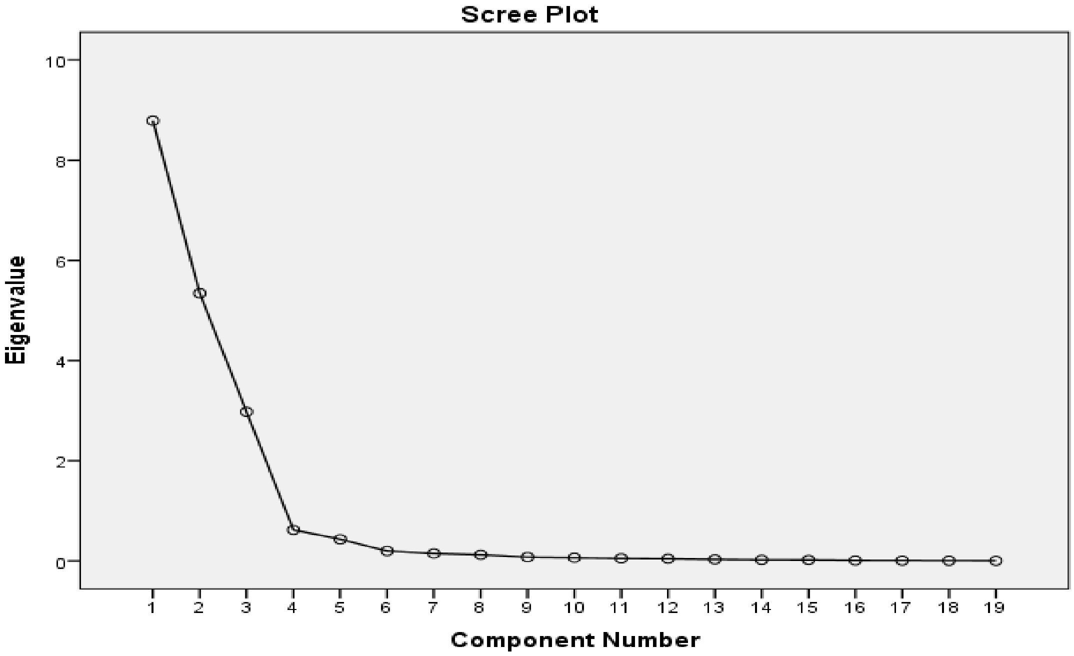


Figure 5-1: Scree Plot for Smart City Core Components

It is clear from the Scree Plot in Figure 5.1 that there is a break between factors 3 and 4; thus, it is ideal to retain the three factors before the break. The Scree Plot clearly shows that only component 1, 2, and 3 capture more of the variance than all the remaining components. This also confirms the results in the total variance explained above. In this regard, the Eigenvalue at the location of the elbow shape is less than 1. These three factors therefore form the basis for further analysis through the use of Varimax with the Kaiser normalisation rotation; this will enable a check on the factors that load on more than one component.

In retaining the three components, the cross-loadings were checked for variables that load on more than one component. Thus, it was observed that six items were cross-loading on two components, which included: SCOMP7, SCOMP6, SCOMP4, SCOMP12, SCOMP15, and SCOMP1. The analysis was re-run several times with the same outcome. Although Tabachnik and Fidell (2007) suggest the removal of cross-loading or free-standing items for better interpretation and further analysis, Yong and Pearce (2013) advocate their retention of with the assumption that it is the latent nature of the variable. In addition, other research findings suggest that it is ideal to focus on the highest loading with a cut-off point. This means that, if an item's highest-loading is greater than an a priori determined cut-off value e.g. .5/.2 or .6/.3 then the researcher can retain the item in the pool (Costello & Osborne, 2005) (Matsunaga, 2010). As can be seen in Table 5.7, the primary loadings are greater than the cut-off value in all the cases. Hence, the items were retained in the pool.

Table 5.7: Structure Coefficient of Extracted Components of Infrastructure

Item	Component		
	1	2	3
SCOMP5	0.955		
SCOMP8	0.955		
SCOMP3	0.949		
SCOMP13	0.933		
SCOMP18	0.927		
SCOMP19	0.923		
SCOMP17	0.922		
SCOMP10	0.884		
SCOMP9	0.71		
SCOMP14	0.651		
SCOMP7	0.394	0.907	
SCOMP6	0.336	0.905	
SCOMP4	0.397	0.903	
SCOMP12	0.395	0.901	
SCOMP15	0.375	0.868	
SCOMP1	0.449	0.864	
SCOMP11			0.994
SCOMP16			0.993
SCOMP2			0.991

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Before the final decision on the number of factors (items) to retain, it is important to consider the outcome of the unrotated loading in the Component Matrix and the rotated loadings of the factor-solutions in the Pattern Matrix and Structure Matrix of the Principal Component Analysis (PCA). According to Pallant (2013), if the Oblimin rotation was used, both the Pattern Matrix and the Structure Matrix Coefficient tables need to be presented and these can be combined into one table along with the information about correlations among the factors. Table 5.8 shows the Pattern and Structure Matrix for the PCA with the Oblimin rotation of the three factor solution for core Smart City Components.

Table 5.8: Pattern/Structure Matrix for the PCA with Oblimin rotation of three-factor solution for Smart City Core Components

Item	Pattern Coefficient			Structure Coefficient			Communalities
	Comp1	Comp2	Comp3	Comp1	Comp2	Comp3	
Smart Infrastructure							
SCOMP5	0.985			0.987			0.948
SCOMP8	0.982			0.985			0.983
SCOMP3	0.981			0.981			0.964
SCOMP13	0.964			0.963			0.973
SCOMP18	0.962			0.963			0.974
SCOMP19	0.955			0.955			0.936
SCOMP17	0.955			0.955			0.978
SCOMP10	0.899			0.905			0.97
SCOMP9	0.781			0.764			0.602
SCOMP14	0.65			0.658			0.82
Smart Institution							
SCOMP7		0.989			0.989		0.989
SCOMP6		0.986			0.986		0.968
SCOMP4		0.983			0.984		0.934
SCOMP12		0.973			0.971		0.437
SCOMP15		0.961			0.965		0.895
SCOMP1		0.946			0.946		0.986
Smart People							
SCOMP11			0.994			0.994	0.913
SCOMP16			0.993			0.993	0.928
SCOMP2			0.992			0.992	0.914

Based on the previous analysis, the correlation matrix table revealed that there are many coefficients of .3 or above in the distribution. The KMO value of the result was .809, which exceeds the .6 threshold (Kaiser, 1970). In addition, Bartlett's Test of Sphericity reached a statistical significance at .000 (Bartlett, 1954) which supported the suitability of the factor analysis of this dataset. The Principal Component Analysis (PCA) also revealed the presence of three components with an Eigenvalue exceeding 1; this explained 46.262%, 28.125%, and 15.682% of the variance respectively. A careful inspection of the Scree Plot also shows a clear break after the third component. Thus, a decision was made to retain three components for further investigation (Cattell, 1966). These three component solutions explained a total of 90.069% of the variance. In summary, the contributions of each component shows that component 1 contributed 46.262%, component 2 contributed 28.125%, and component 3 contributed 15.682%. A direct Oblimin rotation was performed to assist in the interpretation of the components, and the solution revealed the presence of a simple structure where all the three components showed a number of strong loadings of variables on only one component.

Although the intended focus of the factor analysis is to analyse the strength of the relationship among the components, it is important to note that the result indicates a positive correlation between component 1 and component 2 (=.148), a negative correlation between component 1 and 3 (r= -.010), and a negative correlation between component 2 and 3 (r = -.002). Based on these outcomes, the positive correlation indicates some sort of relationship between the Smart institution and Smart infrastructure factors. Ordinarily, one would expect a strong positive relationship between components 1 and 3, and between components 2 and 3 but the result of this pilot study only confirmed a positive relationship between component 1 and 2. The result is strictly based on the perception of the pilot study respondents. Interestingly, the rotation pattern, as reported in pattern matrix and structure matrix tables, showed slight differences in the factor loading for each of the variables. Using the Pattern Matrix and the highest loading items in each component, the three distinct components were carefully identified and labelled accordingly.

5.3.2 Components Naming Taxonomy and Interpretation

The naming and interpretation of the three-factor solution was accomplished by relating the factors to the theoretical concept found in the literature and the preliminary findings of the focus group discussed in Table 5.1. In addition, the labelling of the components acknowledged the highest loading items on each component. In doing so, component 1 was named Smart Infrastructure, component 2 was named Smart Institution, and component 3 was named Smart People.

5.3.2.1 Smart Infrastructure

From the total variance explained, component 1 contributed 46.262% of the total variance. Using the Pattern Matrix, “Building intelligent assets for future infrastructure” (i.e. SCOMP5) contributed the highest variance in this group. Hence, the component was labelled Smart Infrastructure. The other variables in this component include SCOMP8 - Deploying intelligent transportation for innovative services; SCOMP3 - Promoting the idea of smart environment visibly interwoven; SCOMP13 - Deploying robust telecoms & innovative communications systems; SCOMP18 - Improving infrastructure for water system & sanitation; SCOMP19 - Deploying intelligent infrastructure for fire service & emergency response; SCOMP17 - Deploying waste water management solutions for efficiency, sustainability, maintaining high quality of life; SCOMP10 - Building smart energy ecosystems to maximise efficiency, reduce cost and CO2 emission; SCOMP9 - Deploying solid waste management systems (e.g. GIS) to improve city ecosystems, and SCOMP14 - Building cost-effective homes (Shelter). In view of the emphasis placed on the ICT infrastructure factor, which included broadband, IoT and other physical infrastructure by stakeholders, deploying a reliable ICT infrastructure will help to build a sustainable Smart City.

5.3.2.2 Smart Institution

The second component, as summarised in Table 5.5, also contributed 28.125% of the total variance explained with the factor of "Building Context-sensitive Institutions for unified social, political and economic considerations with richer e-approach" (i.e. SCOMP7) contributing the highest variance in this group. Hence, the component was labelled Smart Institution. The other variables in the component included: SCOMP6 - Providing bespoke assistance for health and safety; SCOMP4 - Facilitating learning and improving Smart Education; SCOMP12 - Deploying technologies to support better planning and decision-making (governance system); SCOMP15 – the Provision of independent/Internet based facilities (finance) to benefit citizens, and SCOMP1 - Effective Urban Planning. Based on the literature evidence discussed in Chapters 2 and 3, a sustainable Smart City innovation requires vibrant institutions and governance systems. Smart Institutions are therefore needed to manage critical developments in city sub-sectors, such as within sustainable transport system, healthcare delivery systems, and pollution control, which have a direct impact on environmental sustainability issues.

5.3.2.3 Smart People

The third and final component contributed 15.682% of the total variance explained, with the factor of "Developing skilled human capacity with innovative ideas - highly intelligent People" (i.e. SCOMP11) contributing the highest variance in this group. Thus, the component was labelled Smart People. The other variables in this component were: SCOMP16 - Creating space for enhanced interaction (recreation) amongst citizens, and SCOMP2 - Deployment of a smart living solution. These factors are somewhat interrelated, especially with the new trend of development in fostering cohesion and unity, which requires a conducive space for social interactions amongst citizens.

5.4 Smart City Standards and Frameworks

Two studies on Smart Cities have discussed the issue of standardisation and the metrics to monitor the development of cities from different perspectives. For instance, City Protocol (2015) developed an interesting hierarchical model for a city's governance, evaluation, and transformation (Guallart & Giralt, 2014). The City Protocol model incorporated the original City Anatomy CPA-I 001 body of knowledge, the Anatomy Indicators CPA-PR 002, Anatomy Ontology CPAPR 003, and Liveable District CPC 004, etc. It is important to note that every city in different regions of the world is unique with different development challenges depending on their experiences and history. In this context, while some cities are dealing with the challenges of environmental pollution, others are faced with congestion, energy, and security related issues (Ceballos & Larios, 2016). However, because of the interrelationship that exists amongst the indicators of Smart City systems, a number of standards have been proposed to monitor the performance of cities' Smartness. The existing standards include: ISO-37120 Standard for Sustainable Development and Resilience of Communities – Global City Indicators for Service and Quality of Life; ISO-37101 Sustainable Development and Resilience Communities –Management Systems; ITU Smart Sustainable Cities; Spanish Standards (AENOR) – UNE 178301 on Open Data; UNE 178303 Requirements for Municipal's Asset Management, and NIST – Internet of Things (IoT) Enabled Smart City Framework.

The ISO 37120 Standard, for instance, established 46 core indicators and 54 supporting indicators for measuring Smartness (Hernandez, 2014). According to Hernandez (2014), the ISO-37120 indicators are applicable to any city and can serve as tools for city mayors, urban planners, researchers, professionals and other stakeholders in order to benchmark investment, build Smart sustainable cities, conduct an impact evaluation and comparison, and measure the effectiveness of city governance (see ISO 37120 attached as Appendix A). Overall, the ISO-37120 standard introduces methodologies in the form of indicators for measuring the performance of services in cities, especially in the area of quality of life, with a matrix that attempts to reveal key technologies that underpin many Smart Cities initiatives today. On the other hand, ITU, as highlighted in Chapter 2, introduced a standard specification for Smart Sustainable cities. L. Anthopoulos and Giannakidis (2016) posited that the ITU standard for Smart Sustainable Cities defines a set of primary smart services. Furthermore, the standard introduced a technical report that could form the basis for a global Smart Sustainable City that can afterwards, be adopted in order to develop a framework to measure the performance of Smart Cities (ITU, 2014).

At the sub-regional level, the Spanish standard (AENOR) adopted ISO-37120, which corresponds to its standardisation efforts to introduce UNE-178301 and UNE 178303. The Spanish standards address the Open Data standardisation and requirements for a municipality's asset management. Similarly, in the USA, the National Institute of Standards and Technology (NIST) embarked on two Smart City related standards which included the Internet of Things (IoT) Enabled Smart City Framework standard. This attempted to enhance the interoperability of Smart City technologies across cities with cost effectiveness and convergence that would serve the global Smart City needs (NIST, 2016). The NIST IoT standard was developed in collaboration with ANSI, MISP ITIA and ETSI. For further information on the existing Smart City standard, see (BSI, 2014), (ISO IEC, 2014; Zdraveski, Mishev, Trajanov, & Kocarev, 2017), (Lombardi et al., 2012), and (Zdraveski et al., 2017).

The standard defined in ISO 37120 identified 17 key areas for measurement with 100 indicators. In practice, Cohen (2015) proposed a Smart City model for measuring a city's performance with six dimensions i.e. Smart Economy, Smart Environment, Smart People, Smart Governance, Smart Mobility, and Smart Living. Cohen's model was based on ranking and benchmarking approaches using the indicator average of the six identified dimensions. The model relied on secondary data from different sources, which included the IDC rankings of Smart Cities in Spain, Siemens Green City Index, Global Metro Monitor, and a host of international organisations (Benamrou, Mohamed & Bernoussi, 2016) . Two Smart City scholars have attempted to integrate Boyd Cohen's model of Smart City KPIs with the ISO-37120 through the corresponding indicators to simplify the metrics for measuring cities (for instance, (Ceballos & Larios, 2016). Section 5.3 discusses the KPI models in detail.

5.4.1 Key Performance Indicators (KPIs) for Measuring the Smartness of Cities and the Existing Smart City Wheels

The recent concerns on the need to identify metrics and key performance indicators (KPIs) that can measure the impact of Smart City solutions and platforms in order to improve city Smartness characteristics, through well-articulated performance indicators, is receiving stakeholder support. Many cities are transitioning from traditional cities into Smart Cities and a main motivation for this trend is their perceived ability to improve the standard of living of people residing in such cities (Agbali, Trillo, & Fernando, 2017). However, in order to justify this assertion it is necessary to identify some relevant Key Performance Indicators (KPIs) through which to analyse their impact.

In a comparative study by (Giffinger et al., 2007) on the role of city-rankings in a regional competition focused on operationalising Smart Cities, they identified a comprehensive catalogue of indicators to measure developments in the medium-sized cities of Europe. Drawing from their findings, the authors summarised the characteristics of a Smart City into six major headings, namely Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment, and Smart Living. The study, which adopted the methodology of weighing the influence and importance of the factors or indicators, produced a framework model for analysing Smart Cities with 33 factors described by a number of indicators. Carli, Dotoli, Pellegrino, and Ranieri (2013), in a similar framework for classifying the performance indicators to measure and manage the Smartness of cities, stressed that to achieve the goal of making cities Smarter, there is a need to optimally and intelligently measure and monitor cities' performances, analyse their competitiveness and evaluate their sustainability. Although the authors were of the view that there is no valid set of indicators for measuring the performance of cities in each context and purpose, they proposed a novel two-dimensional framework (human and technological context) to classify the KPIs of a Smart City. This study also adopted the six characteristics of Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment, and Smart Living in the framework to enable policy makers, planners and other stakeholders to make intelligent decisions. Figure 5.2 highlights the six commonly used Smart City wheels proposed by Giffinger et al. (2007).

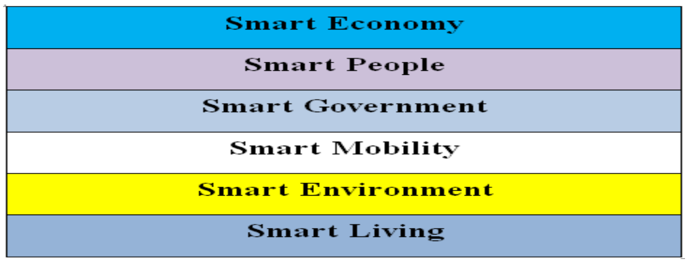


Figure 5-2: Characteristics of a Smart City

(**Source**: Giffinger et al. 2007)

The model and framework were extensively discussed using the above six characteristics. Cohen and Giffinger's model are similar in terms of the six characteristics and their ranking/benchmarking approaches. However, measuring the six characteristics without including infrastructure as a core component could result in ignoring a major issue in the context of cities in developing countries since many such cities are faced with the challenges of deploying an effective infrastructure to drive Smart initiatives. Similarly, the framework proposed by Carli et al. (2013) succeeded in re-grouping the characteristics and the corresponding indicators into objective and subjective dimensions, but the basic issue of identifying the core indicators for measuring the impacts of a Smart City in line with common taxonomy were not addressed. This ignores the challenges of infrastructure provisioning in emerging cities.

In an attempt to further streamline existing Smart City wheels and indicators, (Chowdhury & Dhawan, 2016) introduced the Delphi method to evaluate the set of Smart Cities' performance indicators established by ITU. Chowdhury and Dhawan's model also characterised the key performance indicators for Smart Cities into six similar dimensions identifying information and communication technology (ICT), environmental sustainability, productivity, quality of life, equity and social inclusion, and physical infrastructure with the corresponding parameters to measure performance. The authors attempted to further split the six dimensions into measurable categories with a test case study using the Delphi review in India.

In contrast, Ceballos and Larios (2016), adopted a Kano model to provide empirical support in planning a Smart City using Cohen's model of KPIs with the comprehensive integration of the 17 metrics of measurement models identified in ISO 37120. Ceballos and Larios's principle proposes a Smart City investment model that encourages the improved identity of people within the city by prioritising their service needs in terms of investments in Smart Cities and in their quality of life. The study adopted the use case of CUCEA UDG living Lab – Guadalajara to validate the model. The integration of ISO-37120 resilient cities model with Cohen's model of Smart Cities that retained the six dimensions of the previous Smart City wheels is presented in Table 5.9.

Table 5.9: Integration of ISO 37120 with Smart City Wheel

Smart City Wheel	**ISO 37120**
Smart Economy	- Economy - Finance
Smart Environment	- Energy - Environment - Solid Waste - Wastewater - Water & Sanitation
Smart Living	- Fire & Emergency Response - Health - Safety - Shelter
Smart Mobility	- Telecommunication and Innovation - Transportation - Urban Planning
Smart People	- Education - Recreation
Smart Government	- Governance

(**Source:** Ceballos et al., 2016)

Furthermore, a range of academic literature addresses Smart City development from different perspectives by characterising their core components, while a host of other sources attempt to develop taxonomies that are based on the drivers. In this area, Nam & Pardo (2011a) developed a framework that was based on the previously discussed three core components, both in terms of dimension and factors, namely: technology, people and institutions,. In another example, Lee et al. (2014) classified the characteristics of a Smart City based on its technological and institutional elements that were represented in six taxonomies: urban openness, service innovation, partnerships formation, urban proactiveness, Smart City infrastructure integration and Smart City governance. It is imperative to suggest that Smart Infrastructure should form the core characteristic of Smart Cities. Thus, the six characteristics can be summarised and discussed under the three core dimensions of Smart City (i.e. Smart Infrastructure, Smart Institutions and Smart People).

In order to identify the major drivers of Smart Cities and the practical challenges before proposing a model for measuring the impacts, this study explores the findings from the research in view of the dynamic nature of this field. This chapter therefore aims to provide a novel framework model for measuring Smartness, factoring in the core indicators that can be universal and meet the major challenges of an emerging economy.

5.4.2 Theoretical Framework for Smart City Performance Indicators

Identifying appropriate performance indicators to measure, manage, and monitor the Smartness of cities needs to comply substantially with existing knowledge in the field of Smart City development. The imperative not only involves the development of a novel framework for measurement, but goes beyond this to address the key challenges in detail.

Building on existing knowledge in this field and the outcome of the pilot study, this study identified three core components of Smart Cities with comprehensive factors and key indicators to form the theoretical foundation and suggest a holistic view of metrics with which the KPIs of Smart Cities can be measured. The proposed core components are infrastructure, institution, and people. Infrastructure is at the core of Smart City development. It is also the platform upon which Smart Economy, Smart Mobility, Smart Living and other dimensions are built.

In developing countries, cities are faced with the challenges of infrastructure provision (e.g. power, ICT, transport, water, etc.), which thus need to be measured (Agbali et al., 2017). Therefore, the factors and specific indicators that drive the infrastructure component need further consideration in order to produce an all-inclusive framework that can be adopted by cities in developing countries. There is limited literature to explain infrastructure as a component in this manner; the proposed three dimensions to classify Smart City factors and indicators are validated through a focus group exercise, as highlighted in Chapter 4. Table 5.1 presents the three dimensional framework elements for measuring the impacts of Smart City planning, with greater consideration for infrastructure as a foundation.

It is imperative to emphasise that the infrastructural performance of a city cannot be taken for granted because a Smart Economy, its effective management and the technological advancement that drives Smartness in all dimensions depends on the existence of a Smart infrastructure (Nam & Pardo, 2011b). In addition, the focus of this study is FCT-Abuja, which was selected as the primary case study. Thus, recognising the challenges of the infrastructure deficit that exist in many cities across developing countries, this research integrates different sources of proposed KPIs for Smart Cities. Firstly, it integrates from industry perspectives, secondly from expert opinions in academia, and finally from urban development perspectives, which are dominated by FCT Administration. This helps to develop the conceptual framework.

To articulate the focus, the study received valid feedback from the stakeholders based on the core objectives of the research (described in Chapter 4). In doing so, a number of changes to the existing core components of Smart Cities were made for ease of analysis and to address their perceived interrelationships. Meanwhile, the factors/indicators were streamlined in accordance with the priority dimensions. For instance, the need for a Smart Infrastructure was emphasised as a core component of a Smart City by FCT stakeholders over a Smart Economy, which was emphasised in existing models. The initial definition of the conceptual framework relies mainly on evidence from the literature, such as the framework by Giffinger (2010), the Smart City Framework by Cisco (Falconer & Mitchell, 2012), ISO 37120 Standard, Smart City Wheel by Boyd Cohen (see Figure 5.3), and the ITU Smart and Sustainable Cities Framework.

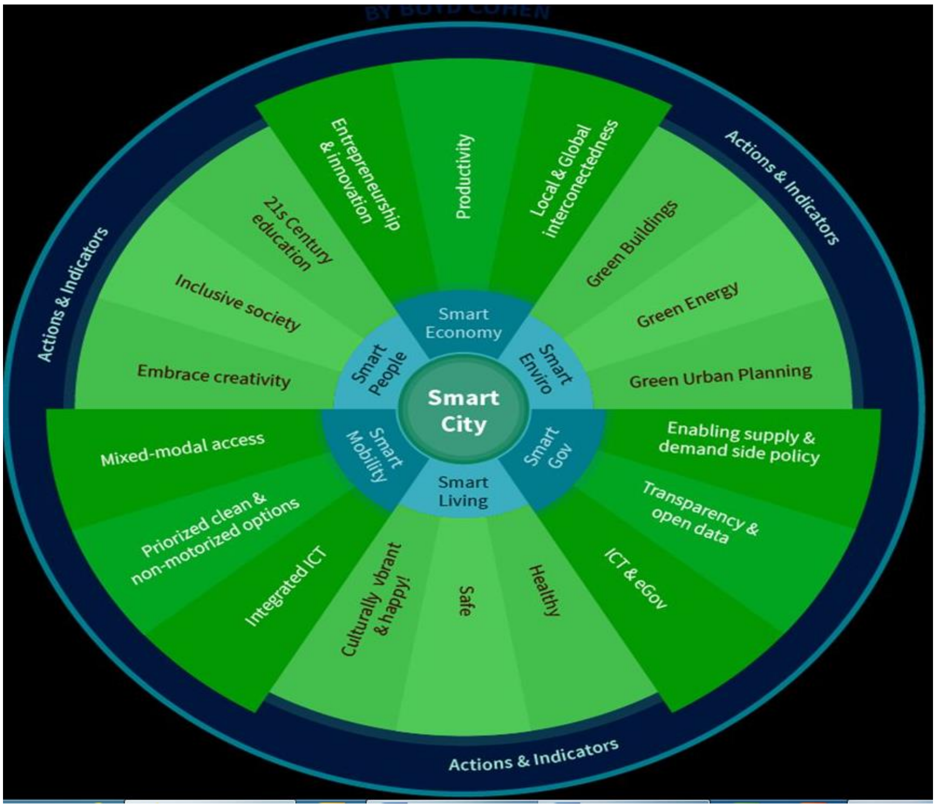


Figure 5-3: The Smart City Wheel

(Cohen, 2013a)

Based on the focus group inputs (see section 5.1), Smart Infrastructure, Smart Institutions, and Smart People were prioritised as the core components of Smart Cities upon which a Smart Economy can strive. In this arrangement, the three agreed core components were used to identify the core factors and indicators of Smart Cities that could conveniently be used to analyse similar indicators used in Europe and America, depending on the peculiarity of the city (as depicted in Table 5.10). The methodological processes are discussed in Chapter 4.

Table 5.10: Key Elements of the Conceptual Framework for Measuring Impacts of Smart Cities

Components	Factors	Indicators
Smart Infrastructure	1. Environmental Sustainability	Reduction in noise pollution
		Improved Air quality (CO, SO2, NO2 reduction)
		Reduction in Greenhouse gas emission per capita
		No of Hospital per Inhabitant
		No of Green Energy Sources & MW per Inhabitant
	2. Availability of Constant Power Supply	Number of green energy sources and megawatts generated per inhabitant
		Rate of uninterruptible power available per inhabitant
	3. Individual Safety	Number of Police Officers per 100 000 Population
	4. Availability of ICT Infrastructure	Number of mobile phone as % of city population
		Number of Internet access as % of city population
		Broadband Access & Smart Technologies as % of City Population
	5. Secured and innovative transport system	Use of environmental friendly vehicles
		Number of autonomous vehicles
		Ratio of Smart Wheelchair as % of City Population
		Robbotic Ambulance Available per Inhabitant
	6. Educational Facilities	Teacher-Student ratio in schools
		% of yearly enrolmonet of school age Population
	7. Attractive Natural Environment	Number of Green Area Available
		Particulate Matter Concentration
Smart Institution	1. Entrepreneurship & Sustainable Dev.	Increased number of new registered businesses
		Reduction in Crime Rate
		Increase in Self Employment
	2. Innovative and Proactive System	Size of Big Data & Open Data Ecosystem
	3. Transparent Governance	Number of crime profiled in rea-time
		Satisfaction with Safety of Life and Properties
		Satisfaction with Quality of Healthcare Delivery
		Satisfaction with Quality of Schools and Key Public Institutions
	4.Productivity	Increased number of innovation hubs
		Revenue Generated in Tourism as % of Total Revenue
	5. Social Cohesion	Rate of Socio-cultural Participation as % of City Population
	6. Public and Social Services	Capital Spending as % of Total Expenditure
Smart People	1. Creativity	Number of Entrepreneurs as % of City Population
		Number of Healthy Citizens as % of City Population
	2. Quality of Life	Increase in Life Expectancy
		Number of Voters Turnout as % of City Population
	3. Social Awareness	Rate of participation in national debate and opinion poll
	4. Flexibility	Potential Capability to Change as % of City Population
	5. Quality Education	Number of educated citizens at different levels of education
		Number of skilled citizen as % of city population
	6. Environment that Supports Productivity	GDP as % of employed citizen
		Ratio of employed to unemployed citizens

The six commonly used Smart City wheels have been discussed in Chapter 2; thus, this chapter will not dwell on the entire six wheels in the theoretical framework since previous research has sufficiently discussed them from different perspectives, as highlighted in the previous chapters. Although, in some of the literature, institutional arrangements were discussed under organisation and governance, the emphasis on institutional capabilities remain unchanged. This chapter therefore considers the need to contribute to the research gap by focusing on infrastructure, institution, and the people as key components of Smart Cities where there is need to identify factors and indicators for measuring smartness, especially in an emerging economy. In doing so, the outcome of the three-stage interviews with experts has been analysed for the refinement of the conceptual framework, as depicted in Figure 5.4.

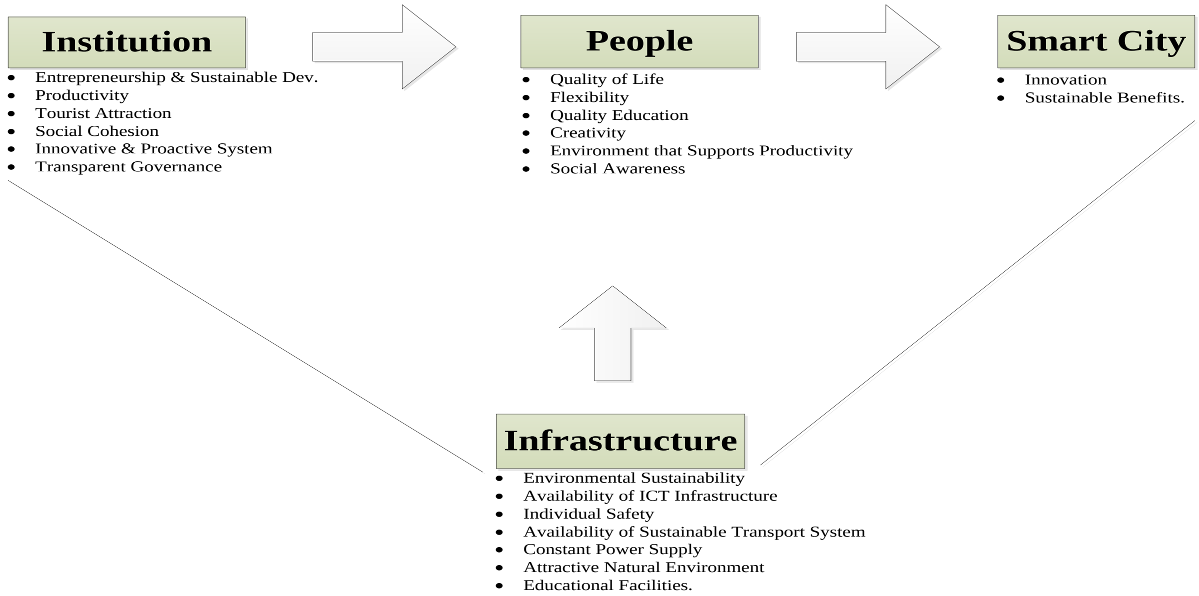


Figure 5-4: The Conceptual Framework for a Smart City

5.4.2.1 The Infrastructure Component

Most of the existing literature on Smart Cities discussed the issue of infrastructure with a focus on ICT. The perception, or alignment, of the infrastructure component with ICT is understandable because of the critical role that ICT plays in materialising plans for a sustainable city. In other instances, infrastructure is seen as technological infrastructure or techno-ware (Schaffers et al., 2011b). In contrast, an ICT infrastructure cannot be singled out as the most critical component in measuring the impact of Smart Cities in that ICT, as an enabler of a Smart City, requires the existence of other infrastructures, such as energy (Smart

Grid), utilities and safety measures. In addition, Schaffers et al. (2011b), discussed infrastructure from a different perspective concerning the dimension of ICT and utilities; they introduced the concept of Smart transportation, mobility and parking, broadband, embedded systems, energy and savings/smart grid, environment monitoring and safety.

Information and Communications (ICTs) are seen as the core and essential physical infrastructure for successful Smart City deployment (ITU, 2014). This explains the viewpoint of key industry players (e.g. IBM and CISCO) that focus mainly on ICTs and emerging technologies as the driving force of Smart City development. In an era of cognitive computing where cities are evolving into a market destination for different sorts of innovation, they need to take advantage of ICTs and emerging technologies to address critical challenges in order to deliver efficient services to citizens (IBM, 2017a). The key elements of ICTs and their related technologies can therefore be tracked, measured and classified under the Smart Infrastructure component.

In supporting the position of infrastructure as a critical component of Smart Cities, Forrester (Washburn et al., 2009) posited that a, “Smart City is a collection of Smart Computing technologies applied to the seven critical infrastructure components and services”. The study further identified seven critical infrastructure components of Smart Cities and services, which are: education, healthcare, administration, public safety, transportation, real estate, and utilities. Washburn et al. presented these critical infrastructure components with real-life examples to help stakeholders visualise the Smartness of a city. These components are summarised below:

Education: In the educational sector, the metrics for quality education range from the availability of digital content, improved access to online resources, and the low cost of educational programmes to technological platforms for collaboration. These are factors that need to be identified and properly classified for measurement.

Healthcare: The availability of accurate diagnosis, patient records, and a platform for a quick response to emergency services, knowledge sharing amongst health workers, tele-medicine facilities, and the existence of various platforms for remote medical services. These also have infrastructure components that need to be identified for measurement.

Public Safety: In public safety, the police and other security agencies (e.g. fire service men) are now leveraging innovative technologies to improve the response rate to emergencies and threats. In this area, Washburn et al. (2009) cited an example of a 911 real-time dashboard providing information on emergency needs that has helped New York City to reduce their crime rate by 27% with the aid of closed circuit televisions (CCTV) and video analytics. The factors affecting the rate of response and the outcomes, as cited in the New York case, can be classified and measured.

Transportation: The financial and environmental impacts of transportation in Smart Cities as well as the reduction in the congestion can be measured. Thus, Stockholm in Sweden as cited by (Naphade, Banavar, Harrison, Paraszczak, & Morris, 2011), implemented a system equipped with lasers and cameras that automatically charged drivers on a ‘pay as you go’ basis, thereby reducing gas emission and congestion.

Utilities: By deploying a Smart infrastructure in the utilities sub-sector, cities can easily transform into a hub of vibrant and sustainable economic development through the use of emerging technologies to optimise resources. According to Naphade et al. (2011), the city of Dubuque, Iowa partnered with IBM to put citizens at the centre of a Smart City project in which water and energy consumption were efficiently monitored in order to optimise individual consumption and encourage economic growth.

Real Estate: The availability of Smart homes, offices and other facilities with cost effective maintenance systems are core components of a Smart City where performance needs to be measured.

Administration: In terms of city administration, this components is all encompassing in that it cuts across all city services outlined above through the provision of a reliable infrastructure to deliver a clean environment, job creation, healthcare, and so forth. All of these require infrastructure components that are measurable.

Environmental Sustainability: Environmental sustainability is one of the most important issues in the urban environment that affects citizens’ quality of life. Two Smart City studies have addressed the issues of the environment as a major characteristic/dimension of Smart Cities, for instance, Giffinger et al. (2007) and Cohen (2015). The metrics for the quality of the environment in this case range from improved air quality and climate change (e.g. CO, NO_2, SO_2, etc.) to traffic flow, which can be measured with the emergence of Big Data analytics in real-time. In Europe, for instance, research findings (Penza, Suriano, Villani, Spinelle, & Gerboles, 2014) revealed that two Smart City scholars were experimenting with solutions for measuring air quality in cities in line with EU's Air Quality Directive 2008/50/EC. This deals with environmental sustainability and therefore represents a critical challenge that Smarter infrastructures for cities must address.

Availability of Constant Power Supply: A constant power supply is crucial in Smart Cities. Thus, the rate of uninterruptible power available per inhabitant and the size of power generation from alternative sources, such as green energy generated in megawatts per inhabitant, can be assessed as part of the impact of Smartness on the development of the city's infrastructure.

Individual Safety: A comprehensive approach to safety in the city is part of the safer city programme launched by the UN-Habitat in collaboration with an African mayor (Lacinák & Ristvej, 2017). Smart integrated technologies used in the field of safety increase the effectiveness of city policing, which can also be assessed. Currently, this area of measurement emphasises the ratio of police to city population.

Secured and Innovative Transport System: Building an innovative and sustainable transport system needs to consider factors around the use of environmental friendly vehicles, a support system for people with special needs, emergency interventions, such as robotic ambulances available per inhabitant, and number of autonomous vehicles in the city.

Educational Facilities: Education as the platform for developing human capital for a Smart City is also crucial. Thus, indicators around teacher to student ratio in schools and the percentage of yearly enrolments of the school-age population need to be identified.

Attractive Natural Environment: In determining the type and layout of a Smart City, city planners need to emphasise the ecological footprint through the infrastructure design for Smartness. The available space for green areas and their particular concentration in the city can be assessed.

Thus, the factors of Smart Infrastructure that must be considered for the development of a Smart City, as captured in the conceptual framework, are based on the findings from the literature review and the outcome of the pilot study.

5.4.2.2 The Institution Component

In defining the Smart Institution as a core component of Smart Cities, a number of authors stress the quality of political strategies, the availability of public services, the support of the government, and policies for governance (Giffinger et al, 2007; Nam & Parado, 2011a). Smart governance, in this context, refers to the concept of a Smart Institution that leverages technologies (ICTs, sensors, RFID, etc) for efficient service delivery (Komninos, 2009). Furthermore, Chourabi et al (2012) discussed the component of Smart governance from the perspective of PPP, leadership, and effective collaboration for quality decision-making. Thus, the Smart Institution includes all the essential factors of institutional arrangements that strive to ensure an improved quality of life for the citizenry and the presence of the factor in different perspectives of governance, sustainability, and other dimensions that only differ in terminology. Themes defining the Smart Institution component, as captured in the conceptual framework, are based on the findings from the literature review and the outcome of the pilot study.

Entrepreneurship & Sustainable Development: For cities to attain Smartness, the key performance indicators relating entrepreneurship are crucial and can be measured as part of the city’s image in maximising their innovative spirit and creative potential for global competiveness. An improved business environment – demonstrated through an increased number of new registered businesses – is an important parameter.

Productivity: Productivity parameters measure key performance indicators relating to income, trade balance at the city level, capital investment, and job creation indices in both formal and informal sub-sectors of the city. In this regard, access to innovation hubs/R&D and revenue generation in tourism as total revenue percentages were also considered.

Innovative and Proactive Systems: Building Smart Cities with innovative and proactive systems with innovation in Big Data and Open Data can help to create Smart solutions to solve the problems of businesses and private citizens. Thus, the size of Big Data and an Open Data ecosystem is crucial as one of the key measurement areas.

Transparent Governance: Transparent governance is another critical factor of a Smart Institution in creating an environment where ideas can grow through stakeholder involvement in decision-making processes. In this regard, citizens' satisfaction with the quality of key government institutions in core sectors, such as health and education, are important indicators.

Equity and Social Cohesion: In Smart Cities, social cohesion is a high priority for city governance. Thus, the main parametres of equity and social inclusion include: dealing with racial discrimination, gender inequalities, transparency (openness) and a participatory system of governance. For instance, one of Boston's major Smart City initiatives includes Participatory China Town, which is a platform for public participation in policy-making for urban planning (Chinatown, 2017).

Public and Social Services: In the area of public and social services, stakeholders placed emphasis on how Smartness could help municipalities to build stronger communities and opportunities for thir citizenry. Thus, capital spending is a major indicator in terms of the percentage of total expenditure for a city.

5.4.2.3 The People Component

In addition to the above two core components, the concept of Smart Cities includes people. As a core component of Smart Cities, Smart People have been addressed extensively in both academic journals and industry reports. The definition of the people component stresses the role of human capital and education in the innovative development of cities, which changes the patterns of citizen engagement to bottom-up rather than top-down (Batty et al., 2012). According to Glaeser (2005), one of the key characteristics of Smart Cities is the availability of a skilled workforce. Similarly, the transformation to a Smart City environment entails capabilities for vibrant R&D (knowledge-base) which are driven by educational institutions for urban diversity, social inclusion, a crime-free society, and a host of other positive societal values (Yigitcanlar et al., 2008). The component of 'people' further highlights the major findings from the literature review and the outcome of the pilot study, as captured in the conceptual framework.

Quality of Life: Who (1998) defines Quality of Life (QoL) as the, "… individual perceptions of their position in life in the context of culture and value systems in which they live and in relation to their goals, expectations, standards and concerns". In Smart Cities, an improved quality of life, either in terms of emotional wellbeing, health status, financial status, or other aspects of life, are of great concern. Quality of Life is beyond national GDP as measure of prosperity for national economies in the context of smart cities; QoL addresses key performance indicators relating to health, education, safety, voters turnout, and convenience (Chowdhury & Dhawan, 2016).

Creativity: It is considered important amongst the findings to attract, retain, and nurture the creative workforce for the city. Therefore, the number of entrepreneurs as a percentage of the city population can be established as a core indicator to assess the level of creativity.

Social Awareness: The level of consciousness of citizens is considered crucial to the understanding of the various sub-systems of the city and how they are interconnected. Here, the rate of participation in national debate and opinion polls was established to guage the level of awareness.

Flexibility: Flexibility is also relevant in building Smart and sustainable Cities in that it emphasises inclusive strategies to address equity and to avoid spatial segregation. Here, the potential capability to change as a percentage of the city population is considered a critical indicator.

Quality Education: Smart Cities need citizens with a range of skills; thus, quality education for citizens is a foundation for high quality performance. Education, in this regard, will be a critical determinant of success and can be assessed by the number of skilled citizens as a percentage of the city population as well as the number of educated citizens at different levels of education.

Environment that Supports Productivity: One of the most critical challenges faced by cities, and one emphasised by the stakeholders, is the need for an environment that supports productivity. Here, the GDP, as a percentage of employed citizens and the ratio of employed to unemployed, were also highlighted as a measure.

The concept of Smart People is rigorously discussed in a number of academic and industry-based Smart City journals (Edvinsson, 2006; Giffinger et al., 2007, 2010; Nam & Pardo, 2011a).

5.5 Summary

This chapter has discussed the models for Smart City KPIs and analysed two KPIs from prior research that have been used to quantify the impact of Smart Cities. Initial findings reveal that most KPIs assume that host cities already have an adequate infrastructure to support the deployment of the concept of Smart Cities. This condition holds true in many developed countries, but the lack of appropriate infrastructure in developing countries makes the case to review the KPIs to ensure that the infrastructure challenge is appropriately considered. The focus of this chapter is the development of infrastructure-centric KPIs that can be readily used to assess the impact of Smart Cities. With many cities around the globe adopting the concept of a Smart City, it has become imperative to proactively identify the critical factors and indicators that will be useful to both developed and developing countries in order to measure how the Smartness of a city impacts on its environment and citizens.

A number of studies have focused on the development of such indicators and many of their derived KPIs are already in use today. A systematic literature review of such prior research shows that many of the KPIs were developed with the assumption that they would (and could) be implemented in developed countries, which already have the required amenities and infrastructure. However, this assumption does not hold for such countries where many amenities and basic infrastructure are lacking. Therefore, this research aims to bridge this knowledge gap by proposing a list of KPIs that can be readily used in emerging cities in the context of developing countries. In particular, this chapter has derived KPIs that consider the infrastructure problems in developing countries.

CHAPTER 6

6.1 Case Study Analysis and Results

This chapter presents the findings from the case study of Boston, Manchester, and FCT-Abuja, and is structured into six distinct sections. Section 1 presents the case study description and profile of participants. Section 2 discusses processes across the three cases with a critical examination of: Boston in North America as a representation of advanced Smart City innovation; Manchester in Europe with similar lessons for Smart innovation, and finally, Abuja city and its aspirations for Smartness, which forms the primary case study. In all the cases, the efforts were targeted at building capabilities for Smart innovation, leveraging the Smart City concept to promote entrepreneurial growth, inequalities and social cohesion. Section 3 analyses the main interview findings and stakeholder perspectives of the critical success factors (CSFs) and the key performance indicators (KPIs) to assess the impacts of Smart innovation. Section 4 presents an overview of existing Smart City initiatives across the cases. Section 5 traces the relationship between smart innovation and the policy efforts of the cities, which is investigated through a comparative analysis while also summarising the cities' challenges/contextual issues. Finally, section 6 presents the key findings.

As summarised in Chapter 4 (the research methodology), the first step towards an effective field investigation was to conduct a pilot study through a focus group of knowledge-rich stakeholders in FCTA. Following a successful pilot study, semi-structured interviews were conducted with core Smart City stakeholders in the three cases investigated, which encompassed key organisations (as highlighted in Tables 6.1a, 6.1b, and 6.1c). Thus, qualitative data was collected from the interviewees in a systematic manner by asking questions relating to the research objectives and the knowledge gaps identified in the Smart Cities literature, as analysed in Chapters 2 and 3. Accordingly, the responses from the participants were organised into different themes using Nvivo version-11. Identifying the themes helped to achieve some of the research objectives as well as proffer answers to the research questions raised in Chapter 1. Therefore, the main themes for this chapter are: Case Study Description, Smart City Drivers, Smart City Perception and Understanding, Smart City Challenges, Smart City Factors, and the Smart City Components which are critical in ongoing Smart City innovations across the three cases investigated. The chapter also discusses and analyses themes that were identified during the data analysis and relevant to the objectives of the study, to provide an overview of ongoing Smart City initiatives and draw lessons from theory and practice.

6.2 Case Description and Background Information

This section presents the findings from the case study of Boston, FCT Abuja, and Manchester city as CASE-1, CASE-2, and CASE-3 respectively. The section is further structured into four sub-sections. Sub-section 1 presents the findings from CASE-1 (Boston), Sub-section 2 presents the findings from CASE-2 (FCT Abuja), and Sub-section 3 presents the findings from CASE-3 (Manchester). Furthermore, sub-sections 2 to 4 discuss the case-by-case findings and provide a cross-case comparative analysis of the findings from the three cases by focusing on the core factors and indicators of Smart City innovation.

6.2.1 CASE-1: A Case Study of Boston

Boston is the capital city of Massachusetts, and is the most populous city in the commonwealth of Massachusetts and the state of New England. Based on the demographic profile of Greater Boston from 2009 to 2013, the metropolitan area was home to 4.7 million people (World Population Review, 2018). Evidence from interviewees suggests that Boston faces issues with mobility and a handful of environmental challenges that it intends to address through Smart City innovations.

In 2010, the city of Boston launched experimental smart initiatives led by Mayor T.M. Menino to become one of the first cities across the world to function as a host to innovation (Convene, 2010). Recently, the vision has facilitated the creation of over 200 new companies and over 5000 new jobs. This development is creating an environment where leading companies, start-ups, and young innovators from industry and academia are coming together to co-create initiatives (Convene, 2010). Also in 2010, the Mayor’s Office set up an R&D laboratory in civic innovation named ‘New Urban Mechanics’. A senior government official in the Mayor’s Office recalled the experience and the imperative behind the initiative:

> (….) The New Urban Mechanics of the Mayor’s Office was first setup as a start-up of two innovators (one computer scientist and a Harvard Business School graduate) with specific task to invent the future of Boston city’s services with the primary objective of

> improving the quality of life for Bostonians. As the first municipal innovation Agency, the organisation was charged with the responsibilities of deploying new technologies, smart and innovative approaches (people-oriented) both for short-term and long-term interventions not only for efficiency of the city infrastructure but for education and improving the experiences and well-being of Boston residents/visitors [MOB].

The city of Boston has launched a long-term Smart City strategy, named "GoBoston 2030" (now called Imagine Boston 2030) comprising a number of strategic goals and targets. The key objective is to transform the city into a mobility innovation laboratory by focusing on People (through an initiative entitled Teaching Hospital for Transportation), Places (through an initiative called Radically Programmable City and Things) and Data (City of Boston, 2015b). In addition, the State of Massachusetts has developed a state-wide innovation strategy for deploying emerging technologies in health information technology (Health IT) in order to advance the quality, accuracy, efficiency, and availability of healthcare delivery whilst also reducing cost (City of Boston, 2015). In particular, Boston is involved in a number of initiatives, such as setting up platforms for innovation ecosystems through the innovation hubs/districts as well as encouraging PPP by collaborating with key industry players; for example, the company Verizon is involved in transforming the city into a Smart and healthy environment to better enable competitiveness. Figure 6.1 highlights some of the innovation hotspots in Boston that support various initiatives with a high concentration of entrepreneurial start-ups and quality innovation; Kendal Square, for instance, has a neighbourhood of about 50,000 people who work within the area on daily basis.

The Smarter Cities Challenge represents IBM's interventionist initiative for collaboration with city leaderships in delivering municipal services and improving urban efficiency; in a press release dated March 15, 2012, Mayor Menino announced the award of IBM's grant entitled "Smarter Cities Challenge 2012" to Boston as one of the winners of the competitive municipal service programme (Boston won as one of the 33 cities to benefit from the initiative during the first phase) (City of Boston, 2015). With commercial activities spreading beyond the traditional down-town areas of Boston, mobility challenges became apparent; this left citizens with limited access to the new job opportunities that were spreading across the metropolis. Thus, on 29th January 2015, the Mayor's Office under Mayor Martin J. Walsh developed GoBoston 2030 as a blue-print with a multi-pronged action plan to address these mobility challenges (City of Boston, 2015b). The final version of GoBoston 2030 was released on 18th May 2017 as Imagine

Boston 2030 (City of Boston, 2017). Table 6.1 presents a summary of the important facts on Boston’s Smart City evolution.

Table 6.1: Important Facts about Boston’s Smart City Evolution

S/N	Date	Programme/Description
1	2010	Mayor Thomas M. Menino launched Boston’s experimental Smart initiatives
2	2010	New Urban Mechanics Formed
3	May, 2010	Boston Implemented Participatory Chinatown
4	15th March 2012	IBM’s Smarter Cities Challenge grant to Boston
5	29th January 2015	Mayor Martin J. Walsh developed the GoBoston 2030
6	2016	Boston Local Sense Laboratory (Hypothetical Testbed for Citizen Science was launched
7	2016	Hybrid KPI for Smart Cities Applications launched
8	18th May 2017	Imagine Boston 2030 was launched

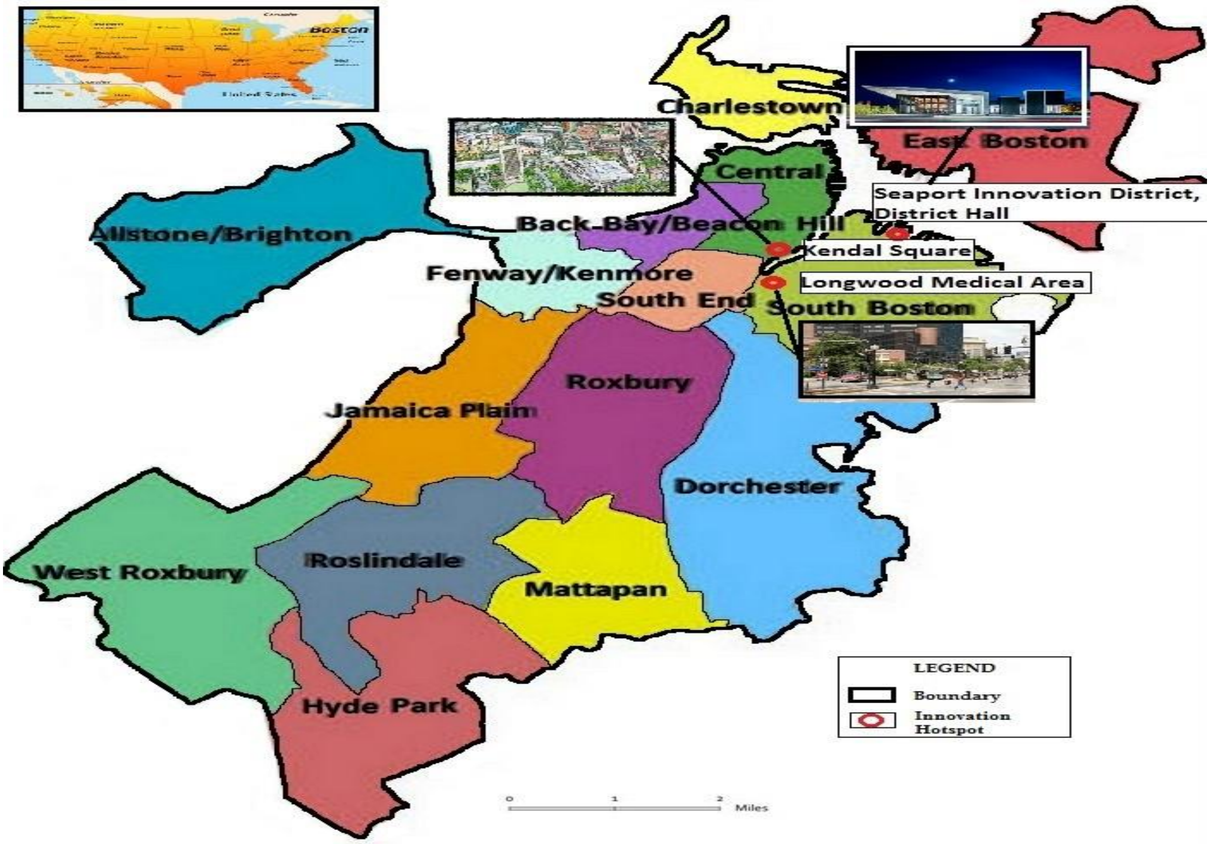


Figure 6-1: Map of Boston Showing Some of the Innovation Hotspots in Boston, Massachusetts

6.2.2 CASE-2: A Case Study of Abuja

The Federal Capital Territory, Abuja (FCTA) is the new Federal capital city of Nigeria. Abuja is one of the fastest developing cities in the world. Based on official statistics from the last national and housing census in 2006, the population of the Abuja metropolitan area was estimated at 1.4 million people (National Population Commission, 2013). Recent unofficial estimates from different sources put the population of Abuja above three million people. For instance, G. Jiriko et al. (2015) suggested that the population of the Abuja metropolitan area is about five million people

In a response to growing awareness of the benefits of integrating the Smart City concept to solve global urban development challenges, stakeholders in Nigeria have commenced a collaborative arrangement to roll out Smart City initiatives. The stakeholders, which include the 36 state governments and the Federal Capital Development Authority, are collaborating with the National Information Technology Development Agency (NITDA) to setup the National Smart Cities Initiative (NSCI) to address the development challenges faced by cities in Nigeria with specific interest in transportation, disaster response, energy, healthcare, education, and environmental related issues, such as climate change (Thisday, 2016). Abuja and Lagos were identified as pilot cities for the project that included one city from each of the six geo-political zones of Nigeria. Table 6.2 presents a summary of key facts about FCTA's Smart City evolution. Figure 6.2 also highlights some of the innovation hotspots supporting various initiatives aimed at kick-starting entrepreneurial start-ups and quality innovation in FCT-Abuja.

Table 6.*2*: Important Facts about Abuja Smart City Evolution

S/N	Date	Programme/Description
1	2012	First Nigerian Eco-City Project (Waru Pozema – Abuja) was launched
2	March 25, 2014	FCT – Abuja was nominated as one of the 16 cities world-wide to receive the IBM's Smarter Cities grant
3	January 01, 2014	Abuja Centenary Smart City project was launched
4	November 10, 2017	Share-Ride Initiative by Taxify Launched
5	Sept. 20, 2017	Abuja was announced officially as one of the winners of the IBM's Smarter Cities grant

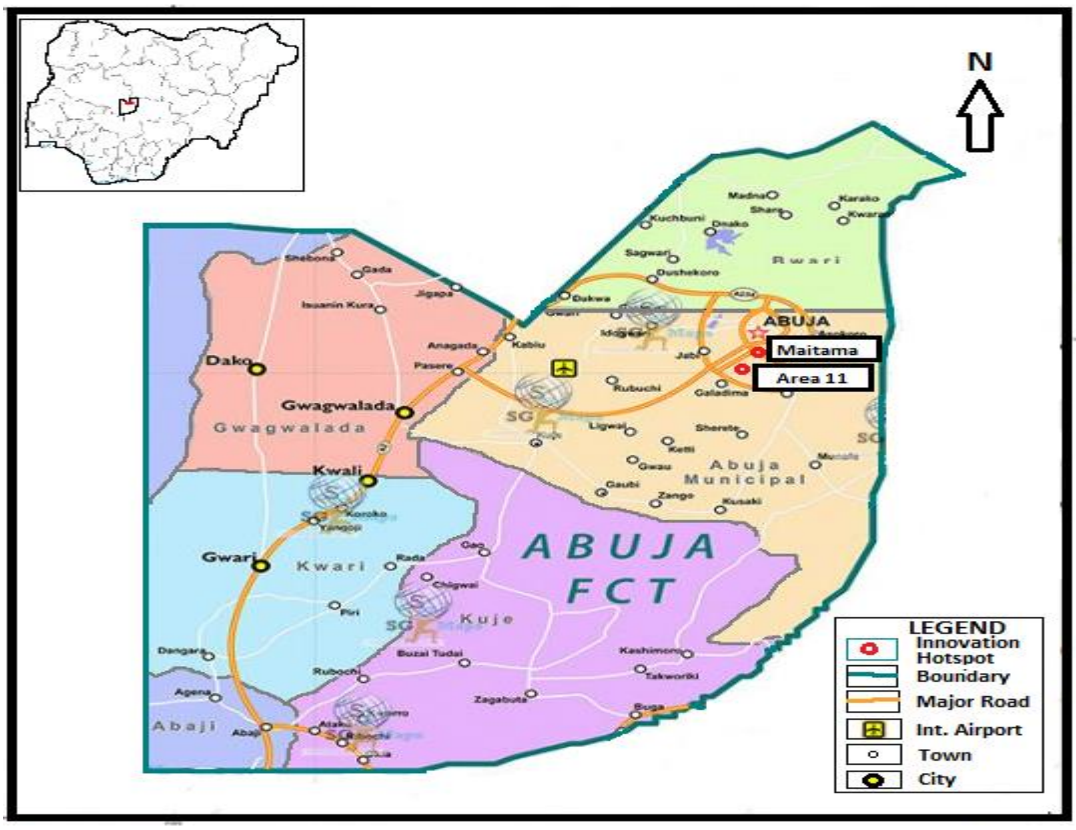


Figure 6-2: Map of FCT - Abuja Showing Study Sites and Locations in FCT, Nigeria

6.2.3 CASE-3: A Case Study of Manchester

Manchester is a metropolitan borough in the Greater Manchester area, and is said to be one of the largest cities in England with a metropolitan area home to 2.55 million people (World Population Review, 2017). The city of Manchester, like many other cities, adopted the Smart City concept as a development strategy, and have also identified mobility, health/safety, and a number of environmental challenges as key areas to be addressed through its Smart City programme. The Greater Manchester Data Synchronisation programme, the Greater Manchester Datastore, Transport for Greater Manchester, and the Media City project were positive examples of Smart City initiatives cited by CCM in Manchester.

In Manchester, the efforts to build a smart and sustainable city started in the early 1990s when the city celebrated the 60th anniversary of the world's first real computer and hosted the UK's first e-village Halls alongside other sustainability programmes (Manchester City Council, 2018c). As recounted by one of the interviewees from senior management [CCM]:

> (…) Manchester started looking into what we call today as Smart Cities 20 years ago. Yeah**!** the efforts started 20 years ago. In the 1990s it was called 'The Knowledge

> Economy or knowledge society.' In Manchester, it is 20 years of work. Smart Cities is about rebranding. We had our first knowledge society framework or strategies in the 1990s. We are founding member of The Knowledge Societies Forum which is European Network of Cities (Forum of EU Cities) and that began as tele-city to telematics. Around 2006 to 2007, there was a desire for digital agenda for EU cities which was all about having access to technologies and good place to do business for international competitiveness. From a strategic point of view, we had our first digital strategies for Manchester City Council in 2009. In summary the focus was on access to IT and services but now the focus has begun to change into how technology is affecting the environment, energy and innovation (i.e. how technologies are affecting the different sectors of the city economy).

The Smart City concept has become an innovative strategy in Manchester by focusing on service improvement for its residents. Manchester is leveraging Smart City adoption through the use of technologies and open innovation to explore ways in which better services can be delivered in critical sectors, such as the environment, transport, health, and energy. Figure 6.3 highlights some of the innovation hotspots taking advantage of the Internet of Things (IoTs), technologies and the sensor networks for Smart City demonstrators projects. Manchester also attracts a high concentration of entrepreneurial start-ups and quality innovation. The effort towards Smartness is also aimed at encouraging meaningful investment through PPP. Table 6.3 presents the summary of important facts about Manchester's Smart City evolution.

Table 6.3: Important Facts about Manchester Smart City Evolution

S/N	Date	Programme/Description
1	2006 – 2007	Founding Member, European Network of Cities (Forum of EU Cities).
2	2009	Manchester launched it's first digital strategies for Manchester City Council.
3	2010	Open Data Manchester was launched
4	3rd December 2015	Manchester won £10 Million prize to become world leader in Smart City innovation.
5	2015	CityVerve (Manchester's Smart City Demonstrator was launched with 21 stakeholder organisations from both public and private sectors including the academia.
6	March, 2015	Connected Healthy City initiative was launched to use city data in improving healthcare
7	November, 2016	Our Manchester Strategy framework (10-years) was launched aiming at transforming Manchester into liveable and low carbon city.

Figure 6-3: Map of Manchester, Showing Study Sites and Locations in Manchester, UK

6.2.4 Leveraging Technical Partnership in Building Smart Infrastructure for Smart City Innovation

Developing a Smarter City is a challenging task for city governments and their development partners, and central to most visions is how such municipalities deploy new infrastructure and processes across the core city sub-systems with the right human capacity to affect Smart changes.

In Boston, the prototype of an IBM initiative that unlocks, shares, and analyses data for future benefit was also cited as a major factor for improvements in this emerging sector. The aforementioned Smart Cities Challenge grant awarded to Boston was part of IBM’s citizenship efforts towards building a Smart Planet (IBM, 2012a), and the “Smarter Cities Challenge” is a major component of this initiative. Through this programme, the corporation focuses on collaboration with city governments to promote the vision of the three I’s, namely instrumentation, interconnectedness, and intelligence of cities, to become more productive, efficient, and responsive (IBM, 2012b). As Palmisano (2008) suggests, the vision of Smarter Cities from IBM’s perspective is a new way for cities to improve their performance, especially in service delivery, addressing mobility challenges, reducing the cost of services, and improving their economies through proper investment in analytics systems for the better management of urban infrastructure. Moreover, the prototyping phase of the Smarter Cities Challenge in Boston was completed in collaboration with Boston University.

In addition, Smart services have started to extend into transport networks in Boston to accelerate their Smart aspirations in the form of innovative technologies for autonomous vehicles that improve safety, provide a better environment, increase access and ensure sustainability. Although this development is not yet popular among citizens, interviewees (senior executives) in both the public and private sectors agreed that serious innovative solutions have emerged in this area. This category of stakeholders further revealed that Boston has started experimenting with this concept by re-thinking the future of transportation in the city. The Seaport Innovation Area officially announced, through the Office of the Mayor, the testing of the first set of autonomous cars at the former Boston Marine Park in December 2016 (Agbali, Trillo, Arayici, & Fernando, 2017). The innovation is part of the preparation for fully autonomous fleets that will involve ride-sharing services and are expected to be in full service by 2021. The initiative is part GoBoston 2030, which is driven by a PPP arrangement through the Massachusetts Institute of Technology and NuTonomy, which is a private partner (See Figure 6.4). Moreover, the company Uber also launched a similar innovation in September 2016. In another instance, core stakeholders interviewed around Longwood Medical Area (LMA) cited the collaboration between Uber and Boston Children's Hospital to provide on-demand services as a similar major medical intervention in the area.

Figure 6-4: Sample of Boston's Autonomous Vehicle

(**Source**: City of Boston)

As part of the key Smart City steps, the city is re-thinking its transport infrastructure to improve access to transportation services and safety. Other examples include the Senseable City Lab., which serves as a testbed for Smart City innovations, the Street Bump app, which enables the city to aggregate data on damaged roads and repair them, and Citizens Connect, and Hub2, which engage residents in neighbourhood planning. In terms of re-appropriating the city infrastructure for open innovation, a number of participatory services are already rolling out through organised innovation platforms that bring together the next wave of innovation and entrepreneurial development.

Similar to Boston, FCT-Abuja was one of the 16 candidate cities selected by the IBM Council Global Partner to benefit from the "IBM Smarter Cities Challenge". In 2014, Abuja city was selected alongside the city of Durban in South Africa and Mombasa County in Kenya to continue IBM's Smarter Cities Challenge collaboration around the world (IBM, 2014). In general, IBM partners with city leaders to deliver support in making cities Smarter and more effective. They focus on critical sectors, such as transportation, public safety, energy, the environment, water and sanitation, social services, economic development, and administration. Although Abuja and Mombasa were selected for partnership in the area of administration, Durban was selected for partnership in the area of economic development.

In its recent report on "The Challenge" defined a set of short to long-term recommendations for its partnership with FCTA by establishing a collaborative revenue recovery management and administrative solution in six core areas. These areas aim to nurture an organisational culture, enforce an enterprising IT strategy, transform processes, establish strategic initiatives, reform policy and regulations, and implement trusted ledger systems. The recommendations were proposed as immediate and first steps for FCTA to improve its revenue collection in order to meet the needs of its citizens.

In addition to the IBM-FCTA Smarter City Challenge partnership, FCT Administration, in collaboration with private sector and multinational development from UAE, Singapore, and South Africa, launched Abuja Centenary City in 2014. Abuja Centenary City is a PPP project labelled as 'a city within a city'. It also adopted the concept of a Smart City in its development strategies by leveraging the latest technologies to provide state of the art services to its citizens (Awuah, 2018)CentenaryCity, 2015). The Centenary Smart City project, which is already enjoying direct foreign investment from United Arab Emirate (UAE), is modelled on the city of Singapore (see Figure 6.5). The first phase of the Centenary City, which is expected to be completed in four years, has commenced.

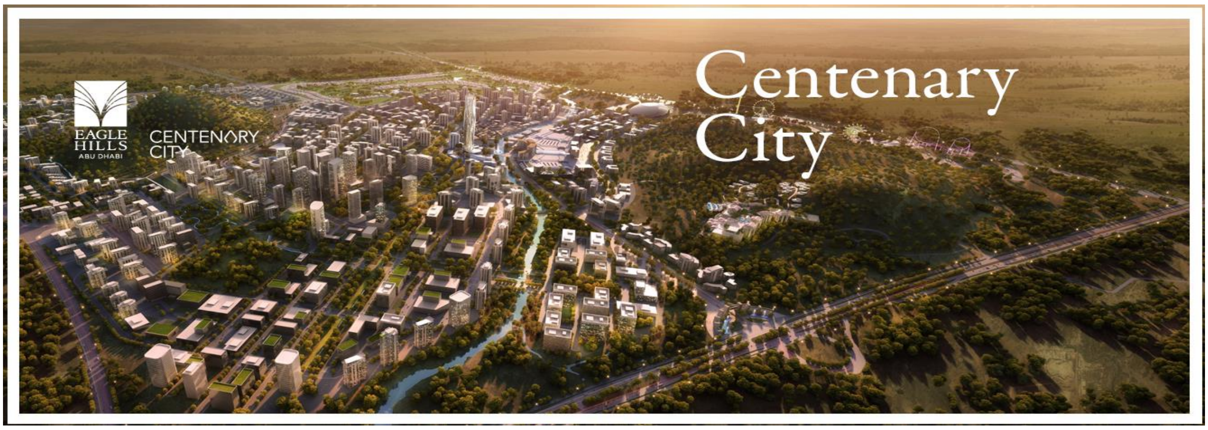


Figure 6-5: Abuja Centenary City Phase-1

(**Source**: CentenaryCity, 2015)

In Manchester, the partnership is a consortium of 21 organisations led by Cisco, Manchester City Council, BT, Manchester Science Partnership, and Innovate UK to deliver Smart City innovation through the SmartImpact – URBACT, Triangulum, Synchronicity, Grow Green, and the CityVerve initiatives. As posited by one of the interviewees [CCM] from senior management, “the CityVerve idea seeks to use Internet of Things (IoT) technologies to redefine the concept of smartness in the context of a living, working city”. The main aim of the initiative is to build a smarter and more connected Manchester city by creating a city that uses technologies to meet the complex and numerous needs of its citizens (CityVerve, 2018).

As a strategy, the partnerships are structured to focus on core sectors with expertise in different sub-sectors that deliver place-based innovation to address the specific challenges of the city. From the perspective of CityVerve, the focus is to leverage IoT technologies to deliver cutting edge solutions that are engineered by world-class experts to improve the delivery of healthcare systems, and transform the transport services and energy sector. CityVerve in Manchester is already delivering services in the area of Smart Parking as a use case solution; the focus is on providing ‘parking space tracking’ for citizens based on driving routes, smart traffic monitoring by creating intuitive and efficient traffic services, sensing trams through real-time data on IoT devices on tram network, talkative bus systems, and City Concierges for way-finding services. In the area of energy and the environment, the effort is focused on enhancing energy management solutions, such as Smart facilities management, next generation building management systems, and Air Quality Monitoring. The CityVerve initiative is fully funded by the government and Innovate UK. See for, instance Figure 6.6, use a case example in air quality sensing on Manchester Oxford Road.

Figure 6-6: Air Quality Sensor Network, Manchester Oxford Road

(**Source**: CityVerve, 2018)

Moreover, the Triangulum initiative is funded by the EU's H_{2020} and its focus is on increased mobility, a percentage reduction of journeys, the energy use in both building and transportation, energy costs, and the number of new jobs created. Also, SynchroniCity is mainly focused on harmonising the market for urban data and IoT enabled services in order to develop tools for co-creation and service integration as well as to address interoperability issues. Similarly, the Grow Green initiative focuses on enhancing greener city initiatives to increase liveability; this is also funded by H_{2020}.

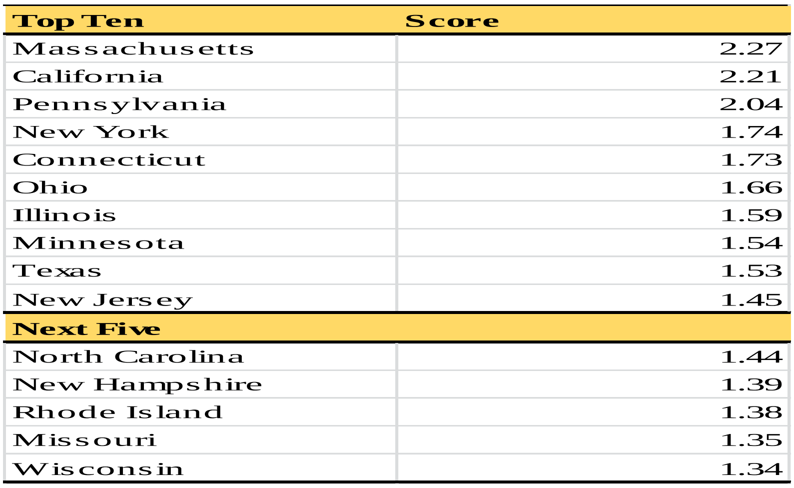
6.2.5 Building Capabilities for Smart Innovation

The sustainability of many components or characteristics of Smart Cities relies on the smartness of institutions. In Boston, there is a consensus among different actors who exist in key clusters that this is strongly related to innovation hubs. The interviewees [MOB], [UMB] emphasised access to innovation hubs as a major strategy for Smart City deployment.

> (…) The State government and the city administration have setup robust and well organized innovation platforms such as the New Urban Mechanics and the PULSE/MassChallenge for interactive and participatory development [MOB].

In addition, the city takes pride in its “established vibrant” innovation hubs, such as Longwood Medical Area (LMA), Kendall Square, the Seaport Innovation Area, and various innovation districts that provide innovative solutions for entrepreneurs by increasing the proximity and density and thus enabling the sharing of knowledge and technologies. For instance, interviewees [DHB] in the health sector (LMA) cited the example of “Second Opinion”, which is an e-health solution, and the telemedicine solution at Boston Children’s Hospital, as major achievements that have resulted from a vibrant innovation landscape in Boston. Similarly, the city is one of the most attractive destinations for venture capital (VC) in the United States of America, closely followed by California (see, for instance, secondary-data shown in Table 6.4). As a result of these vibrant innovation hubs and academic R&D in science and engineering (S&E), Boston has recently taken the lead as a destination for R&D funding from the Federal Government (MassTech, 2015).

Table 6.4: Measure of the Absolute Size of the Innovation Economy of the USA (2015/2016)



Top Ten	**Score**
Massachusetts	2.27
California	2.21
Pennsylvania	2.04
New York	1.74
Connecticut	1.73
Ohio	1.66
Illinois	1.59
Minnesota	1.54
Texas	1.53
New Jersey	1.45
Next Five	
North Carolina	1.44
New Hampshire	1.39
Rhode Island	1.38
Missouri	1.35
Wisconsin	1.34

(**Source**: (MassTech, 2016)

Boston tends to be the centre of the “hardcore tech talent” in the USA; thus, the opportunity to attract VC is highly emphasised. The city tends to have easy access to VC funding, both from local capitalists and the government. For instance, the PULSE/MassChallenge platform conducts competitive awards for start-up innovators (in healthcare/LMA) on a monthly basis. In addition, the available industry statistics (Koivistoinen, 2016) demonstrate a good performance in Boston, which recorded income totalling $704 million from 17 deals. This is a little less than the San-Francisco Bay Area and New York City who are also in the top-10 US Metro Areas.

In terms of improved Big Data analytics/Open Data Initiatives, the study revealed medium to moderate improvements over other sectors amongst Smart City stakeholders in the strategic area of transportation. Interviewees cited the example of Big Data analytics for providing "last-mile" information for timely decisions on transportation routes and leveraging high-connectivity access with most vehicles equipped with on-board computers for GPS data processing and monitoring. Similarly, according to these interviewees, Boston's efforts to release several applications for the consumable visualisation of Big Data contributed to this feat. The prototype of an IBM initiative to unlock, share, and analyse data for future benefits was also cited as a major factor for improvements in this emerging sector. For the healthcare sector, the experts ascribed the low emphasises on tapping the economic opportunity in Big Data analytics/Open Data initiatives to the challenges of privacy.

In FCTA, efforts are being taken to lay the foundation for sustainable development through Smart innovation. To fast-track innovative development that will support the Smart City and ensure sustainable economic growth in the city and Africa in general, FCTA has set up Abuja Technology Village with a masterplan that aims to create an environment built to high global standards that ensures sustainability (see Figure 6.7). Although the Abuja Technology Village is still under construction, the centre is already attracting direct foreign investment to the city (ATV, 2018). Operating under the auspices of Abuja Technology Village Free Trade Zone (ATV), the centre is a member of the International Association of Science Parks and Area Innovation (IASP).

Figure 6-7: Abuja Technology Village Model

(**Source**: ATV 2018)

As a strategy, ATV is collaborating with private sector operators to set up vibrant innovation hubs in strategic locations to serve the needs of the city. In this regard, ATV has setup an incubation centre called ‘Enspire’ to promote sustainable economic growth through innovation, entrepreneurship and commercialisation of technological R&D.

According to experts [SCA], FCTA is rapidly growing into the next ‘haven’ for social innovation and startup activities in Nigeria. New waves of innovative development are appearing in FCTA, encouraged by the establishment of new innovation hubs across the city. For example, Civic Innovation Lab has launched an innovation hub located in the Maitama District with a focus on harnessing innovation and technology service provisioning to effectively address the pressing social and environmental needs of the city (Techpoint, 2017). One of the major objectives of the hub is to address connectivity challenges in the city by connecting the government and the people through start-up communities.

In Manchester, one of the major steps towards building institutional capability for Smart innovation was the official launch of Manchester Inspired Innovation Digital Enterprise Alliance (Mi-IDEA) in September 2017. As noted by one of the key stakeholders [TFM]:

> (…) Manchester’s model of start-up ecosystem is totally different from what you can find in any other city. We have a different approach altogether to make the concept act as the focal-point for co-innovation that will serve as platform for bringing the top policy makers, key industry managers, and their counterparts in the academia to build a blue-print for our dream Smart City. It is the hub for our Smart City demonstrator.

Moreover, with the main goal of becoming a regional leader in Smart City innovation in Europe, in January 2018 Manchester launched another important policy in open innovation. The Manchester Open Innovation Challenge aims to help the transformation of the city through the introduction of smart technologies. As recounted by one of the interviewees [CCM], “In Manchester, our symbol for the city is the bee and in UK and the entire sub-region, we are known with it and we have been building a hive of our own”. The open innovation challenge is being carried out in collaboration with Cisco and Manchester Science Partnership (MSP) and focuses on addressing specific themes around healthcare, transportation, and energy respectively.

6.2.6 Addressing Inequalities and Social Cohesion through Smart Innovation and Entrepreneurship

With the advent of new technologies and social media, social polarisation remains a crucial issue in many major cities. In Smart City discourse, the issue of social polarisation has been discussed; furthermore, the risk that Smart Cities may attract and cater for “Smart Workers” and thus increase the gap in terms of access to opportunities has been recognised (Pollard, 2008). In Boston, the city government recognised the need for all residents, both privileged and less privileged, to have equal access to opportunities. One interviewee [MOB] from senior management expressed a personal view that:

> (…) policy makers must at all times emphasise the need for equity by closing gaps between the privileged and less privileged citizens. In my view, a city can claim to be smart when there is improved social cohesion, connectivity with improved access to information (e.g. last-mile and first-mile), and entrepreneurial development [MOB].

The focus of GoBoston 2030, for instance, is the Smart City initiative that seeks to create and run mobility innovation laboratories focused mainly on the transport sector and integrating research, practice and entrepreneurship with specific targets and smart goals to move the city towards zero deaths (accidents), zero injuries (safety on the roads), zero disparities (equity), and zero carbon emissions (City of Boston, 2015a). Within the GoBoston 2030 framework, poverty reduction through social innovation and entrepreneurship are emphasised.

In FCTA, the focus is on entrepreneurial growth and job creation. One senior official [FCA] in the core stakeholder organisation stated that the main objective of the FCT Smart City initiative is to improve citizens’ quality of life, create a more skilled workforce, generate new jobs in a competitive manner, and address security challenges in the city. Examples of the key sectors targeted to achieve this include transport, healthcare, and the hospitality industry. For example, the FCT Transport secretariat in collaboration with their private sector partners made efforts in 2015 to showcase how it intends to create new jobs for the the large proportion of youths in the city, through share-ride initiatives. This uses the Abuja Urban Mass Transit Buses asa pilot phase covering the three major exit routes of Zuba, Nyanya, and Giri junction along the airport road.

Similarly, Manchester focus on supporting a successful local innovation ecosystem in order to strengthen local investors to enable the city to respond to the current global changes in the business start-up environment. Indeed, one of the interviewees stated that, through the implementation of integrated strategies for social inclusion, the city is making assertive moves to address existing socio-economic disparities and any other form of inequality in the city that is capable of hindering the achievement of a decent quality of life. Manchester's strategies of addressing inequalities through the Smart City concept is similar to Barcelona's inclusive entrepreneurship strategies that have encouraged the establishment of over 18,000 start-up companies/businesses and generated over 32,000 new jobs for the city (URBACT, 2017).

6.3 Qualitative Data Collection and Interview Processes

As summarised in the methodology chapter, the case study investigation adopted semi-structured interviews to capture qualitative data on Smart City developments and stakeholders' perceptions in order to benefit from their embedded knowledge. The semi-structured interview guide developed from the pilot and focus-group exercise in FCT Abuja was introduced prior to the interview to provide an opportunity for interviewees to gain an understanding of the information sheet and the focus of the study. In addition, this provided the chance to consider any concerns or questions they might have before taking the decision to participate in the interview.

In order to make sense of the rich qualitative data collected from the field investigation, the themes covered in the interviews were organised into five core areas of Smart City development using the semi-structured interview guide. The thematic areas also served as a guide to the mind-map for the Nvivo qualitative data analysis and covered the following:

- Smart Cities' Drivers: This refers to the motivating factors or what attracts the stakeholders to the Smart Cities concept.
- Smart Cities' Perceptions: The general understanding of the stakeholders who are involved in Smart City projects and programmes.
- Smart Cities' Components: The different dimensions found in the literature that relate to how stakeholders prioritise their Smart City initiatives.

- Smart Cities' Critical Success Factors: Namely, what is to be achieved (the perceived problems of cities, or the elements for which Smart City innovation has the potential to address).
- Smart Cities' KPIs: Namely, identifying the need for assessment and/or monitoring the performance through metrics of what constitute smartness and how smartness can be measured.
- Smart City Project: An overview of existing Smart Cities initiatives with a descriptive analysis of their impacts, project objectives, implementation strategies, and challenges where known.

The summary of the thematic areas from the empirical data collection, in line with the research design, are outlined in Figure 6.8:

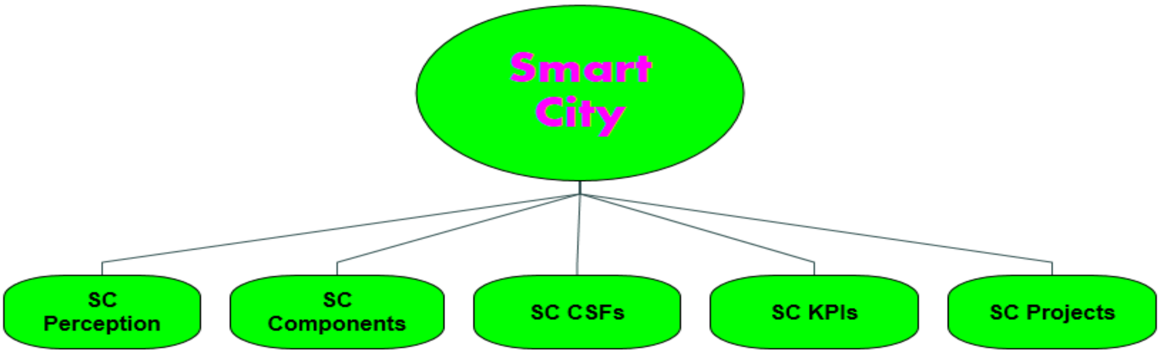


Figure 6-8: Mind-Map of the Thematic Areas from Nvivo.

6.3.1 Sampling Consideration

The interviews in Boston covered a wide range of stakeholders in the core sectors, from senior political offices in city administration to academia, ICT industry, and a host of innovation hubs focusing mainly on the Boston and Cambridge areas. The selection was based on purposeful sampling, which helped to focus on the particular characteristics of the target audience to ensure that the interviewees could provide responses to the interview questions. In addition, the role of stakeholder organisations and the key roles undertaken by participants in ongoing smart innovations formed the criteria for selection. This meant that the entire field investigation was targeted at knowledge-rich individuals who were abreast of the current developments and policy direction of Smart City initiatives across the three cases.

In FCT-Abuja, the main interview sessions were targeted at the senior executives in core stakeholder organisations within the city administration, academia, and the ICT industry, which was located within the Central Business District, Garki District, Wuse District, Maitama, and the Asokoro District of Abuja city. Similarly, the Manchester field investigation followed the same pattern as that adopted in Boston by focusing on stakeholders within the city.

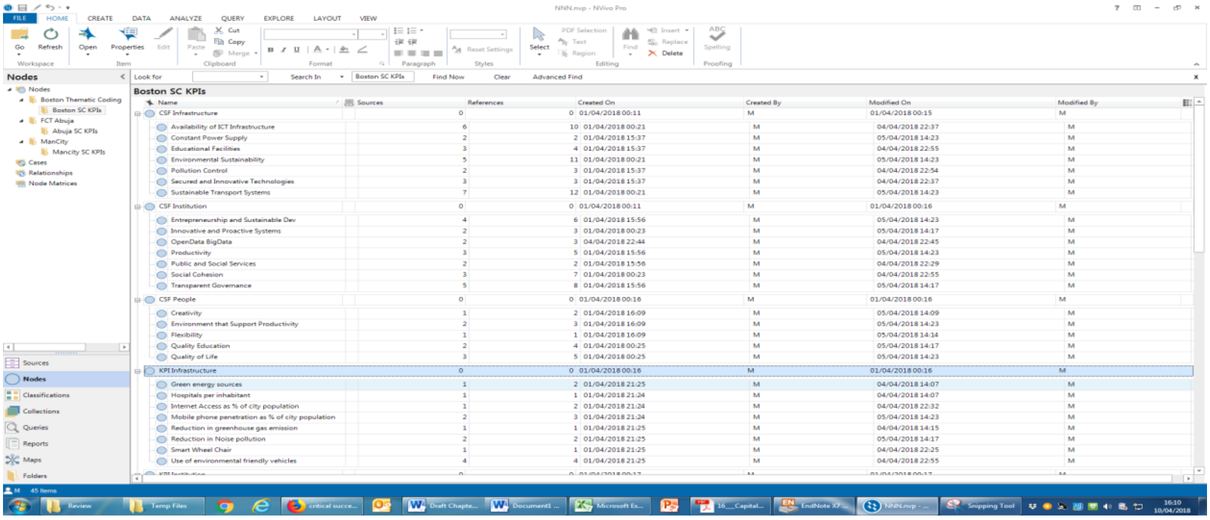
6.3.2 Profile of Participants Interviewed

As highlighted in the methodology chapter, the selection of interviewees followed a purposive sampling technique, which focused both on the specific characteristics concerning the priority areas of interest, and on innovative developments emerging in the cities in order to enrich the findings of the research. In this regard, a total of 10 interviewees across nine core stakeholder organisations actively involved in Smart City deployment in Boston were purposively selected and interviewed between September 2016 and January 2017. In order to improve the coverage, a snowball technique was also employed to accommodate participants mentioned as potential respondents who would have useful perspectives to offer concerning the goal of the study. The choice of 10 highly experienced professionals was based on their expertise in emerging Smart City innovation and their access to valuable information that would help to build a thorough understanding of the nature of the challenges the city faced and how the Smart innovation was helping to address them. A summary of the participant profiles is detailed in Table 6.5.

Table 6.5: Profile of Interviewees and Some Demographics - Boston

Case	**Position**	**Sector**	**Qualification**	**Experience (in years)**
MOB	Cabinet Head/Member	Urban Planning	PhD.	15
MSB	Manager	Information Technology	BSc.	11
SLB	Innovation Coordinator	Academia	PhD	12
SCB	Senior Lecturer	Academia	Professor	9
ICB	Executive Director	Urban Planning	MSc.	13
DHB	Director	Urban Planning	BSc.	7
UFB	Director	Academia	Professor	17
UMB	Director	Information Technology	BSc.	6
MHB	Executive Director/CEO	Urban Planning	MSc.	5
NMB	Founder/CEO	Urban Planning	MSc.	7

As reflected in Table 6.5, the field investigation adequately covered the core stakeholders involved in Boston Smart City innovation who are directly involved in ongoing developments. For the purpose of confidentiality, the study adopted the use of codes to protect the anonymity of the participants, using letters as representative descriptors of individuals e.g. MOB, SLB, SCB, NMB (see Figure 6.9 for the thematic coding):



Boston SC KPIs

Name	Sources	References	Created On	Created By	Modified On	Modified By
CSF Infrastructure	0	0	01/04/2018 00:11	M	01/04/2018 00:15	M
Availability of ICT Infrastructure	6	10	01/04/2018 00:21	M	04/04/2018 22:37	M
Constant Power Supply	2	2	01/04/2018 15:37	M	05/04/2018 14:23	M
Educational Facilities	3	4	01/04/2018 15:37	M	04/04/2018 22:55	M
Environmental Sustainability	5	11	01/04/2018 00:21	M	05/04/2018 14:23	M
Pollution Control	2	3	01/04/2018 15:37	M	04/04/2018 22:54	M
Secured and Innovative Technologies	3	3	01/04/2018 15:37	M	04/04/2018 22:37	M
Sustainable Transport Systems	7	12	01/04/2018 00:21	M	05/04/2018 14:23	M
CSF Institution	0	0	01/04/2018 00:11	M	01/04/2018 00:16	M
Entrepreneurship and Sustainable Dev	4	6	01/04/2018 15:56	M	05/04/2018 14:23	M
Innovative and Proactive Systems	2	3	01/04/2018 00:23	M	05/04/2018 14:17	M
OpenData BigData	2	3	04/04/2018 22:44	M	04/04/2018 22:45	M
Productivity	3	5	01/04/2018 15:56	M	05/04/2018 14:23	M
Public and Social Services	2	2	01/04/2018 15:56	M	04/04/2018 22:29	M
Social Cohesion	3	7	01/04/2018 00:23	M	04/04/2018 22:55	M
Transparent Governance	5	8	01/04/2018 15:56	M	05/04/2018 14:17	M
CSF People	0	0	01/04/2018 00:16	M	01/04/2018 00:16	M
Creativity	1	2	01/04/2018 16:09	M	05/04/2018 14:09	M
Environment that Support Productivity	2	3	01/04/2018 16:09	M	05/04/2018 14:23	M
Flexibility	1	1	01/04/2018 16:09	M	05/04/2018 14:14	M
Quality Education	2	4	01/04/2018 00:25	M	05/04/2018 14:17	M
Quality of Life	3	5	01/04/2018 00:25	M	05/04/2018 14:23	M
KPI Infrastructure	0	0	01/04/2018 00:16	M	01/04/2018 00:16	M
Green energy sources	1	2	01/04/2018 21:25	M	04/04/2018 14:07	M
Hospitals per inhabitant	1	1	01/04/2018 21:24	M	04/04/2018 14:07	M
Internet Access as % of city population	1	2	01/04/2018 21:24	M	04/04/2018 22:32	M
Mobile phone penetration as % of city population	2	3	01/04/2018 21:24	M	05/04/2018 14:23	M
Reduction in greenhouse gas emission	1	1	01/04/2018 21:25	M	04/04/2018 14:15	M
Reduction in Noise pollution	2	2	01/04/2018 21:25	M	05/04/2018 14:17	M
Smart Wheel Chair	1	1	01/04/2018 21:25	M	04/04/2018 22:25	M
Use of environmental friendly vehicles	4	4	01/04/2018 21:25	M	04/04/2018 22:55	M

Figure 6-9: The thematic coding of Interviews using Nvivo 11

Based on the preliminary data supplied before the full interview session, the Abuja case study also consulted a range of stakeholders with participants drawn from three key sectors in different organisations that are fully involved in the ongoing Smart City. With seven interviewees from six organisations, three were top decision makers from the ICT industry, one was from transportation, two were from city administration of which one was a senior political office holder, while one interviewee came from academia, as summarised in Table 6.6. It is important to note that all interviewees were fully abreast of current developments in the field of Smart Cities; this met the requirements of the research, which was targeted at ‘knowledge-rich’ individuals. These individuals were interviewed between 26th June and 28th July 2017.

The criteria for the selection of participants were identical to those in CASE-1 except that CASE-2 leveraged contacts from the already-established platform during the pilot study conducted in June 2016. In this case, the majority of the interviewees were already aware of the study and there was no need to explore the snowballing approach during the main interviews.

Table 6.6: Profile of Interviewees and Some Demographics - Abuja

Case	Position	Sector	Qualification	Experience (in years)
CCA	MD/CEO	Urban Planning	MSc.	11
FNA	Ass. Chief	Information Technology	PhD.	14
FCA	Coordinator/CEO	Urban Planning/Transport	MSc	27
SCA	National Coordinator	Transportation	MSc.	17
AUA	Senior Lecturer/Director	Academia	Professor	21
SCA	Executive Director	Information Technology	BSc.	17
AGA	Director/CEO	Information Technology	PhD.	9

Table 6.6 summarises the background of each interviewee and, as before, to protect their anonymity, three letter codes were used to represent the individuals. Six of the interviewees had over 10 years of relevant experience and only one participant had three years of relevant experience; however, they were involved in the coordination of high-profile individuals involved in Abuja Smart City innovation. Figure 6.9 shows the thematic coding of the interviewees.

In Manchester, five knowledgeable participants in five different stakeholder organisations who are actively involved in the Smart City innovation in Manchester City were interviewed between July and September 2017. As explained in the previous section, the selection of the interviewees across the three cases were uniform throughout the field investigation. A summary of the Manchester interviewees’ profiles is detailed in Table 6.7. Table 6.7 shows that the field investigation in Manchester also focused on senior executives who indicated an interest in this study and were able to commit time to participate. The scope of the field investigation in this case covered the core stakeholders in academia, city administration, and the ICT industry. Again, for the purpose of confidentiality, the use of codes, e.g. CCM, ODM, CHM, IPM, and TFM, were also used as representative interviewee descriptors (see Figure 6.10 for the hierarchical tree representation of the thematic coding).

Table 6.7: Profile of Interviewees and Some Demographics -Manchester

Case	Position	Sector	Qualification	Experience (in years)
CHM	Director/Senior Lecturer	Academia	PhD.	4
IPM	Director	Information Technology	MSc.	27
CCM	Senior Policy Officer	Urban Planning	MA	20
ODM	Founder/CEO	Information Technology	MSc	7
TFM	HOD	Urban Planning	MA	11

6.4 Interview Findings and Analysis of Themes

Discussions from the previous sections dwelt on case description, data collection efforts, sampling considerations, and the profiles of participants recruited for this investigation. In this section, the assessment of the factors that emerged is presented. Therefore, the section explores the full content of the interviews from the field investigation using the qualitative data analysis techniques detailed in Chapter 4.

As outlined in the hierarchical tree representation that used using Nvivo 11 (Figure 6.10), five main themes emerged from the general understanding of the Smartness of cities; this encompassed what it meant to the different stakeholders as well as what constituted Smartness in the context of cities, which addresses the aim and objectives of this study. The themes generated from the interviews included: Smart City Perceptions, Smart City Components (i.e. the different dimensions of priority to stakeholders), Smart City Critical Success Factors (i.e. metrics) for the three components of Infrastructure, Institution, and People, and Smart City KPIs for Infrastructure, Institution, and People. Using these core themes, other sub-themes were conveniently grouped according to the inter-relationships in order to explain the findings from the empirical results. In addition, efforts were made to relate the practical experiences of the stakeholders with the key findings through an overview of the existing Smart City projects and programmes. Figure 6.10 presents the screenshot of the main themes from Nvivo version 11–Pro software.

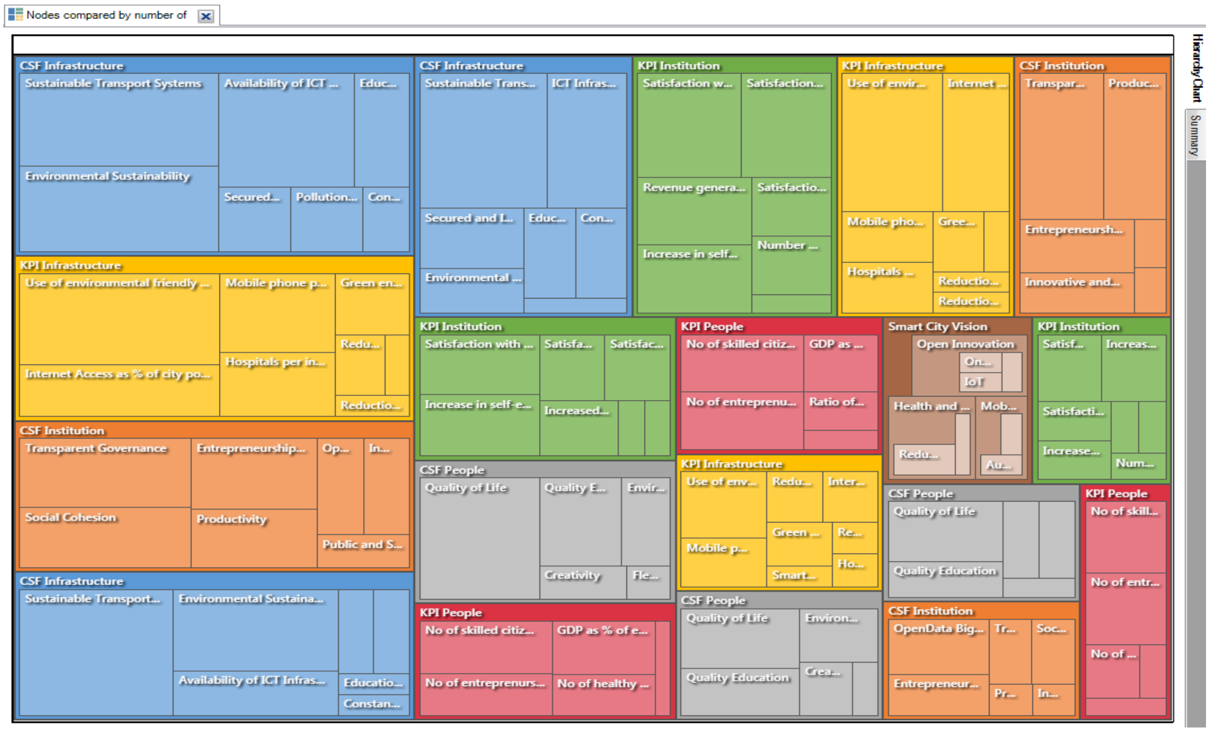


Figure 6-10: Hierarchical Tree Representation of the Theme from Nvivo Software

The arrangement in the hierarchical structure from Nvivo does not necessarily follow any predetermined order in relating the themes to the nodes and their sub-nodes. Notwithstanding, the area or size of the themes represented are directly proportional to the references made as factors of the subject under study. Again, the arrangement of the hierarchical structure of themes from Nvivo may differ slightly from case to case based on pattern of responses in the interviews but the main unit of analysis is uniform across the three cases investigated. Detailed analysis of the significant differences will be explored further under the cross case analysis.

6.4.1 Smart City Perception and Stakeholders Understanding

This section presents the assessment of stakeholders' perceptions and understandings of the Smart City concept in order to relate their views to the ongoing innovations in the cities investigated. Building on the literature findings, the section further explores the comprehensive responses received during stakeholders interviews. In CASE-1 for instance, SLB summarised the Smart City innovation thus:

> (…) Smart City is an evolution of cities merging the physical urban infrastructure realities (the atoms and bits) with the digital realities of cities that enable societies to transform better. It is important to note however that manifestation of technology in cities will not be the same from one city to the other. Thus, technology companies

> selling Smart City solutions as if they are standardized solutions will definitely not get it right across context. This is imperative as Smart City solutions that work well in Mexico City for instance may not work in a city in Nigeria or another city in Asia. In addition, sense of a city in terms of culture and social issues are more important than technology innovation in Smart City deployment for creating the better digital layers of the city [SLB]. Similarly, By Smart City it simply means that we are evolving by connecting the dots between technologies, more efficient approaches, and maximizing multiple benefits of whatever we are doing by ensuring that our initiatives are not in silos such that more people will benefit from them. Many stakeholders tend to focus on technology component but it is important to highlight that there are a number of foundational issues in a process towards building a resilience or smart city.

Most of the stakeholders in Boston held similar views and perceptions on what the concept of Smart City meant for the city; however, UMB disagreed by explaining that a:

> (…) Smart City meant different things to different stakeholders but to us, it is about social equity. We are using Smart City and Internet of Things (IoT) solutions to achieve increased efficiency in providing services to the people.

The views expressed by UMB confirmed the ongoing debate on Smart City definitions and the perception from different stakeholders expressed in literature review.

Furthermore, there was a consensus on the need to adopt smart strategies in addressing cities' challenges among the stakeholders in Boston. While responding to the question of 'why Smart Cities' and 'how will the concept of Smart Cities will help in addressing development challenges', SLB suggests that a:

> (…) Smart City idea can help in addressing urban development challenges but it is important to note that the issue of technological determinism need to be addressed because as cities evolve, so the technologies keep changing the lives of the societies both for good and for the bad. The evolution is similar to the development in automobile that even though automobiles are major cause of environment damages and risks in the cities, its benefits have transform the cities across the globe especially in terms of profile changes. In the same manner, technologies that highly permeate over time with high capacity to accelerate changes could be the major sources of pollution and other environmental risks. The question therefore is how we consider the benefits and think more of the imagination and appropriation (cost go lower) of these technologies [SLB];

In comparison, UFB states that;

> As a matter of priority, stakeholder engagement is needed in deploying smart apps for creating the better sense of the market. Then Smart City solutions can be deployed to

> manage the challenges in energy sector i.e. connecting Smart City solutions to Smart Grid, Smart Solar, wind and other renewable energy sources to decentralize the energy system that will allow a city to distribute energy infrastructure in a decentralized manner. Thus, Smart City innovation is needed in energy sector to identify better strategies of banking (storing) energy in automobiles. For instance, the concept of storing energy in automobile is already being experimented in Netherland while an example of Social Smart City is already ongoing in Naivasha, Kenya enabling people in the informal sector to bank and save money through a Safari related initiative [UFB].

Furthermore, MOB cautioned: “we need to make sure that efforts to make cities smarter does not create more gaps in terms of access to opportunities. In this regard, policy makers must at all times emphasise the need for equity by closing gaps between the privileged and less privileged citizens”. Others, such as SCB, imagined that the Smart City concept could be used to increase social interaction amongst citizens as well as improve the efficiency of city services. The position was supported by MSB, who believed that a Smart City could improve a number of city based elements; for example, technology can be used to improve efficiency, address security issues and improve economic development in cities.

In CASE-2, the stakeholders with similar backgrounds held similar views on their perception and understanding of the Smart City concept; this was especially notable amongst interviewees involved in urban planning and administration. For example, FNA stated that:, “(…) to me, [a] Smart City is about the use of new technologies that will enable cities to improve their performance and enhancing quality of life for the people.” Similarly, FCA agreed that;

> [The] Smart City concept is a new revolution seeking to improve productivity across every sector of the city … the concept of [the] Smart City is needed to address [the] mobility challenges of Abuja city, reduce crime and criminality associated with transportation, increase productivity, and improve liveability of the city.

In comparison, WCA was of the view that a Smart City embraces the use of Smart Solutions, which take advantage of technology, data and information to improve services and infrastructure management. WCA believed that a smarter FTCA would improve environmental sustainability, and mobility in the city by easing its associated pressures and challenges. Moreover, WCA believed it would reduce crime, enforce justice, and improve the city’s prospects for sustainable economic development through increased revenue generation. From a similar perspective, SCA perceived that a Smart City, as a means to deploy sensors for Smart Parking and traffic management solutions, enhanced some aspects of the Abuja transport systems and enabled a better integration of its services for improved revenue generation, cost savings, and job creation.

In CASE-3, the stakeholders were of the view that a Smart City concerns innovation because technology alone could not solve the problems of cities but could facilitate the development of solutions to problems.

> (…) Smart City stakeholders in Manchester are concerned on how to deal with challenges from how people get into the city, environment, and mobility generally. One of the big problems we face in the city is the capacity of transport infrastructure e.g. parking within the city, climate change, carbon neutral environment, aging population, etc. If you ask many people, they don't know what Smart City is. For instance, I asked a colleague what is your understanding of Smart City? He simply told me 'just give me the right information when I need it' and that is his own view about Smart City. Smart City may be tech-led, but the idea is to de-risk innovation. Our colleagues who are very much enlightened are saying 'we need to change and Smart is the answer' but how? [CCM].

A key industry individual held similar views that a Smart City did not necessarily mean a technology-enabled city. Rather, it concerned whether technologies (used appropriately) could help people in their daily activities. This meant ensuring that technological innovation for cities were social. ODM stated that "(…) that cities evolve organically (that way, technologies must address people's needs), they are chaotic, and merciless in nature. In that regard, the resilience of cities means that things can be aided through technology". Similarly, TFM admitted that a Smart City is a city that works for its citizens i.e. it makes its citizens happy.

A senior manager who emphasised the need to deploy a smart infrastructure to enable cities to espond adequately to local, national, and international challenges stressed that the "(…) Smart City concept is about doing things together in more intelligent ways" [IPM]. Meanwhile, CHM agreed with this position but also noted that, "Smart Cities is about modern infrastructure and integrated services, i.e. [a] Smart City is more around bringing things together different elements of communities and institutions."

The need to focus on innovation and the way in which to deploy new technologies to improve the experiences of the people around the city was emphasised among the key participants in CASE-3.

6.4.2 Smart City Core Components and the Degree of Emphasis

Building on the results of the pilot study, discussed in Chapter 5, this section further analyses the different dimensions of Smart City innovation to assess stakeholders' priority components in order to understand the different perspectives within different city regions. In addition, the analysis compared the different perspectives within the dimensions identified from the literature in order to streamline them to a manageable level. Tables 6.8, 6.9, and 6.10 show the breakdown of participants' references to the specific components of Smart Cities. The question about the Smart City core component was posed to solicit suggestions from interviewees with regard to the priority areas of their Smart City initiatives, and in order to assess the focus of various projects and programmes. Specifically, Table 6.8 summarises the list of components identified by respondents in CASE-1 as important components of their Smart City innovations. The components and characteristics of Smart Cities are discussed in Conceptual Framework section later in this chapter.

Table 6.8 shows that four dominant themes were referenced by the stakeholders, which included the following components: people, infrastructure, institution, and health. It is significant to note that the Smart Living component commonly referenced in the literature as one of the six Smart City wheels was not a priority amongst these stakeholders. Similarly, water, sanitation and energy were rarely mentioned as priority themes in their Smart City initiatives. The findings of this study, however, reveal the need to streamline the focus in view of the realities on the ground in order to bridge the gap between theory and practice.

In addition to highlighting the priority areas and Smart City components, some participants made valuable comments in support of their Smart City focus and vision. For instance, for the people component interviewees offered comments, such as: "(..) it is important to note that our Smart City philosophy is people centered. So for government, all innovation should be social innovation" [UMB] and;

> The efforts towards Smart Boston is not necessarily about prioritizing but the transport sector is currently the focus in the Smart City initiative because of the large number of people coming to work in Boston and the extremely large academic community within the city. So if you ask me, it is people first. It is important keeping the people at the core of our Smart City initiatives" [MOB].

Table 6.8: Smart City Core Components and the Degree of Emphasis in CASE-1

Component	**Sources**	**References**	**Percentages (%)**
Education Component	2	3	3.03
Energy Component	1	2	2.03
Environment Component	6	7	7.07
Governance Component	3	4	4.04
Health Component	6	10	10.1
Infrastructure Component	8	21	21.21
Institution Component	6	14	14.14
Living Component	1	1	1.01
People Component	9	36	36.36
Water & Sanitation Component	1	1	1.01
Total	**43**	**99**	**100**

In CASE-2, the interviewees responded to the same question on Smart City components, stating the priorities and state the vision of their Smart City initiative. The breakdown of the references to particular components are shown in Table 6.9.

Table 6.9: Smart City Core Components and the Degree of Emphasis in CASE-2

Component	**Sources**	**References**	**Percentages (%)**
Education Component	2	3	3.26
Energy Component	2	2	2.17
Environmental Component	5	15	16.3
Governance Component	3	4	4.35
Health Component	3	5	5.43
Infrastructure Component	7	23	25
Institution Component	7	17	18.48
Living Component	3	4	4.35
People Component	7	19	20.65
Water & Sanitation Component	0	0	0
Total	**39**	**92**	**100**

It was observed that the CASE-2 stakeholders were more concerned with the infrastructure component, which had the highest reference at 25%. In contrast, infrastructure was not one of the six Smart City wheels commonly referenced in the literature. Therefore, these views will be further analysed in this study to establish the factors that influence place-based innovation on stakeholder priorities with respect to Smart City innovation. The response also shows that about 21% of the references concerned the people component, with another 18.48% references relating to the institution component. Furthermore, 16.3% of the references concerned the environment. Very few references were made to the education component while water and sanitation were not referenced at all and thus not seen as important components amongst CASE-2 stakeholders.

In CASE-3, views expressed by participants were similar to those of CASE-1 in terms of their pattern of innovation. Specifically, with respect to the Smart City core components, there seems to be significant emphasis on people, which was mentioned by all interviewees (stakeholders in CASE-3). Drawing from interviewees' responses to the interview questions and the subsequent emphasis, most Smart City innovation revolves around people.

Table 6.10: Smart City Core Components and the Degree of Emphasis in CASE-3

Component	Sources	References	Percentages (%)
Education Component	1	1	1.09
Energy Component	2	3	3.26
Environmental Component	4	10	10.87
Governance Component	3	5	5.43
Health Component	2	4	4.35
Infrastructure Component	5	18	19.57
Institution Component	5	19	20.65
Living Component	0	0	0
People Component	5	31	33.7
Water & Sanitation Component	1	1	1.09
Total	**28**	**92**	**100**

As shown in Table 6.10, a high level of emphasis was placed on the people component (33.7%), whilst the institution and infrastructure components represented 20.65% and 19.57%, respectively. Compared with other components, the environment was also referenced frequently, at 10.87%; however, less emphasis was placed on governance (5.43%), health (4.35%), and energy (3.26%). Similarly, education (1.09%), and water and sanitation (1.09%) were not priority components amongst these stakeholders. Interestingly, the 'Smart Living' component, which was among the six Smart City wheels emphasised in the literature, was not emphasised in this case.

6.5 Smart City Key Performance Indicators KPIs

The theme of Smart City KPIs was also regularly noted by the interviewees across all cases with some degree of agreement on the need to measure Smart City impacts. While some interviewees tended to suggest the benchmarking of cities based on existing frameworks, others were of the view that, since cities develop organically and in different conditions, it is important for each city to develop their own KPIs for performance measurement, which may not be the same ‘across the board’. For instance, CCM noted that there were very few framework standards for measuring Smart Cities due to the maturity level of the concept, but that the region could rely on the British Standard for Smart Cities. He further revealed that, through its CityVerve instrument, CASE-3 was already developing a set of Smart City KPIs for an impact assessment around transport infrastructure, health, and the environment. Similarly, CASE-1 was also developing hybrid Smart City KPIs through the instrument developed by the Local Sense Laboratory. The analysis of the KPIs was further broken down into core factors, usually referred to as critical success factors, and the core indicators. As established in the literature, some indicators were classified as core indicators while others were classified as supporting indicators (see, for instance, ISO 17320). The core indicators used in this study were strictly based on the factors and indicators emphasised by the interviewees.

6.5.1 Smart City Critical Success Factors CSFs and the Degree of Emphasis

This section discusses the degree of emphasis placed on the Smart City factors. Firstly, through the information obtained from the interviews, an attempt has been made in the review and analysis of the Critical Success Factors to assess the degree of emphasis on the core factors across the three cases investigated. Secondly, each case study was analysed to identify the different ways in which the stakeholders considered the relevance of the identified factors for Smart City KPIs; this was in accordance with the core components of Smart Infrastructure, Smart Institution, and the Smart People. Thirdly, a cross case analysis of the factors was conducted to compare the level of agreement. Since the focus of the analysis is to identify the core factors based on the emphasis across the cases, the consolidated tables generated from the three cases were presented and discussed. However, the case-by-case analysis was also tabulated and attached as Appendix E. Tables 6.11 to 6.13 present summaries of the interviewee responses.

6.5.1.1 Core Factors of Smart Infrastructure

The outcome of the experts' interviews revealed varying degrees of emphasis regarding the core factors of Smart Infrastructure. Based on the level of emphasis, sustainable transport systems seemed to attract the attention of most Smart City stakeholders. In CASE-1, for instance, sustainable transport systems, with 26.67% references, was highly emphasised by interviewees; this was followed by environmental sustainability with 24.44% of the references. Also, the availability of an ICT infrastructure was emphasised in CASE-1, whilst the need for educational facilities (at 8.89%), a constant power supply (at 6.67%), and pollution control (at 6.67%) were also highlighted as core factors of a Smart Infrastructure. In comparison, secured and innovative technologies had the fewest references (at 4.44%) and thus represent the lowest priority based amongst the stakeholders in CASE-1 (see Table 2a in Appendix E for the individual analysis).

Similarly, in CASE-2, sustainable transport systems (at 34.38%) was frequently referenced and thus considered a critical success factor for Smart Infrastructure. This was followed by environmental sustainability, with 21.88% of the references, whilst a constant power supply (12.5%) was highly emphasised in CASE-2. Interestingly, the availability of ICT infrastructure (9.38%), educational facilities (9.38%), and secured and innovative technologies (9.38%) received equal attention amongst CASE-2 stakeholders. Surprisingly, the factor of pollution control (3.13%) that tends to be a serious concern amongst Smart City policy makers was the lowest priority amongst CASE-2 interviewees (see Table 2b in Appendix E for the individual analysis).

The results for CASE-3 were similar to those for CASE-1, where sustainable transport systems (at 39.39%) was frequently referenced by interviewees. This was followed by environmental sustainability at 27.27%. However, secured and innovative technologies and educational facilities had the fewest references at 3.08% and thus represented the lowest priority amongst the CASE-3 stakeholders. Also, the availability of ICT infrastructure was frequently emphasised in CASE-3, whilst the need for educational facilities (at 8.89%), a constant power supply (at 6.67%), and pollution control (at 6.67%) were also highlighted as core factors of a Smart Infrastructure (see Table 2c in Appendix E for the individual analysis).

The results from these cases suggest that seven factors were referenced as essential to Smart City innovation within the Smart Infrastructure component. Although the degree of emphasis differed slightly across the individual cases, there was a significant level of consensus on a number of factors, namely sustainable transport systems, environmental sustainability, and the availability of ICT infrastructure, which were also established in the literature. However, where CASE-1 identified secured and innovative technologies as less important, CASE-2 indicated that pollution control was the least significant factor for their Smart City innovation. Meanwhile, CASE-3 results indicated that secured and innovative technologies and educational facilities were less critical to their Smart City innovation (see Table 6.11 and Figure 6.11).

Table 6.11: Summary of Emphasis on the Core Factors of Smart Infrastructure

	CASE-1		**CASE-2**		**CASE-3**	
Factor	**Reference**	**%**	**Reference**	**%**	**Reference**	**%**
Availability of ICT Infrastructure	10	22.22	3	9.38	5	15.15
Secured and Innovative Technologies	2	4.44	3	9.38	1	3.03
Educational Facilities	4	8.89	3	9.38	1	3.03
Environmental Sustainability	11	24.44	7	21.88	9	27.27
Pollution Control	3	6.67	1	3.13	2	6.06
Constant Power Supply	3	6.67	4	12.5	2	6.06
Sustainable Transport Systems	12	26.67	11	34.38	13	39.39
Total	**45**	100	**32**	**100**	**33**	**100**

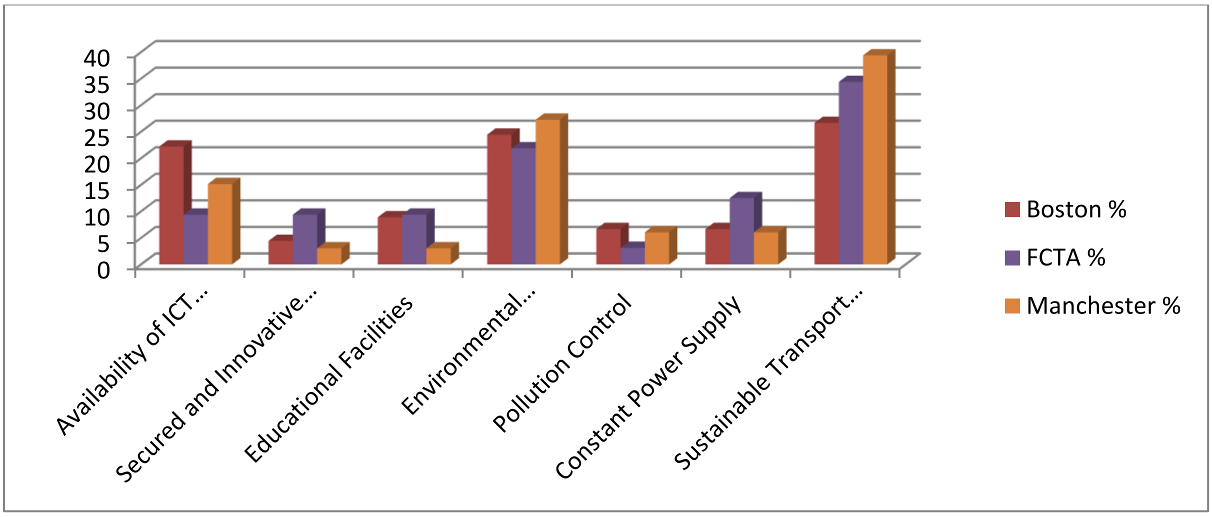


Figure 6-11: Summary of Emphasis on the Core Factors of Smart Infrastructure

It is important to note, however, that a number of factors established in the literature were not mentioned nor emphasised by the stakeholders interviewed across the cases. These factors included: a sustainable public water supply, individual safety, and an attractive natural environment.

6.5.1.2 Core Factors of Smart Institution

With respect to Smart Institutions, there seemed to be more emphasis amongst interviewees across the cases on transparent governance, productivity, and entrepreneurship and sustainable development. In CASE-1, for instance, transparent governance (23.53%), social cohesion (20.59%), and entrepreneurship and sustainable development (17.65%) were frequently cited as critical success factors of a Smart Institution. Furthermore, CASE-1 also emphasised productivity (14.71%), Open Data/Big Data (8.82%) and innovative and productive systems (8.82). However, among these stakeholders, less emphasis was placed on public and social services (5.88%) as a core factor of a Smart Institution. Table 3a in Appendix E for the individual analysis.

In CASE-2, transparent governance (34.78%), productivity (26.09%), and entrepreneurship and sustainable development (17.65%) were frequently cited as critical success factors of a Smart Institution. In addition, CASE-2 participants also emphasised innovative and productive systems (13.04) but placed less importance on Open Data/Big Data (4.35%) and on public and social services (4.35%). Interestingly, social cohesion (0%) was not emphasised as core factor of a Smart Institution among these stakeholders. Table 3b in Appendix E for the individual analysis of the factors. Similarly, CASE-3 placed equal emphasis on the factor of transparent governance (23.81%) and productivity (23.81%), which was followed by Open Data/ Big Data (19.05%) and entrepreneurship and sustainable development (19.05%). The emphasis on social cohesion (9.52%) was also high amongst these stakeholders. However, these stakeholders indicated that public and social services were not seen as an important Smart Institution factor (See Table 3c in Appendix E for the individual analysis).

The results suggested that seven factors were referenced as essential to the Smart Institution component of Smart City innovation. Again, the degree of emphasis differed slightly in individual cases; there was a significant level of consensus on a number of factors, namely transparent governance, productivity, and entrepreneurship and sustainable development as critical factors of the Smart Institution component. However, where CASE-1 portrayed the factor of social cohesion as critical, CASE-2 did not consider social cohesion at all. Similarly, CASE-3 made no reference to public and social services as a critical factor in their Smart City innovation (see Table 6.12 and Figure 6.12).

Table 6.12: Summary of Emphasis on the Core Factors of Smart Institution

Factor	CASE-1		CASE-2		CASE-3	
	Reference	**%**	**Reference**	**%**	**Reference**	**%**
Entrepreneurship and Sustainable Dev	6	17.65	4	17.39	4	19.05
Innovative and Proactive Systems	3	8.82	3	13.04	1	4.76
OpenData BigData	3	8.82	1	4.35	4	19.05
Productivity	5	14.71	6	26.09	5	23.81
Public and Social Services	2	5.88	1	4.35	0	0
Social Cohesion	7	20.59	0	0	2	9.52
Transparent Governance	8	23.53	8	34.78	5	23.81
Total	**34**	**100**	**23**	**100**	**21**	**100**

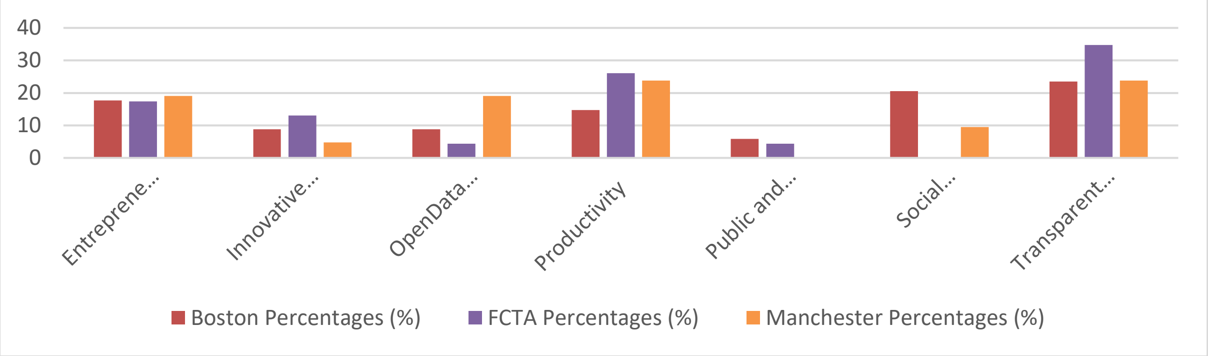


Figure 6-12: Summary of Emphasis on the Core Factors of Smart Institution

Based on the results of the interview analysis, it is important to note that a number of factors established in literature were not mentioned by stakeholders across the cases. These factors included: participation in decision-making, tourist attractions, flexibility of the labour market, and secured service delivery systems.

6.5.1.3 Core Factors of Smart People

In relation to Smart People, there seemed to be more emphasis on the quality of life factor across all the cases. In CASE-1, for instance, quality of life (33.33%) was portrayed as the most important factor of Smart People in a Smart City. Furthermore, quality education (26.67%), an environment that supports productivity (20%), and creativity (13.33%) were also emphasised. However, among these stakeholders less emphasis was placed on flexibility (6.67%) as a core factor of Smart People. Table 4a in Appendix E for the individual analysis.

In CASE-2, the pattern of emphasis was similar with both quality of life (47.62%) and quality education (23.81%) highly emphasised as critical success factors for assessing Smart People. Considerable emphasis was also placed on an environment that supports productivity (14.29%) and creativity (9.52%). As indicated in table 6.13, flexibility was also least emphasised in CASE-2 (Table 4b in Appendix E for the individual analysis). In CASE-3, the outcome was similar, where quality of life (38.46%) was the factor most emphasised followed by quality education (23.08%). However, creativity (15.38%) and an environment that supported productivity (15.38%) were perceived as equally significant among the participants in CASE-3. Incidentally, the factor of flexibility was also the factor least emphasised by these participants (See Table 4c Table 4b in Appendix E for the individual analysis).

Across all cases, the result suggests that five factors were referenced as essential to the Smart People component of a Smart City. Contrary to the analysis of the Smart Infrastructure and Smart Institution, the degrees of emphasis under Smart People was similar across the cases, demonstrating a strong consensus. For instance, quality of life was highly emphasised across all cases as the most critical factor for Smart People, and this was followed by quality education and productivity. Across the three cases investigated, there was consensus on the factor of flexibility as the least significant factor of the Smart People component (see Table 6.13 and Figure 6.13).

Table 6.13: Summary of Emphasis on the Core Factors of Smart People

	CASE-1		CASE-2		CASE-3	
Factor	**Reference**	**%**	**Reference**	**%**	**Reference**	**%**
Creativity	2	13.33	2	9.52	2	15.38
Environment that Support Productivity	3	20	3	14.29	2	15.38
Flexibility	1	6.67	1	4.76	1	7.69
Quality Education	4	26.67	5	23.81	3	23.08
Quality of Life	5	33.33	10	47.62	5	38.46
Total	**15**	**100**	**21**	**100**	**13**	**100**

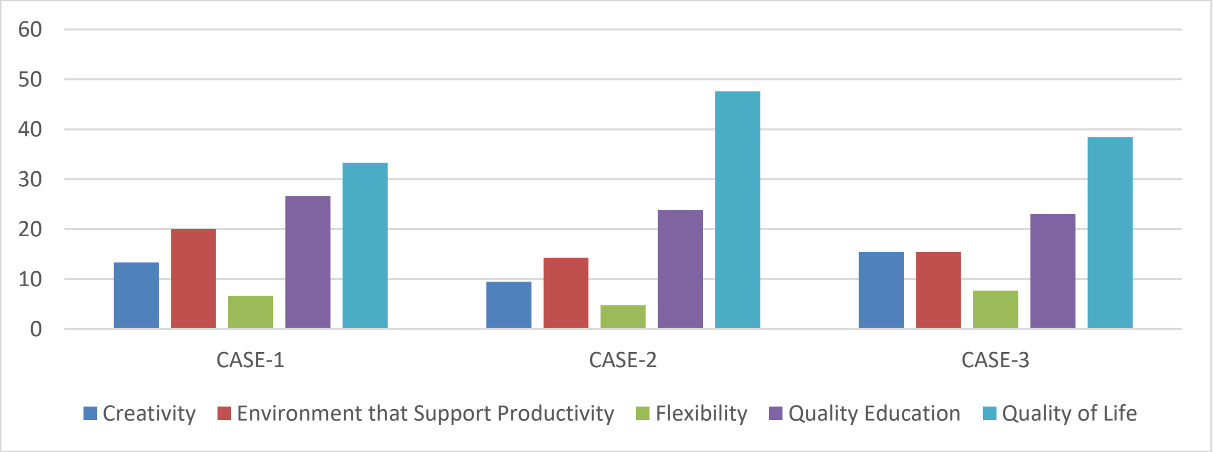


Figure 6-13: Summary of Emphasis on the Core Factors of Smart People

It is also important to note that a number of factors established in literature as critical factors of Smart People, namely unity, social awareness, and participation in public life, were not mentioned by any stakeholders across the cases.

In most cases, some of the factors were captured as suggestions and possible benefits as well as deliverables of a Smart City to its communities; this reflected some of the project objectives. Some of the interviewees also took the opportunity to highlight drivers of their Smart City initiatives while others identified city challenges which they intended to address through Smart City solutions. The latter concerned how a smart innovation could generally address development challenges in their city. A number of participants referred to the same issues discussed as Smart City critical success factors without mentioning the specific problems of their city, which they intended to address through Smart City solutions. In comparison, others took the opportunity to highlight some of the salient issues in need of Smart City innovation in their key sectors.

In particular, CASE-2 emphasised security as one of the major challenges identified by interviewees that was to be addressed through their Smart Mobility initiative. Participants raised concerns, such as:

> (…) we need [a] Smart City to address some issues in critical sectors like transport and security. It is important to note that the transport sector in FCT is run primitively without control, giving rise to incidences of crime around the city e.g. **'One-chance';** The Smart City concept will help to reduce crime by unregistered transporters who take advantage of unregulated systems in the transport sector to commit crimes [FCA].

Moreover, WCA agreed with FCA's view but placed greater emphasis on identity management and made comments such as: "Identity Management i.e. Citizen Identity and Asset Identity with unique identification for vehicles, houses, farms, and businesses are serious challenges that FCTA Smart City initiative must address as a matter of priority." In addition, they emphasised the need to generate revenue and create jobs through their Smart City initiatives.

6.5.2 Smart City Core Indicators and the Degree of Emphasis

This section reports on the indicators identified as possible metrics for assessing the Smartness of cities. The question about key indicators was posed as part of a section on Smart City visions and success factors across the cases investigated. Similar to the CSF analysis, the discussion was based on the core components of Smart Infrastructure, Smart Institution, and Smart People. Firstly, through the information obtained from experts' interviews, an attempt was made to assess the degree of emphasis on the core indicators of Smart Cities across the three cases investigated. Secondly, each case study was analysed to identify the ways in which the stakeholders considered the relevance of the indicators for Smart City KPIs. Thirdly, a cross case analysis of the indicators was carried out to compare the level of agreement. Again, since the focus of the analysis is to identify the core indicators based on the emphasis across the cases, the consolidated tables generated from the three cases were presented and discussed while the case-by-case analysis was tabulated and attached as Appendix E. Tables 6.14 to 6.16 present the summaries of the responses from the interviewees.

6.5.2.1 Core Indicators of Smart Infrastructure

The outcome of the interviews revealed varying degrees of emphasis regarding Smart Infrastructure as a core indicator. Across the cases, the need to assess the use of environmentally friendly vehicles seemed to attract the attention of most Smart City stakeholders. As shown in Table 6.14 and based on the Nvivo analysis, the pattern of responses by CASE-1interviewees indicated that the use of environmentally friendly vehicles (25%) was a major concern. The other indicators of Smart Infrastructure that were popularly referenced during the stakeholder interviews were: mobile phone penetration as a percentage of the city population (18.75%), green energy sources (12.5%), internet access as a percentage of the city population (12.5%), and a reduction in noise pollution (12.5%). With varying degrees of importance, indicators concerning smart wheelchairs (6.25%), hospitals per inhabitant (6.25%), and a reduction in greenhouse gas emission (6.25%), were also highlighted (See Table 5a, Appendix E for the individual analysis of the indicators in CASE-1).

In CASE-2, the same thematic arrangement used for CASE-1 was adopted for the Nvivo analysis. The outcome also revealed that the use of environmental friendly vehicles (32.43%) was a priority indicator amongst the Smart City CASE-2 stakeholders, followed by internet access as a percentage of the city population (12.5%). The emphasis on internet access can be attributable to the fact that broadband, and the other physical infrastructures required for such a sustainable Smart City innovation, were insufficient in the city. This area will be explored further in the comparative analysis. The indicator for mobile phone penetration as a percentage of the city population (16.22%) was also emphasised amongst CASE-2 stakeholders. Moreover, other Smart Infrastructure indicators that were popularly referenced during the CASE-2 stakeholder interviews were: hospital per inhabitant (13.51%), green energy sources (8.11%), and a reduction in greenhouse gas emission (5.41%). However, indicators for smart wheelchairs (2.7%) and a reduction in noise pollution (2.7%) were the least emphasised in this case (See Table 5b, Appendix E for the individual analysis of indicators in CASE-2).

Similarly, the use of environmental friendly vehicles (34.62%) was highly emphasised as a priority indicator amongst the CASE-3 stakeholders; this was followed by internet access as a percentage of the city population (23.08%). The indicators around mobile phone penetration as a percentage of the city population (11.54%) and hospital per inhabitant (11.54%) were also emphasised amongst CASE-3 stakeholders. Furthermore, green energy sources (7.69%), a reduction in greenhouse gas emission (3.85%), a reduction in noise pollution (3.85%), and smart wheelchairs (3.85%) were similarly the least emphasised indicators in this case (see Table 5c, Appendix E for the individual analysis of indicators in CASE-3).

Based on the interview responses, the cross-case analysis of the results suggest that eight indicators were referenced as essential for assessing the Smart Infrastructure component. The results show there ws a significant level of consensus on a number of indicators, namely the use of environmental friendly vehicles, mobile phone penetration as a percentage of the city population, and internet access as a percentage of the city population were critical indicators of a Smart Infrastructure. Similarly, although the smart wheelchair was mentioned across the cases the result indicated that it was the least emphasised. Regarding the other four indicators mentioned during the interviews, the level of emphasis across the three cases differed significantly (see Table 6.14 and Figure 6.14).

Interestingly, a number of indicators emphasised as important in the literature were not mentioned in any of the cases; for example, an efficient transport network and transport systems per inhabitant. Moreover, the use of environmental friendly vehicles, improved air quality, and robotic mobile ambulances were mentioned when prompted to cite specific examples.

Table 6.14: Summary of the Emphasis on the Core Indicators of a Smart Infrastructure

Indicator	CASE-1		CASE-2		CASE-3	
	Reference	**%**	**Reference**	**%**	**Reference**	**%**
Green energy sources	2	12.5	3	8.11	2	7.69
Hospitals per inhabitant	1	6.25	5	13.51	3	11.54
Internet Access as % of city population	2	12.5	7	18.92	6	23.08
Mobile phone penetration as % of city population	3	18.75	6	16.22	3	11.54
Reduction in greenhouse gas emission	1	6.25	2	5.41	1	3.85
Reduction in Noise pollution	2	12.5	1	2.7	1	3.85
Smart Wheel Chair	1	6.25	1	2.7	1	3.85
Use of environmental friendly vehicles	4	25	12	32.43	9	34.62
Total	**16**	**100**	**37**	**100**	**26**	**100**

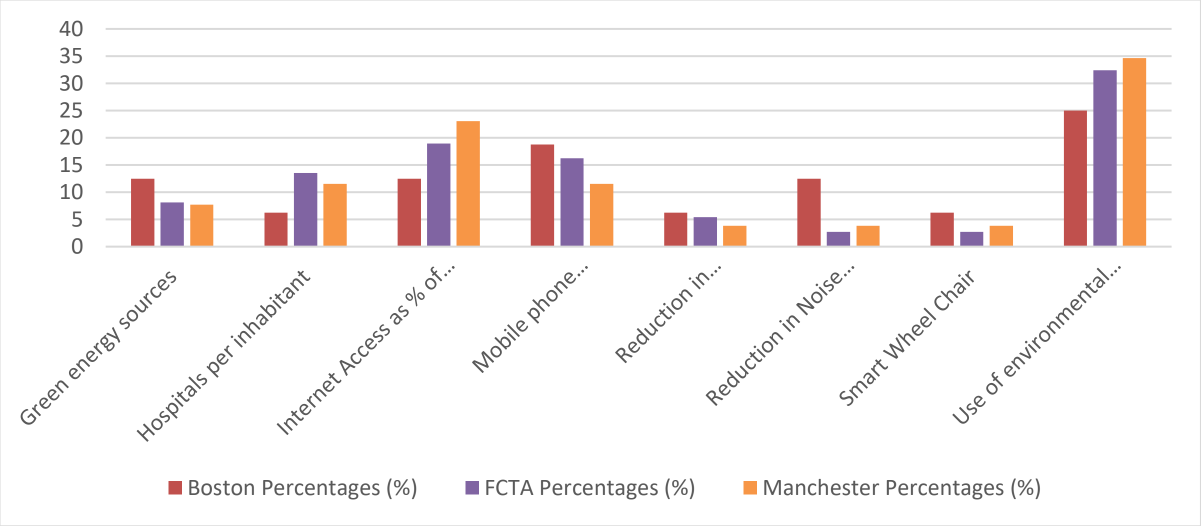


Figure 6-14: Summary of the Emphasis on the Core Indicators of a Smart Infrastructure

6.5.2.2 Core Indicators of Smart Institution

In relation to the core Smart Institution indicators, the degree of emphasis differed significantly between the cases. Although interviewees made reference to similar indicators, there were disparities in the references made to these indicators across the cases. For instance, indicators around the increased number of innovation hubs (23.08%) and satisfaction with the quality of schools and key public institutions (23.08%) were highly emphasised in CASE-1; this was followed by an increase in the self-employment rate (15.38%) and satisfaction with the quality of healthcare delivery (15.38%). As summarised in Table 6a, Appendix E, indicators around the amount (number) of crime profiled in real-time (7.67%), the revenue generated by tourism as a percentage of the total revenue (7.69%), and satisfaction with safety (of life and property) (7.69%) were the least emphasised in CASE-1.

In CASE-2, satisfaction with the quality of healthcare delivery (23.33%) was highly emphasised followed by satisfaction with the quality of schools and key public institutions (20%). The other indicators concerning an increase in the self-employment rate (16.67%), the revenue generated in tourism as a percentage of the total revenue (16.67%), the satisfaction with safety (of life and property) (10%), and the amount (number) of crime profiled in real-time (10%) were also perceived as important core indicators for assessing Smart Institution. The analysis shows that an increased number of innovation hubs (3.33%) was the least emphasised indicator in this case (see Table 6b, Appendix E for the individual analysis of indicators). In contrast, CASE-3 participants emphasised an increase in the self-employment rate (23.81%) and satisfaction with the quality of healthcare delivery (23.81%), an increased number of innovation hubs (14.29%), satisfaction with the quality of schools and key public institutions (14.29%), and satisfaction with safety (of life and property) (14.29%). The amount (number) of crime profiled in real-time (4.76%) and revenue generated in tourism as a percentage of the total revenue (4.76%) were the least emphasised in CASE-3 (See Table 6c, Appendix E for the individual analysis of indicators).

Moreover, indicators around the increased number of innovation hubs (23.08%) and satisfaction with the quality of schools and key public institutions (23.08%) were highly emphasised in CASE-1 followed by an increase in the self-employment rate (15.38%) and satisfaction with the quality of healthcare delivery (15.38%). As summarised in Table 6.15 and Figure 6.15, the amount (number) of crime profiled in real-time (7.67%), revenue generated in tourism as a percentage of the total revenue (7.69%), and satisfaction with safety (of life and property) (7.69%) were the least emphasised.

Therefore, the cross-case analysis of the results suggest that seven indicators were referenced as essential for assessing the Smart Institution component. The result shows there is significant level of consensus on a number of indicators, namely an increase in the self-employment rate, satisfaction with quality of schools and key public institutions, and satisfaction with quality of healthcare delivery as critical indicators of Smart Institution. However, the level of emphasis differs significantly between the cases; for instance, CASE-1 made a significant number of references to the increased number of innovation hubs, which were seen as critical, whilst interviewees for CASE-2 were more concerned with the revenue generated from tourism as a percentage of the total revenue, and so on (see Table 6.15 and Figure 6.15).

Table 6.15: Summary of the Emphasis on the Core Indicators of Smart Institution

	CASE-1		CASE-2		CASE-3	
Indicator	**Reference**	**%**	**Reference**	**%**	**Reference**	**%**
Increase in self-employment rate	2	15.38	5	16.67	5	23.81
Increased number of innovation hubs	3	23.08	1	3.33	3	14.29
Number of crimes profiled in rea-time	1	7.69	3	10	1	4.76
Revenue generated in tourism as % of total revenue	1	7.69	5	16.67	1	4.76
Satisfaction with quality of healthcare delivery	2	15.38	7	23.33	5	23.81
Satisfaction with quality of schools and key public institutions	3	23.08	6	20	3	14.29
Satisfaction with safety of life and properties	1	7.69	3	10	3	14.29
Total	**13**	**100**	**30**	**100**	**21**	**100**

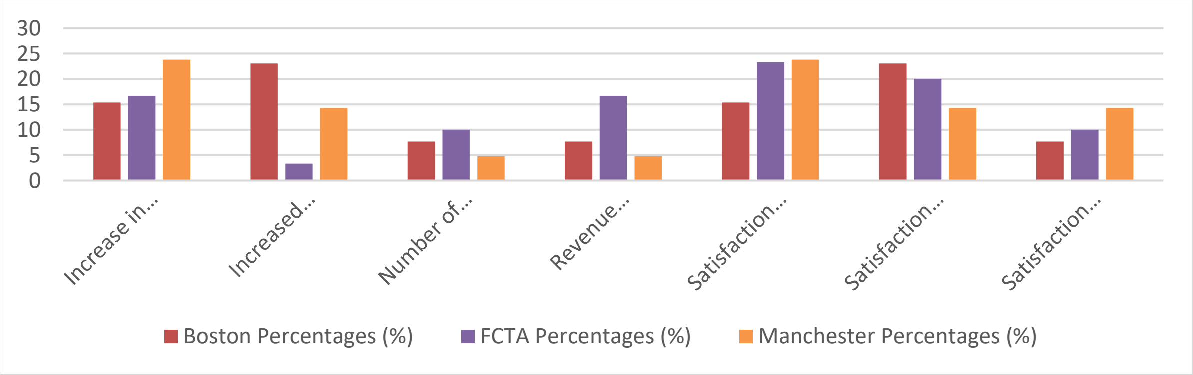


Figure 6-15: Summary of the Emphasis on the Core Indicators of Smart Institution

Again, it is important to note that the increased number of new registered businesses and number of visitors to tourist centres, which were emphasised as important indicators in the literature, were not mentioned in any of these cases.

6.5.2.3 Core Indicators of Smart People

Regarding Smart People, the importance of the number of entrepreneurs as a percentage of the city population and the number of skilled citizens as a percentage of the city population were emphasised across all cases. In CASE-1, the number of entrepreneurs as a percentage of the city population (33.33%) and the number of skilled citizens as a percentage of city population (33.33%) were highly emphasised; this was followed by the number of healthy citizens as a percentage of city population (16.67%). The analysis shown in Table 7a, Appendix E indicates less emphasis on the GDP as a percentage of the employed citizens in the city (8.33%) and the ratio of employed to unemployed citizens (8.33%).

Similarly in CASE-2, the number of entrepreneurs as a percentage of the city population (31.25%) and the number of skilled citizens as a percentage of city population (31.25%) were highly emphasised followed by the GDP as a percentage of employed citizens in the city (18.75%) and the ratio of employed to unemployed citizens (12.5%). Interestingly, the number of healthy citizens as a percentage of the city population (6.25%) was less emphasised in this case (See Table 7b Appendix E). In CASE-3, the number of skilled citizens as a percentage of the city population (29.41%) was highly emphasised, which was followed by the number of entrepreneurs as a percentage of the city population (23.53%) and the GDP as a percentage of employed citizens in the city (23.53%). The indicator for the number of healthy citizens as a percentage of the city population (17.65%) was also slightly emphasised, while ratio of employed to unemployed citizens (8.33%) was less emphasised (See also Table 7c Appendix E).

The cross cases analysis revealed that five indicators were referenced as essential for assessing the Smart People component. The result shows there is a significant level of consensus in a few areas, namely the number of skilled citizens as a percentage of the city population and the number of entrepreneurs as a percentage of the city population, which were perceived as critical indicators of Smart people. Interestingly, CASE-2 and 3 agreed on GDP as a percentage of employed citizens in the city, but this was not confirmed by the stakeholders in CASE-1. The level of emphasis also differs significantly with respect to the number of healthy citizens as a percnatge of the city population and the ratio of employed to unemployed citizens (see Table 6.16 and Figure 6.16).

Table 6.16: Summary of Emphasis on the Core Indicators of Smart People

Indicator	CASE-1		CASE-2		CASE-3	
	Reference	**%**	**Reference**	**%**	**Reference**	**%**
GDP as % of employed citizens in the city	1	8.33	3	18.75	4	23.53
No of entrepreneurs as % of city population	4	33.33	5	31.25	4	23.53
No of healthy citizens as % of city population	2	16.67	1	6.25	3	17.65
No of skilled citizen as % of city population	4	33.33	5	31.25	5	29.41
Ratio of employed to unemployed citizens	1	8.33	2	12.5	1	5.88
Total	**12**	**100**	**16**	**100**	**17**	**100**

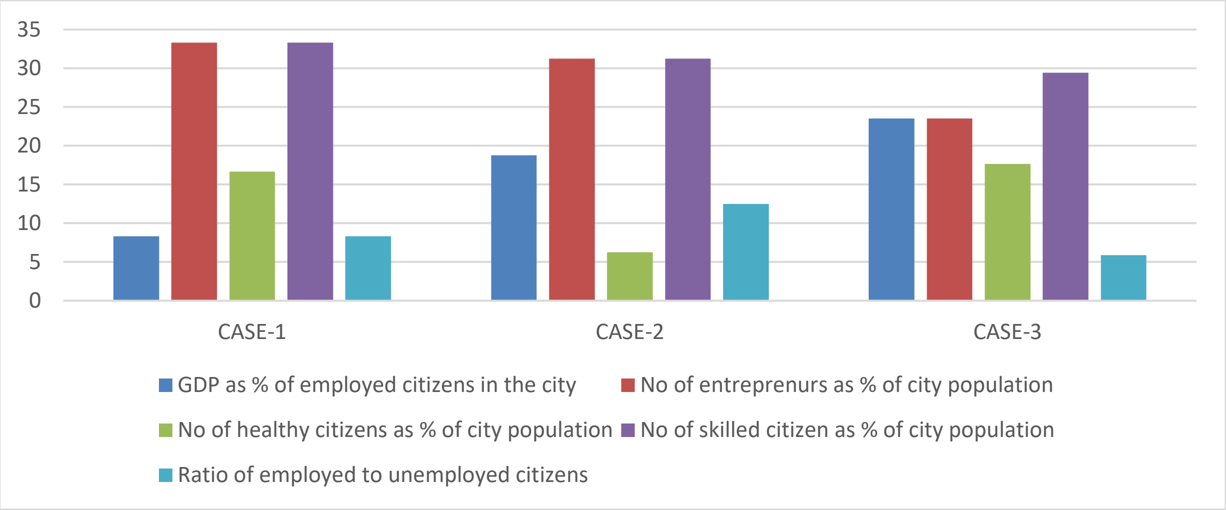


Figure 6-16: Summary of Emphasis on the Core Indicators of Smart People

Moreover, the percentage of educated citizens at a different level of education, which was emphasised in the literature as critical to the Smart People indicator was not mentioned across the three cases investigated. Instead, stakeholders were more concerned with the number of skilled citizens as a percentage of the city population.

In general, all the participants in CASE-1 agreed on the need to measure the social impacts of Smart Cities and in suggesting the areas to measure. They issued comments such as;

> (…) we can measure the impact of intelligent interception based on how it has reduced accident [SCB]. We can measure productivity of the people. In the same manner, measuring the impacts of cities should not be seen as abstract or standardised concept because different cities in different region may require different KPIs for measurement or (….) Smart City Success Factors should be city centric in line with the cultural and social values of the city (i.e. citizen based) as there is no standard Smart City KPIs anywhere. However, efficient service delivery/cost, social equity, quality of life of the citizens, environmental sustainability, productivity or entrepreneurial growth of the city can be used as key performance indicators.

In CASE-2 for instance, majority of the participants agreed on the need to measure both the social and economic impacts of Smart Cities as core factors. For instance, SCA posited that measuring the social and economic impacts was central to all innovation in the city, whilst FNA offered the following comment:

> (..) We are looking at measuring the impacts of Smart City initiatives through social and economic indicators and we shall develop a framework with key indicators of performance that will be evaluated periodically and (…) to measure performance we definitely need some metrics that take cognisance of our own environment in Abuja in terms of culture, social, and economic indicators. This is expected to be fashion out through the stakeholder engagement amongst the partners in both public and private sectors [FNA].

In CASE-3, identifying the Smart City KPIs to assess the impacts of the smartness of cities was considered the most important aspect of their initiatives. Therefore, measuring the performance of a Smart City could be tedious but benchmarking through peer review by using the basic factors and KPIs, the impacts of Smart Cities can be analysed.

6.6 Overview of Existing Smart City Projects and Programmes

This section further explores the practice-based experience of stakeholders to draw lessons from their challenges and opportunities as they relate to place-based innovation. The responses from participants reveal a series of Smart City innovations across critical sectors. For example, in CASE-1, a total of 14 relevant Smart City initiatives were mentioned during the stakeholders interviews. The initiatives cited cut across critical sectors, such as transportation, environment, education, health, and urban planning. To gather all relevant information relating to the project objective, the impacts and outcome of the initiatives are captured in Table 6.10a. In addition, information on funding sources, governance structure, stakeholders, services, and known challenges to these initiatives were highlighted. On the sources of funding, participants mentioned special funds and budgetary provision, for instance:

> (….) 'special funds'; "funding is through multinational partners and R&D" and "budgetary Provision and support from development partners. Similarly on implementation strategies, participants issued comments like (…) our strategy is to collaborate with stakeholders improve connectivity and promote open innovation for increasing access or (…) as part of our strategy, we study cities from critical point of view to understand the nature of radical changes while developing the tools to learn about them and (…) our key strategy is to identify innovation that are capable of addressing the challenges of the city [UMB].

A number of the Smart City initiatives mentioned by the interviewees were complete while others were ongoing (as outlined in Table 6.17).

Table 6.17: Summary of the Key Smart City Initiatives in Boston (CASE-1)

S/N	Project	Project Objective	Impacts/Outcome
1	Local Sense Lab	Hyperlocal data on how people live and sensor data to transform the cities, change businesses, and change lives	It is now serving as a test-bed for Smart City solutions.
2	OpenData Portal	To achieve value-addition for smart innovation	Creating more opportunities and economic value in real-time data for innovators.
3	Sharable City	To promote ride-sharing, similar to the Uber innovation.	Sensing vehicles for analysing drivers' behaviours and the urban environment, and Cityways for recreation.
4	Participatory China Town	Participatory Neighbourhood planning.	A participatory process of data collection for planning and policy development.
5	Boston Safest Driver	To monitor and track drivers' behaviours remotely in real-time.	Reduced road accidents.
6	Autonomous Vehicle	To improve safety on the roads, in the environment, and the access and sustainability of the city.	The project is being experimented as a testing phase.
7	Online Gaming	To educate people on climate change	It served as a platform for communication, education and social change approaches to raise climate change awareness among citizens.
8	City Ways	To understand the factors that influence outdoor activities amongst Bostonians, such as weather and urban morphology.	The platform serves self-tracking applications used by people to monitor how they exercise daily.
9	e-Trash	For the better tracking of waste movement, especially e-waste	Environmental sustainability and reduced pollution.
10	e-Health	Collaboration with innovators and State agencies to take advantage of emerging	With the aid of technology innovation, Boston healthcare systems has eliminated the issue of

		technologies for Big Data analytics and OpenHealth, by opening up health data.	repeated tests on patients because healthcare providers in Massachusetts now have unlimited access to patient health information.
11	Hybrid KPI for Smart City	A framework to measure the impacts of Smart City services with respect to the sensitivity of KPIs per project.	Still ongoing
12	Smart Traffic Light	To control traffic during rush hour	Traffic management.
13	Technology for Autism Now	A start-up dedicated to children living with autism, aimed at improving the quality of their lives at home, in school and in society.	Improving quality of life for children with special needs.

With respect to the known challenges, information was scant on the sources of challenges and how the challenges were mitigated. However, a few comments from participants point to a bureaucratic bottle-neck and the absence of a regulatory framework:

> (…) no regulatory powers over public transportation; our health sector is currently facing the challenges of building a cross-sector database that can support timely decision due to lack of synergy in the sector; (…) people in Boston neighbourhood are segregated and (…) for the concept of Smart City to help in addressing the challenges of cities, the experiences of the city need to be taken into account properly [MOB].

All the participants described the governance structure of their project as ‘bottom – up’ and gave positive comments on their Smart City impacts, such as:

> (…) Our Smart City is benefiting the people by closing the gaps between the privileged and less privileged citizens; (…) Citizens especially the innovators are already exploring the Boston’s Open Data initiative for informed decision-making. In addition, security Agencies are also using the initiatives for reducing crimes and drug abuse [MOB];

In particular, according to key stakeholders the health sector has recently grown to become a major contributor to the State’s GDP. Morrover, the productivity of Boston city is around the highest in America.

In CASE-2, the interviewees cited some Smart City related projects and programmes targeted at transforming the Federal Capital City (FCC) into a model Smart City region in Africa. Table 6.18 summarises the responses of the CASE-2 stakeholders and provides an overview of their Smart City initiatives. It is important to note, however, that some of the programmes cited by the interviewees were in existence prior to the current Smart City aspirations of FCTA. For instance, the Abuja Geographical Information System (AGIS) was set up about a decade before the Smart City era, but one of the participants in this study cited AGIS as the focal-point of the FCTA Smart City initiatives aimed at blocking revenue leakages.

Table 6.18: Summary of The Key Smart City Initiatives in FCTA (CASE-2)

S/N	Project	Project Objective	Impacts/Outcome
1	Abuja Centenary Smart City project	The idea is to create a better city with modern amenities where the experiences of people can be improved in terms of business, recreation and cultural values.	Ongoing.
2	Abuja Geographical Information Systems (AGIS) Initiative.	To provide a state-of-the-art digitised geo-spatial data infrastructure for FCTA.	A computerised work-flow system for land administration matters and a smart revenue generating system for FCTA.
3	Abuja Integrated Smart Transport Systems.	To develop an Integrated Transport System – namely a bus service system that can provide real-time bus location information to riders within the Abuja service area.	Ongoing.
4	Abuja Eco-city (First Nigeria's Eco-city) Initiative.	To develop in FCTA an efficient and environmentally-friendly community with the standard city infrastructure of a modern Smart City.	Ongoing (expected to create about one million jobs).
5	Abuja Smart Districts Initiative.	To introduce the model of PPP in the prudent-utilisation of city resources (part of the land-swap initiative) in FCTA.	Job creation, revenue generation, and the resettlement of displaced citizens.

Based on the insights provided by the participants, seven Smart City initiatives were mentioned during the stakeholder interviews in FCTA, but further investigation of the initiatives revealed that two of the projects (i.e. the e-Health solution and the Electronic School Systems by FCT-UBEB) were not part of Smart City initiatives of FCTA. The findings of this study further revealed that the sources of funding for most of the initiatives were through budgetary provision and multilateral donor agencies. The exceptions to this were Abuja Centenary City and the Abuja Eco-City initiatives; for instance, CCA claimed that:

> (…) the entire Centenary City project is a PPP arrangement involving both local and foreign institutions. It is expected to operate as a free-trade zone. In this arrangement, government's investment is mainly the space which means decisions on the project are strictly that of the private investors [CCA].

Similarly, the participants cited the inconsistency of government policies as major challenges that militate against the FCTA's Smart City development. FCA stated that a;

> Lack of political will is a big challenges (politicians come and go with indiscriminate projects and programmes without sustainability plan). Again, governance structure in FCDA generally can be very challenging especially in terms of regulatory process because FCTA has no State Assembly which means all our bills has to pass through the National Assembly where it is sometimes very difficult to get bills passed unlike States where governors can easily talk to speakers to get important bills passed into law easily; (…)

Moreover, SCA claimed that "a (…) lack of understanding of the Smart City concept especially amongst the top decision makers (i.e. leadership) is affecting the initiative negatively. Whilst CCA stated that " (…) the major challenge is bureaucratic delays of the process; (…) Presently the project is stalled due to investors fear in a direct reaction to change of leadership in Nigeria". Finally, WSA indicated that "I can say with full confidence that funding is not the issue but the political environment is the challenge of the project".

Regarding the impacts and outcomes of the cited project/programmes, the majority of the participants simply affirmed that the initiatives are still "*ongoing*" with positive results expected.

> (…) We are lucky to have a good transport policy in place since 2005. Further, the environmental impacts assessment on some of the initiatives revealed that expansion and modernisation of city infrastructures will affect a lot of people and businesses. Specifically, road network expansion, construction of Abuja Metro System for Light Rail Network, Re-introduction of Abuja Bus Rapid Transport System and a host of other projects will displace some communities as well as disrupting business activities along the routes [FCA].

In CASE-3, the move towards a Smart Manchester city commenced three decades ago with some initiatives, such as the "knowledge society framework" developed in 1990. Participants acknowledged that the strategies around smartness tends to be best when they come from urban strategies, which is needed for sustainability. Table 6.19 summarises the responses of the CASE-3 interviewees and provides an overview of the Smart City initiatives highlighted during the interviews.

Table 6.19: Summary of Key Smart City Initiatives in Manchester (CASE-3)

S/N	Project	Project Objective	Impacts/Outcome
1	CityVerve Internet of Things (IoT) and Smart City initiative (by Innovate UK).	The project idea is to build/deliver a smarter and more connected city of Manchester.	Ongoing – The project will deliver a platform for the management of chronic respiratory conditions, talkative bus stops, community wellness, smart lighting, bike sharing, and smart air-quality monitoring
2	The Triangulum Project (2015 to 2020 by H2020).	To transform students quarters into a Smart City district which includes the renovation of historical buildings and the generation of an autonomous energy grid for the entire district with heat and electricity.	Ongoing –The project will create jobs, improve cost effective energy systems, air quality, and increased mobility.
3	Manchester Synchronicity Initiative.	To deliver a Digital Single Market for Smart Cities to serve as a Single Digital City Market for the EU.	Ongoing.
4	SmartImpact Project.	A two-year project initiated to deliver local impacts from Smart City planning that focus mainly on governance issues, financing, and organisational issues.	Ongoing
5	The Greater Manchester Data Synchronisation Initiative.	To open up city data that can be shared among the relevant departments and innovators.	Prototyping concluded successfully in September 2017. The project helped TFGM in releasing data around the UK in 2010 (the first in the history of the UK).
6	Grow Green Initiative	To create a healthier urban environment in Manchester.	Ongoing – High-quality green spaces in communities.
7	CityMoves Project	To promote healthy living and the positive use of data/technology in healthcare for citizens.	The project was trialled between 23October 2017 and 21December 2017.
8	Air Quality Monitoring	To deliver real-time data on environmental pollution for timely decision-making.	Ongoing
9	Smart Parking initiative	To provide citizens with parking space tracking and availability in real-time based on their driving route.	Ongoing
10	Smart Traffic Monitoring	To leverage IoT technologies in monitoring traffic with a view to reducing pollution in order to enhance citizens' quality of life while making the city more sustainable.	Ongoing
11	Sensing Tram	To provide real-time tram information to passengers in order to improve their travel experience.	Ongoing

In CASE-3, a total of 11 Smart City initiatives were mentioned during the interviews. Based on the insights provided by the participants, the majority of projects are ongoing while some of the programmes were trialled successfully. For instance, the CityMoves initiative by Connected Health Cities, in collaboration with Nokia, ran successfully from 23rd October to 21st December 2017. In CASE-3, it can be said that there is good funding mechanism from both the government and development partners in the region. For instance, CityVerve and other key Smart City initiatives are fully funded by EU’s Horizon 2020 (H2020), Innovate UK, and the government. Confirming this position, TFM stated:

> (…) our Smart City initiative is funded through multilateral institutions like Innovate UK and the H2020 initiative of European Union. Although still at piloting stage but the initiative have attracted about Fifteen Million Great Britain Pounds Sterling (£15,000,000.00) so far.

Similarly, CHM revealed that their initiative is funded by a development partner: “our city project is funded by Department for Health. The project is got a lot of money.”

However, there were divergent views as to what constitutes challenges to stakeholders in CASE-3. While some emphasised the absence of a Smart City plan as a major challenge, other highlighted the issue of privacy and access to relevant information. In this regard, CHM stated that “(…) one of the major challenges is privacy and access to data. Another issue ‘is not knowing’ what other stakeholders are doing in the sector. Again, creating awareness to sensitise the general public is also a big challenge.” From the view point of an innovator however, ODM emphasised leadership as the major challenge of Smart City deployment in CASE-3.

In terms of the outcome of their Smart City project/programmes, the majority of interviewees agreed that tapping into the idea of Smart City innovation helps to create job opportunities and encourages entrepreneurial development. Confirming this position, TFM stated that, “(…) our efforts towards Smart City are built on Open Innovation and since we started, many start-ups especially in the technology sector have been setup. Recently, our unemployment rate has reduced significantly”. Agreeing with this statement, CCM stated;

> (…) our Smart City innovation is already impacting on the life of the people including city infrastructure. It is also creating jobs especially the sustainability programmes and economic growth initiatives. All of them have the end result of improving the quality of life for the people.

Therefore, in terms of environmental impacts, all participants agreed that thse would be positive.

6.7 Tracing the Relationship between Smart City Policy Efforts and Key Trend of Development Across Cases

The three case studies revealed different perspectives and approaches towards leveraging the Smart City concept to address the socio-economic development of cities. These findings encourage a critical engagement with Smart City deployment by closely examining the relationship between Smart City innovation and policy development; this includes an investigation into the realities on the ground in terms of infrastructure (e.g. Broadband), sustainable economic (GDP) growth, and budgetary provision for the realisation of the Smart City ambitions. These key issues are summarised under the following sub-headings.

6.7.1 Policy Dimension

In policy development, Boston has shown strong leadership envisioning a long-term strategy for Smart innovation through the GoBoston vision. GoBoston 2030 is a Smart City initiative that seeks to create and run a mobility innovation lab focusing mainly on the transport sector and integrating research, practice and entrepreneurship with specific targets and Smart goals to move the city towards zero deaths (accidents), zero injuries (safety on the roads), zero disparities (equity), and zero carbon emissions. GoBoston 2030 aims to achieve ambitious goals by aligning the city’s resources i.e. the people – through the Teaching Hospital for Transportation, the places – through the Radically programmable City, and things – through Data, in order to mobilise entrepreneurs, practitioners, and researchers to co-create a smarter Boston. The GoBoston initiative received commitment through the introduction of the new Urban Mechanics initiative and the IBM Smarter Cities challenge engagement (Agbali et al., 2017).

Similarly, Manchester City Council recently adopted a new digital strategy for smart growth to show the ways in which the city intends to deploy emerging technologies that will help in meeting the city’s objectives (Manchester City Council, 2018b). The new digital strategy articulated how the application of emerging technologies can promote civic innovation in order to make Manchester more ‘liveable’. It also emphasised the need for digital education and skills, digital infrastructure, digital public services for the city, and digital future-proofing for the city. In comparison, in FCTA a policy roll out to support Smart innovation is still very weak due to a bureaucratic bottleneck within and outside FCTA. For instance, according to a senior official interviewed the bill for the FCTA Smart City initiative under the integrated transport system for FCT, which was submitted in 2014, the initiative is yet to receive approval from the National Assembly.

6.7.2 Broadband Infrastructure Dimension

Broadband infrastructure is one of the basic requirements to help stimulate the transformation towards Smarter Cities (Komninos et al., 2013). Smart City services are accessed over a multitude of devices and platforms, including mobile technologies, TVs, and interactive urban spaces which require robust broadband access. Consequently, CASE-1 has invested heavily in broadband connectivity in both mobile and fixed networks to meet the demands of the city. The current global broadband average connection speed for Boston stands at 14.7Mbps/12.1Mbps (TestMy.net, 2018). In addition, CASE-1 is located in a region with a global average broadband provision of 27.39Mbps/8.78Mbps for mobiles and 84.66Mbps/29.88Mbps for fixed broadband network (Speedtest Global Index, 2018). Figure 6.17 and Table 6.20 show these figures in more detail for speed and development.

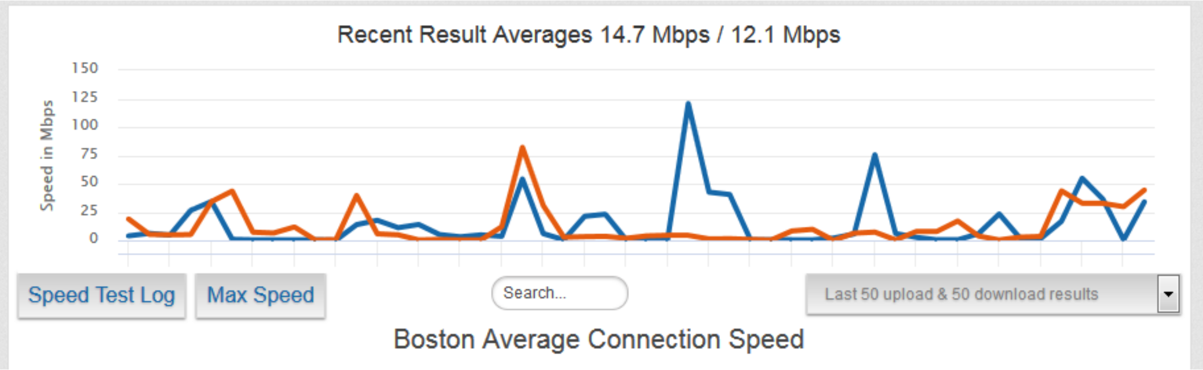


Figure 6-17: CASE-1 (Boston's) Average Broadband Connection Speed (TestMy.net, 2018)

In CASE-2, the current global average broadband average for the same period is fairly low compared to the standard for CASE-1 and CASE-3, especially with regards to upload speed. The average connection speed for CASE-2 stood at 17.6Mbps/2.6Mbps (TestMy.net, 2018). Again, CASE-2 is in a region with the lowest global average at 9.85Mbps/4.15Mbps for mobiles and 9.63Mbps/7.82Mbps for a fixed network (Speedtest Global Index, 2018). Figure 6.18 and Table 6.20 show more information regarding speeds and development.

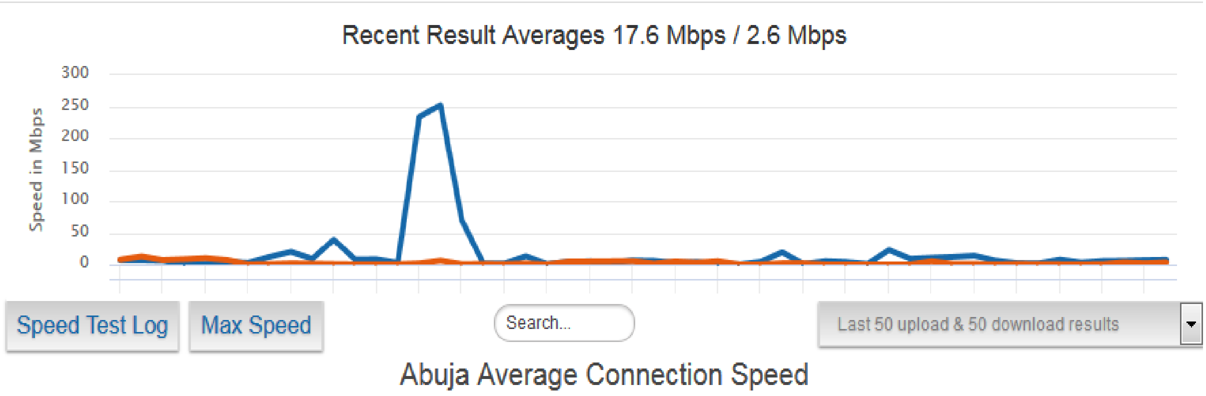


Figure 6-18: CASE-2 (FCTA's) Average Broadband Connection Speed (TestMy.net, 2018).

In CASE-3, the global average for the same period is above the two cases, especially in terms of download speed. The current average speed for CASE-3 stood at 59.5Mbps/9.1Mbps (TestMy.net, 2018). At the regional level, CASE-3 is in a region with a global average broadband provision at 26.80Mbps/10.80 for mobiles and 50.45Mbps/10.84Mbps for a fixed network (Speedtest Global Index, 2018). Figure 6.19 and Table 6.20 show further information on speeds and development.

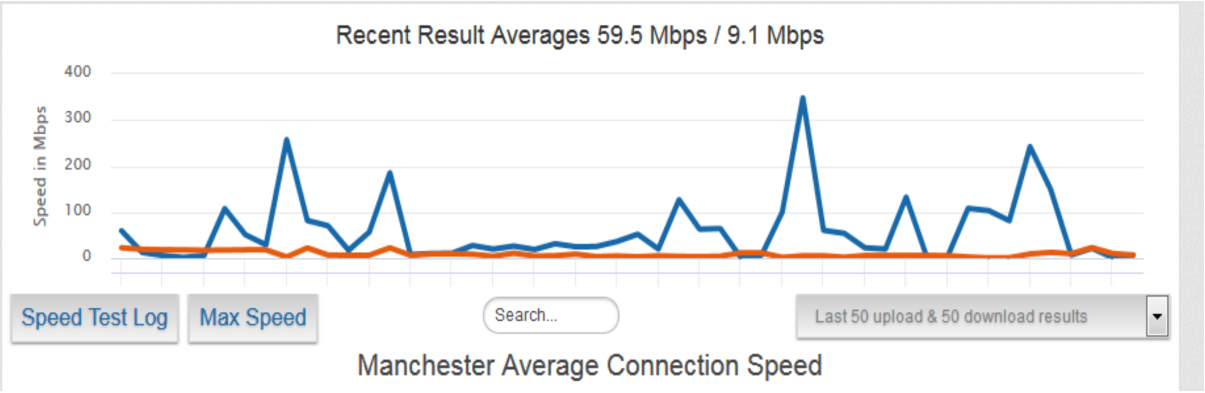


Figure 6-19: CASE-3 (Manchester's) Average Broadband Connection Speed (TestMy.net, 2018).

6.7.3 GDP Growth and Budgetary Dimension

Another crucial issue among the cities investigated is the budgetary provision for development. As asserted by Mohanty, Choppali, and Kougianos (2016), higher efficiency can reduce the operational cost and improve the sustainability of a Smart City. However, the challenge is the cost optimisation over the complete system life cycle, which suggests that a small operational cost will make it easier for cities to function in the long run with a minimal burden on the city budget. CASE-1 in a recent budget for the 2018 fiscal year proposed $3.14 billion for sustainability, increased investment, and fiscal responsibility (City of Boston, 2018). Within the same period, CASE-2 proposed $132.122 million for capital projects and programmes for 2018 (Budget Office, 2018). Compared to the budgets for CASE-1 and CASE-2, CASE-3's annual for the same fiscal year is moderate at $704.915 million (Manchester City Council, 2018a).

Table 6.20: Comparative Analysis of Basic Development Indices Accross the Three Cases

S/N	Item	CASE-1	CASE-2	CASE-3
1	GDP per Capita	$77,502 (Growth Rate 1.44% -2016)	$2,457.80 (Growth Rate 12.1% -2016)	$58,946 (Growth Rate 2.33% -2016)
2	Annual Budget	$3.14 Billion	$132.122 Million	$704.915 Million
3	Broadband City Level	14.7Mbps/12.1Mbps	17.6Mbps/2.6Mbps	59.5Mbps/9.1Mbps
4	Broadband Regional Level	27.39Mbps/8.78Mbps mobile and 84.66Mbps/29.88Mbps fixed	9.85Mbps/4.15Mbps mobile and 9.63Mbps/7.82Mbps fixed	26.80Mbps/10.80 mobile and 50.45Mbps/10.84Mbps fixed

In relation to growth, CASE-1 recorded their GDP per capita at $77,502 in 2016 with a growth rate of 1.44% (Open Data Network, 2016a). In comparison, $2,457.80 per capita was recorded by CASE-2 within the same period (Trading Economics, 2016). Again, the GDP per capita for CASE-3 in the same period (2016) was considerably high at $58,946 with an annual growth rate of 2.33% (Open Data Network, 2016b). These data are illustrated in Table 6.20.

6.7.4 Challenges and contextual issues of the cities

Smart City innovation offers new opportunities for municipal managers to deliver efficient services to their citizens and serve as urban strategies to improve the quality of life for the people, whilst and at the same time posing a challenge in managing the innovation echo system for effective results. Many of the interviewees in CASE-1 saw Smart City innovation as an evolution that connected the dots between technologies, providing more efficient services, and maximising multiple benefits for the people to feel the impact of city initiatives and programmes. A cabinet level official talked about the major challenges of the city in the area of regulatory authorities; "[The] (…) Office of the Mayor has no regulatory powers over some sensitive sub-sectors of the city. For instance, [the] Office of the Mayor has no regulatory powers over public transportation but public transport is crucial to our resilient and Smart City vision" [MOB].

Growing smart initiatives offer opportunities to improve environmental sustainability, local air quality, providing efficient traffic management, and crime profiling. At the same time, it poses a challenge in managing the stakeholders' echo system for the realisation of the desired results. For example, a senior academic stated that:

> (…) The concept of Smart City should provide social inclusion platforms. For instance, in transport sector where people spend over 45% of the income does not require high-tech solutions to manage. Instead, focusing on low-tech solution with social alternatives through collaborative planning and constant stakeholder engagement can help to address the problem of the sector [SLB].

Similarly, CASE-2 seeks to deploy Smart City technologies to build a Smart Mobility system with a vision to become one of the top 20 Smart Cities of the world by 2020 in terms of urban mobility services (Opeifa, 2017). Thus, the transport sector is critical for municipal managers to recognise the implications of the sector for the economy and security of the city. However, building an enabling environment that supports the realisation of the city's smart vision is a challenge. As recounted by a senior director directly involved in the Smart City initiatives;

> (…) Generally, the political class are not supportive of the Smart City vision like many other sustainable policies in the past. In this system, politicians come and go with indiscriminate projects and programmes without sustainability plan. The lack of political will is what is delaying everything about our Smart City initiatives to date [FCA].

CASE-3 tends to share these challenges, which were expressed in the other cases in terms of mobility problems. Keeping the city connected, for instance, offers a positive opportunity to attract local and international investors, and at the same time poses a challenge in getting the people to commute within the city in a more economical and sustainable manner. A senior city administrator recounted that;

> (…).the main challenge of our city today is the exponential population growth. The growth is now impacting heavily on the existing transportation systems. The population growth has increased the city's daily trip to 800 trips per day. Overall, not having a

> Smart City action plan in place was also mentioned as a challenge. As expressed by one of the interviewees, not having a Smart City plan has introduced a situation where we have many people researching on Smart cities at the moment but it is difficult to say how many are really doing it and how we can assess the impacts of what they are doing [CCM].

Overall, the contextual challenges of the three cities investigated were similar, especially in the area of mobility. The next section presents the chapter summary.

6.8 Chapter Summary and the Key Interview Findings

This chapter has broadly explored the Smart City innovation with further consideration of the issues raised in cross-case stakeholder interviews through a content analysis. To achieve this, the analysis was conducted in two broad sections with sub-sections for Smart City perception and stakeholder understanding, Smart City drivers, stakeholder perceptions on priority components, identified challenges for smart city solutions, Smart City KPIs and factors, and an overview of smart city projects/programmes across the cases.

The interviewees sought to investigate, assess, and draw lessons from Smart Cities practices in the three cases. With the main aim being to understand what Smart City means to different stakeholders and how to measure Smartness and its impacts, the inputs captured from the respondents were organised into structured data, which will serve as inputs to the final framework. Thus, the chapter has helped to lay the foundation to develop a Smart City framework to promote innovation in social and economic development, which is the main aim of the study. To achieve this, a pilot study was first conducted within the primary case study followed by semi-structured interviews with stakeholders across the three cases, which focused on key participants who play strategic roles in the sector. The chapter has also helped to re-shape the structure of the survey component of the study, especially on the core components of Smart Cities.

In all, the interview findings were categorised into different themes as depicted in the mind-map that used the Nvivo 11 content analysis. The main themes were finally discussed with some key findings as summarised below.

- The issues concerning a lack of a precise definition of the Smart City concept has been confirmed based on different viewpoints expressed by stakeholders in this study. While industry experts, especially from ICT, believe that the Smart City evolution is about technological innovation, city administrators and their counterparts in academia feel it is more about social innovation and collaborative efforts that must be based on the history, culture and the experiences of the cities concerned. This difference reinforces the inconsistencies in the understanding of Smart City amongst stakeholders in different sectors and in different city regions.
- The Smart Infrastructure component of a Smart City which previously was paid less attention appears possibly a priority issue to the six Smart City wheels established in the literature which were previous more popular in Smart City KPIs.
- A number of factors, such as quality of life, productivity, sustainability, entrepreneurship and job/wealth creation, have been noted across the cases as critical success factors and indicators of Smart City innovation, which also tend to direct the focus and priority areas of different Smart City initiatives.
- Another important finding was that of a consensus amongst stakeholders on the need to measure the impacts of smartness through well-defined key performance indicators (KPIs) for Smart City programmes and projects.
- A further finding worthy of note is the fact that sustainable transport systems tend to dominate the common use case examples among Smart City stakeholders. Not only was it confirmed by interviewees in this study but it was viewed as important and commonly referenced as a critical success factor and major driver of Smart City innovation.

The findings at this stage represent stakeholders views qualitatively explored across the cases. The next chapter will explore the analysis of the survey outcome from the field investigation.

CHAPTER 7

7.1 Analysis of Smart City Critical Success Factors (CSFs) and the Key Performance Indicators (KPIs)

The previous chapter analysed and discussed the results of the qualitative data (interviews with experts) undertaken in the three case studies that are adopting Smart City initiatives. By using inferential statistics this chapter helps to profer answers to research question-c, namely to test how the understandings differ among stakeholders with respect to specialisation and education. The chapter also helps to answer research question-d, which was, ‘what underlying relationships exist among the critical success factors/indicators of Smart Cities and how do cities prioritise these factors and indicators in assessing the impacts of their Smartness’?

As highlighted in the methodology, in order to draw lessons from a range of experiences, the cities were selected from North America, Europe, and the primary case was from Africa. In this chapter, the analysis is based on the outcome of a survey undertaken in the Federal Capital City of Abuja, Nigeria. The discussion in the previous chapter qualitatively analused the views of Smart City practitioners in these different cities. In this chapter, the views will be explored further with a wider audience using a different method. This is intended to further explore the findings in order to improve the validity of the research with more contributions from a larger audience who are key stakeholders in Smart City innovation. As noted in the methodology, the study adopted a mixed method investigation to benefit from the complimentary advantages of qualitative and quantitative methods. In brief, a total of 139 survey instruments were hand-delivered to respondents, of which 107 completed survey instruments were retrieved successfully giving a response rate of 76.98%. As stated in Chapter 4, the survey instruments were administered to Abuja Smart City stakeholders from the ICT industry, academia, transport, and the city’s administration. Therefore, the target audience for the data collection exercise were drawn from both public and private sectors within the city of Abuja.

The preliminary analysis of the data collected through the survey were based on descriptive statistics to first establish a clear profile of the respondents by using statistical tools, such as frequencies, simple means, and percentages for the systematic presentation of key demographic characteristics of the survey respondents. Furthermore, in order to prepare the data for more in-depth analysis, the test of internal consistency was conducted. In this regard, the alpha coefficient test was found to be more appropriate to assess the reliability of the multiple-item variables involved (Bernstein & Nunnally, 1994). Although there are other relevant tests for the single component, for instance the Composite Reliability test and the Principal Component Analysis (PCA), the most commonly used is Cronbach’s Alpha Coefficient (Pallant, 2013). Thus, the reliability of the scales used was tested using Cronbach’s Alpha. The chapter therefore conducted further inferential tests using the Kruskal-Wallis H Test and the correlation analysis of the Smart City KPIs was tested for the validity and integrity of the research findings. The chapter further employed the System Dynamics approach to analyse the causal relationship among the core components of Smart Cities estabished in this study; this mainly aimed to propose a summarised framework model for Smart Cities, which is one of the core objectives of the study.

7.2 Respondents’ Profile and Demographics

As noted in 7.1 above, a total of 107 completed survey instruments were returned. Of the returned instruments, two were considered invalid due to entry errors (i.e. multiple entries on questions requiring checking only one answer. Thus, the total included in the analysis was reduced to 105. Tables 7.1 to 7.5 present the breakdown of respondent profiles and demographic information.

7.2.1 Respondents’ Employment Status

The survey first considered the employment status of respondents in order to identify and establish the quality of the survey audience and their level of involvement in the policy and/or initiatives under consideration. It was considered imperative to establish that those who participated from the sectors listed were sufficiently knowledgeable to provide credible information on the Smart City evolution in FCTA. Table 7.1 summarises the respondent’s employment status.

Table 7.1: Respondents' Employment Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Temporary	24	22.9	22.9	22.9
	Permanent	81	77.1	77.1	100
	Total	105	100	100	

As shown in Table 7.1, 24 of the respondents (equating to 22.9%) were in temporary employment while a total of 81 respondents (representing 77.1% of the total survey population) were permanent staff in their respective organisations. Temporary staff in this study refers to members of staff who are non-pensionable, which includes consultants, contract staff, and Youth Corp members. This results suggests that majority of the respondents (77.1%) were in a good position to provide credible information for the study as representatives of the target audience.

7.2.2 Respondents' Educational Qualification

The level of education attained by the respondents was considered important in order to establish their competence in providing certain information for the study as well as to establish any relationship between the respondent's level of education and other factors that may influence their views. Table 7.2 presents the summary of respondents' level of education.

Table 7.2: Respondents' educational qualification

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	HND	42	40	40	40
	BSc	48	45.7	45.7	85.7
	MSc	9	8.6	8.6	94.3
	PhD	6	5.7	5.7	100
	Total	105	100	100	

It can be seen from Table 7.2 that all the respondents are well educated as they hold at least a first degree or its equivalent. Therefore, the majority of the respondents (45.7%) were educated up to BSc level, followed by those with an educational qualification at HND level (40%), while respondents who had attained an MSc (8.6%) and PhD (5.7%) were in the minority. It is important to note that none of the respondents had below graduate educational qualifications (NCE, OND, and SSCE).

7.2.3 Respondents’ Experience in Information Technology (IT)

Table 7.3 shows that 50.5% of the respondents are highly experienced stakeholders with an IT background, 36.2% have moderate IT experience, while only 13.3% have minimal to low experience in IT.

Table 7.3: Respondents' Experience in Information Technology (IT)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	14	13.3	13.3	13.3
	Medium	38	36.2	36.2	49.5
	High	53	50.5	50.5	100
	Total	105	100	100	

Table 7.3 shows that majority of the respondents have IT experience. This is understandable because most of the active participants of the FCTA Smart City initiative are professionals who depend on ICT tools and technologies in their day-to-day activities. The number of highly experienced IT respondents, in this case, can be explained by their access to skills development opportunities. It can also be said to be part of the deliverables of the Federal Government’s efforts in driving IT penetration in Nigeria and in their sustained efforts to build an IT-driven economy in which IT government agencies are involved in substantial training and sensitisation through public service campaigns.

7.2.4 Respondents’ Prior Smart City Awareness

In order to establish whether experts who are fully and generally aware of Smart City development were involved in the survey, provision was made in the survey instrument for respondents to rank their level of Smart City awareness within the range of ‘low’, ‘medium’ or ‘high’. Table 7.4 presents the summary of respondents’ self-assessment on their prior Smart City awareness.

Table 7.4: Respondents' Prior Smart City Awareness

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	36	34.3	34.3	34.3
	Medium	47	44.8	44.8	79
	High	22	21	21	100
	Total	105	100	100	

As shown in Table 7.4, the majority of the respondents, i.e. 44.8% (medium) and 21.0% (high), have a medium to high awareness of Smart City initiatives, while 34.3% (low), who are in minority, have a low general awareness of Smart City developments.

7.2.5 Respondents' Work Experience

In addition to establishing respondents' status of employment, outlined in section 7.2.1, the survey sought to determine the level of respondents' work experience in their respective organisations. Table 7.5 presents a summary of respondents' work experience.

Table 7.5: Respondents' Work Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-5	46	43.8	43.8	43.8
	06-Oct	25	23.8	23.8	67.6
	Nov-15	29	27.6	27.6	95.2
	16-20	2	1.9	1.9	97.1
	21-25	3	2.9	2.9	100
	Total	105	100	100	

It can be seen in Table 7.5 that 43.8% of the respondents were stakeholders who have between 0 to 5 years in service at their organisation; this is followed by 27.6% who have between 11 to 15 years service, and 23.8% with between 6 to 10 years service. However, respondents with between 16 to 20 years and 21 to 25 years service only comprised 1.9% and 2.9% of the survey population, respectively.

7.2.6 Respondents’ Sector of Practice

In recognising the importance of Smart Cities as innovation ecosystems, the survey also sought to establish the spread of stakeholder involvement across the core sectors of participation, namely: city administration, academia and the ICT industry. Table 7.6 indicates that 35.2% of the respondents work in the ICT industry; this is followed by 34.3% who work in city administration, while 30.5% of the respondents work in academia.

Table 7.6: Respondents' Sector of Practice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ICT Industry	37	35.2	35.2	35.2
	City Admin	36	34.3	34.3	69.5
	Academia	32	30.5	30.5	100
	Total	105	100	100	

The pattern of distribution amongst respondents (shown in Table 7.6), is fairly evenly spread, with only marginal differences in the number of participants per sector. However, further analysis on the composition of respondents from city administration and academia suggests that individuals from these two sectors were from diverse backgrounds in terms of their areas of specialisation. Nevertheless, the goal (which was achieved) was to cover a sizeable number of respondents across the sectors under investigation using the Nigerian Smart City stakeholders list as a guide.

7.2.7 Respondents’ Areas of Specialisation

In addition to the respondents’ sector of practice (detailed in section 7.2.6), the survey also considered the respondents’ area of specialisation in order to assess the nature of stakeholder involvement in building the FCTA Smart City initiative and in the pattern of responses for this study. Table 7.7 presents the summary of the respondents’ area of specialisation.

Table 7.7: Respondents' Area of Specialisation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	IT Expert	58	55.2	55.2	55.2
	Urban Planner	19	18.1	18.1	73.3
	Transport Expert	18	17.1	17.1	90.5
	Security Expert	10	9.5	9.5	100
	Total	105	100	100	

The results in Table 7.7 indicate that majority (55.2%) of respondents are IT experts, which is followed by 18.1% who indicated that they are professionals in urban planning, and 17.1% are transport experts, while only 9.5% are security experts. The pattern suggests that professionals in Information Technology (IT) are more involved in ongoing Smart innovations in FCTA. The list of stakeholders obtained from the secretariat of the Nigerian Smart City Initiative also supports this position.

7.2.8 Respondents' Views on the Core Components of Smart Cities

As noted in literature, the people element determines the success or failure of any initiative. Similarly, the literature emphasised institutional arrangements for the quality of political strategies and policy governance as well as the need for essential physical infrastructure for sustainable Smart Cities. Moreover, the analysis of the pilot study and the qualitative analysis of the stakeholder interviews prioritised these components. As such, this section further explores the assertion by asking the survey respondents whether they thought these components should represent the priority dimensions of Smart City innovation. They were asked to select 'yes' or 'no' or 'I don't know; the results are shown in Table 7.8.

Table 7.8: Respondents' Dis/Agreement on the Core Components of SC

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	99	94.3	94.3	94.3
	No	2	1.9	1.9	96.2
	Don't Know	4	3.8	3.8	100
	Total	105	100	100	

The results indicate that 94.3% of the respondents believe that infrastructure, institution, and people are core components of Smart Cities, while 1.9% of the respondents disagreed. Interestingly, 3.8% were unable to either confirm or reject by selecting ‘I don’t know’ as their response.

7.2.9 Respondents’ Ranking of the Core Components

In this section, the exercise aimed to confirm the respondents’ perspectives on the priority components discussed in section 7.2.8. The outcome was further tested to compare the views of the respondents’ priorities amongst the three core components. In this case, respondents were asked to rank their priority component according to their own perception on a five point Likert scale of ‘Very Low’, ‘Low’, ‘Medium’, ‘High’, and ‘Very High’. The results are analysed in a cross tabulation presented in Table 7.9 and Figure 7.1

Table 7.9: Respondents’ Ranking of the Core Components

Rank	**Infrastructure**		**Institution**		**People**	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Very Low	3	2.9	3	2.9	3	2.9
Low	1	1.0	3	2.9	2	1.9
Medium	19	18.1	15	14.3	26	24.8
High	34	32.4	47	44.8	30	28.6
Very High	48	45.7	37	35.2	44	41.9
Total	**105**	**100**	**105**	**100**	**105**	**100**

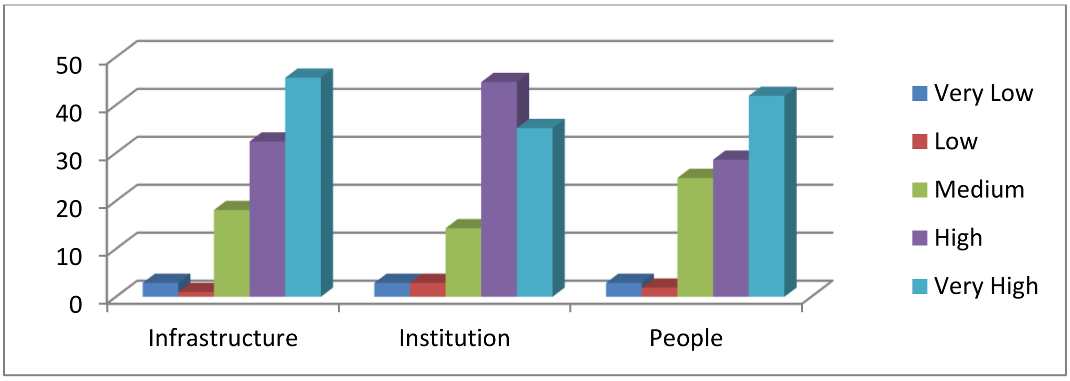


Figure 7-1: Respondents' Ranking of the Core Components

As illustrated in Table 7.9 and Figure 7.1, the majority of respondents very highly (45.7%) or highly (32.4%) prioritised infrastructure, which together comprise 78.1% of the total survey population. In comparison, few ranked infrastructure as 'very low' (2.9%) or 'low' (1.0%), which (combined) comprise just 3.9% of the survey population. Furthermore, 18.1% of the respondents believe that it is moderately important having selected 'medium'. With respect to the institution component, the majority indicated that the institution component is significant, with 35.2% ranking it 'very high' and 44.8% ranking it 'high'. In contrast, a low proportion of respondents indicated that it was not important, ranking it either as 'very low' (2.9%) or low (2.9%), which together comprise 5.8% of the responses. Meanwhile, 14.3% indicated that the institution component is of moderate importance having selected 'medium'. Finally, the majority of respondents indicated that the people component of a Smart City is important, with 41.9% selecting 'very high' and 28% selecting 'high'; together these comprise 69.9% of the responses. In comparison, the minority of respondents were of the view that people component is not important, having chosen 'very low' (2.9%) or low (1.9%), which together comprise 4.8%. However, 24.8% of the respondents held the belief that the people component is of moderate importance by selecting 'medium'.

7.3 Analysis of the Critical Success Factors (CSFs) for the Smart City Components

The previous sections summarised the demographic information of the respondents and analysed their views on the Smart City core components using descriptive statistics. This section presents the analysis of the KPIs for the three components, namely infrastructure, institution, and people. The descriptive statistics, tests, correlation analysis, and System

Dynamics simulation outlined out in this chapter address research question-d and objective four of the study.

7.3.1 Analysis of the Critical Success Factors (CSFs) for Smart Infrastructure

This section concentrates on the reliability test, in evaluating the Critical Success Factors (CSFs) of Smart Infrastructure. In doing so, a number of statistical procedures were followed, including a test for the reliability of the data collected. This entailed using Cronbach’s Alpha test, a mean score of the variables, and establishing the relationships among the variables measured as Smart Infrastructure factors. Moreover, to compare variables across the sectors represented by the respondents in this study, a non-parametric test for the independent samples was carried out using the Kruskal-Wallis test. At the end of the section, a summary of the key assumptions reached from the outcome of the analysis are highlighted.

7.3.1.1 Reliability Test for Factors of Smart Infrastructure

In order to establish the reliability of the survey instrument and the data used in this study, Cronbach’s Alpha test was used to determine the internal consistency of the data set that constitutes the sample. This measure is deemed necessary to enable the researcher to study the properties of the measurement scales. In other words, a reliability test allows the researcher to determine the degree to which a set of items comprise a scale cluster, and to determine whether they measure a single unidimensional latent construct (Field, 2013) Nunally & Bernstein, 2007; (Julie Pallant, 2013). In this context, reliability is seen as the extent to which a test, or a set of procedures, produce similar results under consistent conditions at all times. For the Cronbach’s Alpha test, it is commonly accepted that a reasonable threshold for consistency in advanced research projects is 0.7. In comparison, for psychometric tests, an acceptable internal consistency falls within the threshold of 0.75 to 0.83 (Nunnally & Bernstein, 1978) (Nunnally & Bernstein, 2007). However, there is debate concerning the acceptable cut-off point; whereas Nunnally and Bernstein (2007) suggests a value of more than 0.6 as adequate, a value of 0.7 is generally recommended as a reasonable threshold for Cronbach’s Alpha (Hair, Black, Babin, Anderson, & Tatham, 1998)

Based on the Smart Cities factors identified in literature and the feedback from the interviews with experts across the three cases, 12 factors emerged for a Smart City infrastructure, which were subsequently used to develop the survey instrument for this study. These factors were ranked on a five-point Likert scale that defined the level of importance to respondents, from 1, which represented ‘very low’, to 5, which represented ‘very high’. In this study, the data collected from respondents were input into SPSS version 23, and, after the data cleansing and editing, Cronbach’s Alpha test was run successfully. The results are shown in Table 7.10.

Table 7.10: Reliability Statistics - Smart Infrastructure’s CSFs

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N. of Items
0.731	0.713	12

As shown in Table 7.10, the Cronbach’s Alpha coefficient for the infrastructure factors is 0.731. This indicates that the internal consistency of the data collected for this survey is within the acceptable limit.

In order to assess the respondents’ perceptions on what defines the Smart City Infrastructure and to determine the core factors for measuring Smartness, question one in section C of the questionnaire sought to establish the views of the stakeholders through a 12 item question on a five-point Likert scale. This allowed the respondents to rank the importance of the factors in accordance with their own perceptions. The results are summarised in Table 7.11.

Table 7.11: Mean Score and Descriptive Statistics of Smart Infrastructure CSFs

		INF1	INF2	INF3	INF4	INF5	INF6	INF7	INF8	INF9	INF10	INF11	INF12
N	Valid	105	105	105	105	105	105	105	105	105	105	105	105
	Missing	0	0	0	0	0	0	0	0	0	0	0	0
Mean		**3.49**	**4.06**	**4.07**	**4.04**	**3.2**	**3.58**	**3.78**	**3.46**	**4.1**	**4.3**	**3.05**	**3.18**
Median		4	4	4	4	3	4	4	4	4	4	3	3
Mode		4	5	5	5	3	4	4	4	4	4	2[a]	4
Std. Deviation		0.952	0.959	0.953	0.98	1.023	1.036	0.92	0.981	0.746	0.667	0.944	0.907
Variance		0.906	0.92	0.909	0.96	1.046	1.073	0.846	0.962	0.556	0.445	0.892	0.823
Skewness		-0.163	-0.649	-0.678	-0.577	0.136	-0.088	-0.455	-0.096	-0.456	-0.438	0.113	0.025
Std. Error of Skewness		0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236

As shown in Table 7.11, five items were selected as the highest priority factors of a Smart Infrastructure. These included: INF3 (the availability of ICT infrastructure) with a mean score of 4.07; INF2 (the availability of a constant power supply) with a mean score of 4.06; INF4 (the availability of a sustainable transport system) with a mean score of 4.04; INF9 (individual safety) with the mean score of 4.10, and INF10 (secured and innovative technologies) with a mean score of 4.30. Another four items were also seen as priority factors of Smart City infrastructure, which included: INF7 (pollution control) with a mean score of 3.78; INF6 (educational facilities) with a mean score of 3.58; INF1 (the availability of a smart grid) with a mean score of 3.49, and INF8 (environmental sustainability) with mean score of 3.46. In comparison, a further three factors were selected as the least important factors for measuring Smart City Infrastructure, and these were: INF11 (the availability of a sustainable public water supply) with a mean score of 3.05; INF12 (the existence of sustainable healthcare facilities) with a mean score of 3.18, and INF5 (an attractive natural environment) with a mean score of 3.20.

It is important to note that the respondents gave responses for all the items listed, which indicated high response rate for this study. Furthermore, information about the distribution of the scores indicate that INF1, INF2, INF3, INF4, INF6, INF7, INF8, INF9, and INF10 are negatively skewed suggesting a clustering of the scores at the highest end (Julie Pallant, 2013). Moreover, it is also important to recall that the outcome of the interviews with experts discussed in the previous chapter indicated that a sustainable transport system was the highest priority in assessing Smartness. The survey summary therefore agrees with the outcome of the interviews with experts, which identified the following core factors for assessing the Smartness of a city: the availability of a sustainable transport system, the availability of an ICT infrastructure, environmental sustainability, and the availability of a constant power supply. The next section discusses the results of the non-parametric test for the factors of a Smart City infrastructure.

7.3.1.2 Kruskal-Wallis Test for Factors of a Smart Infrastructure's CSFs

This section presents the results of the non-parametric test for independent samples carried out to compare the variables amongst the Smart Infrastructure factors across the categories of respondents covered in the survey. To achieve this, the Kruskal-Wallis test was run to determine if there are any disparities among the scores for the different groups of participants, first in terms of their area of specialisation (with their different backgrounds of information technology professionals, urban planners, transport experts, and security experts) and second, in their answers to the question on infrastructure CSFs which was repeated based on their educational qualification. The test was deemed necessary to assess the difference between the groups of participants in this study. The Kruskal-Wallis H test is a non-parametric alternative to a one-way test between a group's analysis of variance; it is applicable to this study as allows for comparisons between the scores on more groups of continuous variables (Jullie Pallant, 2005).

In this exploratory study, the differences among the respondents from differing backgrounds were analysed to determine any disparity in the pattern of responses. This was achieved using the mean ranks, p-value, and the post-hoc values. Table 7.12 explains the analysis of the Kruskal-Wallis test dissimilarities on the rankings of the Smart Infrastructure factors.

Table 7.12: Kruskal-Wallis Test for Infrastructure Factors Based on Respondents' Areas of Specialisation

Test Statistics^{a,b}

	Inf1	Inf2	Inf3	Inf4	Inf5	Inf6	Inf7	Inf8	Inf9	Inf10	Inf11	Inf12
Chi-Square	0.978	2.737	4.054	3.28	1.228	4.148	7.155	1.289	4.8	1.184	1.361	1.232
df	3	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.806	0.434	0.256	0.35	0.746	0.246	0.067	0.732	0.187	0.757	0.715	0.745

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' area of specialisation

As shown in Table 6.12, the p-values for all items (Inf1 through to Inf12) were above 0.05 indicating that there is no significant difference in the response pattern among the group concerning the variables, which represents a 95% level of confidence. Generally, a p-value below 0.05 indicates that there is significant difference among the groups, while a p-value above 0.05 suggests there is no significant difference among the groups (Julie Pallant, 2013). Thus, from Table 6.12, it can be seen that none of the variables recorded a p-value of less than 0.05.

The test was also repeated to determine whether there is any disparity in the pattern of responses among the respondents, based on the sector in which they work. Table **7**.13 and Figure 7.2 presents the median ranks, p-values, and the post-hoc values.

Table 7.13: Kruskal-Wallis Test for the Infrastructure Factors Based on Educational Qualifications

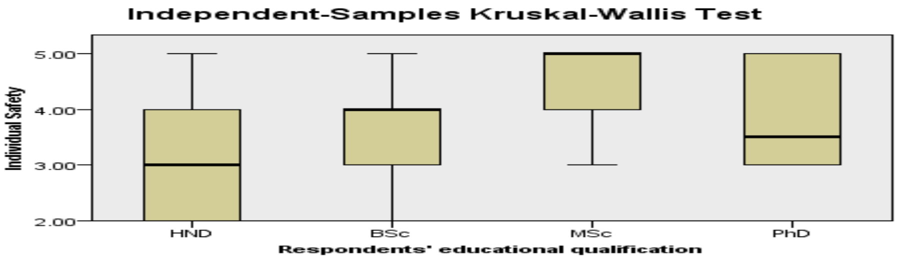
Test Statistics[a,b]

	Inf1	Inf2	Inf3	Inf4	Inf5	Inf6	Inf7	Inf8	Inf9	Inf10	Inf11	Inf12
Chi-Square	6.41	0.314	0.538	1.533	4.341	5.291	2.663	12.598	3.018	2.269	3.98	3.345
df	3	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.093	0.957	0.911	0.675	0.227	0.152	0.447	0.006	0.389	0.519	0.264	0.341

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' educational qualification

Using the respondents’ educational qualification as a grouping variable to assess if there was any significant difference among the group, the results show similar trends but with a strong indication that there is a statistically significant difference among the group which relates to Inf8 (environmental sustainability). As shown in Table 7.13, item Inf8 recorded a very large Chi-square value of 12.598 and a p-value of 0.006, which is less than the alpha value of 0.05; this was tested at a 95% level of confidence. However, all other factors have a very low Chi-square value (as low as 0.3, 0.5, 1.533 and so on) with a p-value above 0.05, which indicates that there is no significant difference among the groups. The result suggests that the educational qualification does not necessarily reflect in the participants’ responses to questions, with the exception of Inf8 (as highlighted in Table 7-13). To confirm, where differences occur among the groups, a post-hoc test was run to examine the statistically significant differences. Figure 7.2 is the Kruskal-Wallis post-hoc test for the Infrastructure Factors based on the respondents’ educational qualifications.



Total N	105
Test Statistic	12.598
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	.006

1. The test statistic is adjusted for ties.

Figure 7-2: Kruskal-Wallis Post-hoc Test for Infrastructure Factors Based on Educational Qualification

Based on a visual inspection of Figure 7.2, it is sufficient to assume that the difference responses amongst HND, BSc, MSc, and PhD respondents relate to the factor of environmental sustainability. Clearly, all the groups of respondents (i.e. HND, BSc, MSc, and PhD) have different median ranks at 3.0, 3.5, 4.0 and 5.0, respectively. In addition, the results show different dimensions of the box-plot for all the groups, which gives an indication that there is an underlying fact about the distribution across the groups. The post-hoc analysis indicates that there is a statistically significant difference among the groups which relates to the environmental sustainability factor of a Smart Infrastructure.

7.3.1.3 Spearman (rho) Correlation Analysis of the CSF for Smart Infrastructure

In order to examine the relationship among the CSFs of the Smart Infrastructure component, Spearman's Rank Order Correlation (rho) was employed. According to Julie Pallant (2013), Spearman rho is designed for ordinal level, or rank, data and is useful when data do not meet some stringent conditions of a parametric analysis. As the survey data collected for this study were designed for ordinal and nominal measures, Spearman rho is the most appropriate tool for analysis. The Spearman rho correlation coefficient can take values from -1 to +1. Results that produce values from -1 to 0 indicate a nil correlation (association). In such cases, the negative can be translated thus, 'as one variable increases, the other decreases'. Values from 0 to +1 signal a positive correlation (association); therefore, as one variable increases, it impacts positively on the other. Table 7.14 presents a detailed correlation analysis of the CSFs of a Smart Infrastructure.

Table 7.14: Spearman's Correlation Analysis of the CSF for Smart Infrastructure

Correlations

			INF1	INF2	INF3	INF4	INF5	INF6	INF7	INF8	INF9	INF10	INF11	INF12
Spearman's rho	INF1	Correlation Coefficient	1.000	.359**	.335**	.328**	0.144	.343**	.572**	.608**	-0.037	-0.029	.424**	-0.104
		Sig. (2-tailed)		0.000	0.000	0.001	0.142	0.000	0.000	0.000	0.707	0.772	0.000	0.293
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF2	Correlation Coefficient	.359**	1.000	.970**	.944**	-0.054	.451**	0.102	.282**	0.126	0.138	0.085	-0.074
		Sig. (2-tailed)	0.000		0.000	0.000	0.581	0.000	0.300	0.004	0.201	0.160	0.391	0.454
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF3	Correlation Coefficient	.335**	.970**	1.000	.948**	-0.044	.477**	0.084	.265**	0.102	0.111	0.077	-0.079
		Sig. (2-tailed)	0.000	0.000		0.000	0.658	0.000	0.396	0.006	0.300	0.259	0.436	0.421
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF4	Correlation Coefficient	.328**	.944**	.948**	1.000	-0.058	.446**	0.099	.260**	0.131	0.122	0.059	-0.059
		Sig. (2-tailed)	0.001	0.000	0.000		0.554	0.000	0.316	0.007	0.183	0.216	0.551	0.547
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF5	Correlation Coefficient	0.144	-0.054	-0.044	-0.058	1.000	0.057	0.132	.199*	-0.016	-0.131	0.128	0.051
		Sig. (2-tailed)	0.142	0.581	0.658	0.554		0.562	0.180	0.042	0.871	0.182	0.193	0.607
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF6	Correlation Coefficient	.343**	.451**	.477**	.446**	0.057	1.000	0.045	.258**	-0.075	-0.094	0.118	0.108
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.562		0.652	0.008	0.447	0.342	0.229	0.272
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF7	Correlation Coefficient	.572**	0.102	0.084	0.099	0.132	0.045	1.000	.325**	0.178	.204*	0.103	-0.026
		Sig. (2-tailed)	0.000	0.300	0.396	0.316	0.180	0.652		0.001	0.070	0.037	0.295	0.794
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF8	Correlation Coefficient	.608**	.282**	.265**	.260**	.199*	.258**	.325**	1.000	-0.121	-0.054	.491**	0.063
		Sig. (2-tailed)	0.000	0.004	0.006	0.007	0.042	0.008	0.001		0.219	0.586	0.000	0.524
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF9	Correlation Coefficient	-0.037	0.126	0.102	0.131	-0.016	-0.075	0.178	-0.121	1.000	.551**	-.407**	-0.054
		Sig. (2-tailed)	0.707	0.201	0.300	0.183	0.871	0.447	0.070	0.219		0.000	0.000	0.587
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF10	Correlation Coefficient	-0.029	0.138	0.111	0.122	-0.131	-0.094	.204*	-0.054	.551**	1.000	-.340**	-0.065
		Sig. (2-tailed)	0.772	0.160	0.259	0.216	0.182	0.342	0.037	0.586	0.000		0.000	0.510
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF11	Correlation Coefficient	.424**	0.085	0.077	0.059	0.128	0.118	0.103	.491**	-.407**	-.340**	1.000	0.161
		Sig. (2-tailed)	0.000	0.391	0.436	0.551	0.193	0.229	0.295	0.000	0.000	0.000		0.101
		N	105	105	105	105	105	105	105	105	105	105	105	105
	INF12	Correlation Coefficient	-0.104	-0.074	-0.079	-0.059	0.051	0.108	-0.026	0.063	-0.054	-0.065	0.161	1.000
		Sig. (2-tailed)	0.293	0.454	0.421	0.547	0.607	0.272	0.794	0.524	0.587	0.510	0.101	
		N	105	105	105	105	105	105	105	105	105	105	105	105

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Based on the outcome of the analysis, the most significant and highest correlation coefficient was found between INF2 and INF3 (i.e. the availability of a constant power supply and the availability of an ICT infrastructure); the correlation coefficient between these two factors was positive calculated at rs=.970. The second highest positive correlation coefficient was found between INF3 and INF4 (i.e. the availability of an ICT infrastructure and the availability of sustainable transport systems), which was calculated at rs=.948. The third highest positive correlation was found between INF2 and INF4 (i.e. the availability of a constant power supply and the availability of sustainable transport systems), which was calculated at rs=.944. The fourth strongest correlation was found between INF1 and INF8 (i.e. the availability of a smart grid and environmental sustainability); this was calculated at rs-.608. The fifth strongest correlation was found between INF1 and INF7 (i.e. the availability of a smart grid and pollution control), which was calculated at rs=.572. Meanwhile, the sixth was found between INF9 and INF10 (i.e. individual safety and secured and innovative technologies) which was calculated at rs=.551. In addition, there is a strong correlation between INF11 and INF8, INF3 and INF6 as well as between INF2 and INF6. However, negative correlations were also found in the analysis. For instance, the negative correlations were very weak between INF9 and INF11, INF10 and INF11, INF8 and INF9.

In view of the evidence from the correlation analysis of the CSFs for Smart Infrastructure, it is sufficient to suggest that the most predominant CSF for a Smart City infrastructure is INF2 and INF3. On one hand, a constant power supply positively influences the availability of ICT infrastructure, the availability of sustainable transport systems, and educational facilities, on the other hand, the availability of an ICT infrastructure positively influences the deployment of sustainable transport systems, educational facilities and a constant power supply. Another interesting finding from this analysis is that the availability of a smart grid positively influences environmental protection, which is an indication that Smart City innovation in the energy sector can improve environmental sustainability. Furthermore, the availability of a smart grid (renewable energy sources) has a significant influence on pollution control. Therefore, at the core of a Smart Infrastructure for Smart Cities are the following factors: a constant power supply, ICT infrastructure, environmental sustainability, sustainable transport systems, a smart grid, educational facilities, and pollution control. Although interviewees did not emphasise the importance of secured and innovative technologies as a priority factor, the descriptive and correlation analysis from the survey responses suggest otherwise, that it is a critical factor for a Smart Infrastructure. Therefore, secured and innovative technologies will be considered one of the core CSFs for a Smart Infrastructure and further explored through the experts' review.

7.3.2 Analysis of the Critical Success Factors (CSFs) for Smart Institution

In this section, the perception of Smart City stakeholders on KPIs for a Smart Institution is reviewed and analysed in line with research question-d and objective four of this study. As noted in the literature, Smart Institution encompasses the quality of political strategies, the availability of public services, the support of government and policies for governance which includes leadership and effective collaboration for quality decision-making (Nam & Pardo, 2011a). These assertions were explored further in this study by asking the survey respondents about their perceptions of some identified KPIs for measuring the Smartness of the institution component of Smart Cities. Responses were rated on a five-point Likert scale that listed the Smart Institution factors (as extracted from academic journals, industry based Smart City standards, white papers and the interviews with experts). The Likert scale was used to measure, from one (representing 'very low') to five (representing 'very high') depending on respondents' opinions on the importance of the factors.

7.3.2.1 Reliability Test for Factors of Institution

Prior to the detailed analysis, the reliability assessment was carried out to validate the data. The reliability test, in this case, was deemed fit to establish the extent to which the individual items related to one another, as discussed in the previous sections of this chapter. Table 7.15 presents the results of the reliability test for the Smart Institution factors.

Table 7.15: Reliability Statistics: Smart Institution CSFs

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N. of Items
0.817	0.83	11

Table 7.16: Item Total Statistics - Smart Institution CSFs

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Ins1	43.88	19.148	0.589	0.525	0.796
Ins2	44.49	19.387	0.348	0.266	0.815
Ins3	44.02	20.25	0.296	0.317	0.817
Ins4	43.92	18.379	0.517	0.485	0.799
Ins5	44.32	19.76	0.275	0.296	0.823
Ins6	43.97	18.97	0.568	0.379	0.796
Ins7	43.84	18.291	0.723	0.735	0.784
Ins8	44.07	17.871	0.59	0.526	0.791
Ins9	43.99	16.913	0.63	0.629	0.786
Ins10	44.19	18.483	0.607	0.486	0.792
Ins11	44.36	18.368	0.361	0.257	0.82

It can be seen from Table 7.15, that the Cronbach's Alpha coefficient for the institution factors is 0.817. This indicates that the internal consistency of the data collected for this survey is within the acceptable limit. Furthermore, the item-total statistical correlation values for all the items in Table 7.16 were greater than and/or up to the 0.3 threshold, which is a satisfactory outcome.

It is important to note that this question (question two, section C of the survey instrument) sought to investigate the views of the stakeholders on the priority factors for a Smart Institution using the same pattern described in the preceding section. This was achieved through an 11-item question on a five-point Likert format that allowed the respondents to rank according to their own priority. The results are summarised in Table 7.17.

Table 7.17: Mean Score and Descriptive Statistics of Smart Institution CSFs

	Ins1	**Ins2**	**Ins3**	**Ins4**	**Ins5**	**Ins6**	**Ins7**	**Ins8**	**Ins9**	**Ins10**	**Ins11**
N Valid	105	105	105	105	105	105	105	105	105	105	105
Missing	0	0	0	0	0	0	0	0	0	0	0
Mean	**4.63**	**3.60**	**4.21**	**4.58**	**3.41**	**4.53**	**4.67**	**3.93**	**4.51**	**4.31**	**3.90**
Median	5.00	4.00	4.00	5.00	4.00	5.00	5.00	4.00	5.00	4.00	4.00
Mode	5	4	4	5	4	5	5	5	5	4	4
Std. Deviation	0.542	1.006	0.756	0.744	1.026	0.589	0.583	1.003	0.878	0.640	1.043
Variance	0.293	1.012	0.571	0.553	1.052	0.347	0.340	1.005	0.771	0.410	1.087
Skewness	-1.087	-0.800	-0.506	-1.855	-0.078	-0.849	-1.573	-0.565	-2.518	-0.390	-0.637
Std. Error of Skewness	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236

The item statistics for a Smart Institution also revealed that seven items were considered priority factors for assessing a Smart Institution. These items included: Ins7 (transparent governance) with a mean score of 4.67; Ins1 (entrepreneurship and sustainable development) with a mean score of 4.63; Ins4 (productivity) with a mean score of 4.58; Ins6 (Open Data and Big Data initiatives) with a mean score of 4.53; Ins9 (innovative and proactive systems) with a mean score of 4.51; Ins10 (social cohesion) with a mean score of 4.31, and Ins3 (secured service delivery systems) with a mean score of 4.21. However, four items were scored as the lowest priority factors of a Smart Institution, namely: Ins8 (international accessibility) with a mean score of 3.93; Ins11 (participation in decision-making) with a mean score of 3.90; Ins2 (flexibility of the labour market) with a mean score of 3.60, and Ins5 (tourist attraction) with the least mean score of 3.41.

Again, it is important to note that the factor of productivity and transparent governance were also emphasised during the interviews with experts. The outcome of the survey therefore confirmed that when assessing the performance of a Smart Institution, the issue of productivity and transparent governance are critical to Smart City innovation.

7.3.2.2 The Kruskal-Wallis Test for Smart Institution CSFs

In order to compare the variables (factors of a Smart Institution) across the four respondent categories, a non-parametric test for independent samples was carried out using the Kruskal-Wallis test. The test was deemed fit to determine if there were any disparities among the scores of the different groups. This was based on participants' areas of specialisation (i.e. information technology professionals, urban planners, transport experts, and security experts) and their answers to the question on key performance indicators for institution. The test was repeated for the sector and education qualification. Tables 7.18, and 7.19 present the results of these tests. Thus, in both tables: Ins1 is used to represent entrepreneurship and sustainable development; Ins2 stands for flexibility of the labour market; Ins3 denotes secured service delivery systems; Ins4 represents productivity; Ins5 stands for Tourist Attractions; Ins6 denotes Open Data and Big Data initiatives; Ins7 represents transparent governance; Ins8 stands for international accessibility; Ins9 denotes innovative and proactive systems; Ins10 stands for social cohesion, and Ins11 represents participation in decision-making.

Table 7.18: Kruskal-Wallis Test for Institution Factors Based on the Area of Specialisation

Test Statistics[a,b]

	Ins1	Ins2	Ins3	Ins4	Ins5	Ins6	Ins7	Ins8	Ins9	Ins10	Ins11
Chi-Square	4.194	1.693	10.003	1.849	3.186	1.593	5.91	0.542	1.138	4.972	2.021
df	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.241	0.638	0.019	0.604	0.364	0.661	0.116	0.91	0.768	0.174	0.568

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' area of specialisation

As illustrated in Table 7.18, the p-values for all items (Ins1 through to Ins11) were above 0.05 indicating that there is no significant difference in the response pattern among the group concerning the variables. Most items achieved a 95% level of confidence, except for item Ins3 (0.019) where the p-value was less than 0.05, with very large Chi-square of 10.003. This indicated that there was a significant difference among the groups based on their area of specialisation. In order to confirm where the differences occurred among the groups, a post-hoc test was run to examine the statistically significant difference. Figure 7.3 is the result of the post-hoc independent-sample Kruskal-Wallis test, which was based on the area of specialisation.

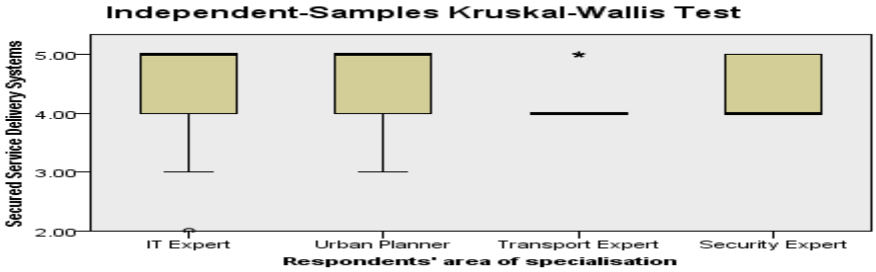


Figure 7-3: Kruskal-Wallis Post-Hoc Test for the Institution Factors Based on the Area of Specialisation

Based on a visual inspection of Figure 7.3, it is sufficient to assume that the difference in responses amongst the transport experts relates to the secured service delivery systems. Thus, the results show an asterisk (*) on the 'transport experts' with respect to 'secured service delivery systems' which indicates that there is an underlying influence behind the distribution of the median ranking by the stakeholders in the transport sector related to 'secured service delivery systems' as a core factor of a Smart Institution.

The Kruskal-Wallis test is repeated for respondents' level of education to compare the disparity. Table 7.19 shows the result of the Kruskal-Wallis test based on respondents' educational qualifications.

Table 7.19: Kruskal-Wallis Test for Institution Factors Based on Education

Test Statistics^{a,b}

	Ins1	Ins2	Ins3	Ins4	Ins5	Ins6	Ins7	Ins8	Ins9	Ins10	Ins11
Chi-Square	5.3	4.87	2.687	27.82	7.834	2.927	23.532	9.568	14.789	5.77	10.358
df	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.151	0.182	0.442	0	0.05	0.403	0	0.023	0.002	0.123	0.016

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' educational qualification

As shown in Table 7.19, the p-values for items Ins1, Ins2, Ins3, Ins6, and Ins10 were above 0.05 indicating that, at a 95% level of confidence, there was no significant difference in the response pattern among the group concerning the variables. However, items Ins3, Ins5, Ins7, Ins8, Ins9, and Ins11 have p-values of less than 0.05 and with a very large Chi-square of 27.820, 23.532, 9.568, 14.789, and 10.358 respectively. This indicates that there is a significant difference among the group responses based on their education qualification. Again, to confirm where the differences occurred among the groups, a post-hoc test was run to examine the statistically significant differences. Figure 7.4 is the result of the post-hoc independent-sample Kruskal-Wallis test, based on education qualification.

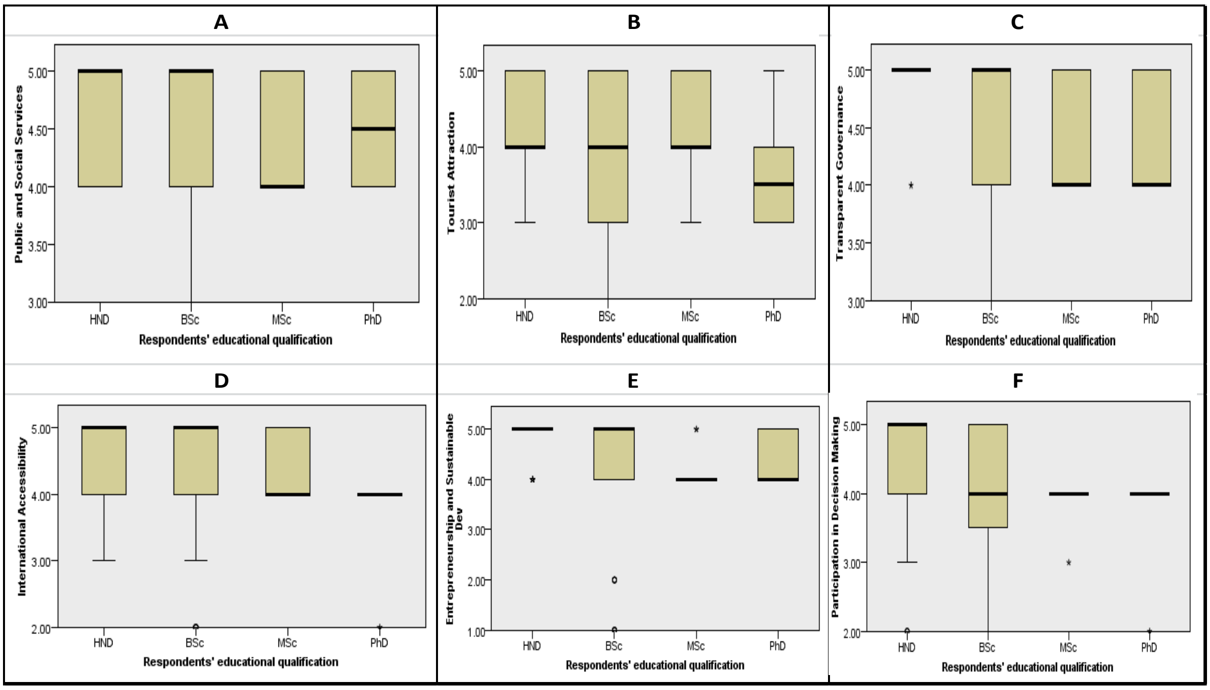


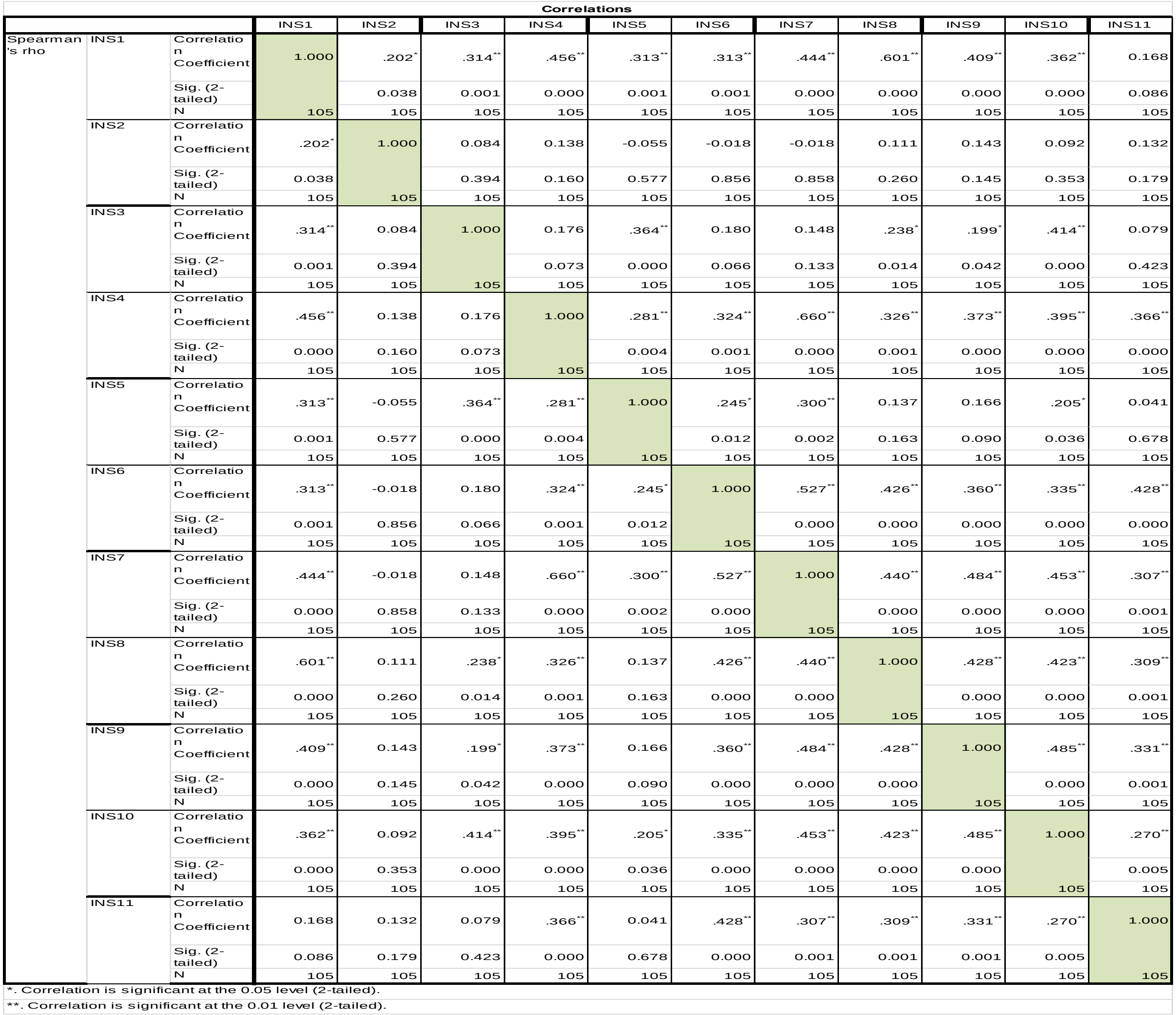
Figure 7-4: Kruskal-Wallis Post-Hoc Test for Institution Factors Based on Education Qualification

Based on a visual inspection of Figure 7.4, it is sufficient to assume a difference in responses in the post-hoc analysis in A, B, C, D, E, and F. In A, the median ranks for HND and BSc respondents were the same at 5.0, but with different box-plots with respect to the ‘Open Data and Big Data initiative’ factor; moreover, these two (HND and BSc) were notably different to respondents with an MSc and PhD. In B, the median ranks for HND, BSc, and MSc respondents were also the same at 4.0, but notably different from respondents with a PhD, in relation to the factor of ‘tourist attraction’. In C, the mean ranks for HND and BSc respondents were the same at 5.0, while those of MSc and PhD were also the same at 4.0. Based on these dimensions, MSc and PhD respondents tended to hold similar views on the factor of ‘transparent governance’ as a core factor of a Smart Institution. In D, both HND and BSc respondents were had median ranks of 5.0, and the same dimension in the box-plot. This also indicates that respondents with these levels of education held similar views on ‘international accessibility’ as a factor of a Smart Institution. In E, which relates to the factor of ‘innovative and proactive systems’, a visual inspection shows clear differences among the groups. Lastly in F, the median ranks for respondents with a BSc, MSc, and PhD were the same at 4.0 and showing a significant difference across the four groups in relation to ‘participation in decision-making’ as a Smart Institution factor. This indicates that there was a significant difference among the groups based on their education qualification in relation to the six factors under consideration.

7.3.2.3 Spearman (rho) Correlation Analysis of the CSF for Smart Institution

In assessing the relationship among the CSFs of the Smart Institution component, the same procedure described in 7.3.1.3 was followed using the Spearman’s Rank Order Correlation (rho). Table 7.20 presents the detailed correlation analysis of the CSF of Smart Institution.

Table 7.20: Spearman’s Correlation Analysis of the CSF for Smart Institution



Correlations

			INS1	INS2	INS3	INS4	INS5	INS6	INS7	INS8	INS9	INS10	INS11
Spearman's rho	INS1	Correlation Coefficient	1.000	.202*	.314**	.456**	.313**	.313**	.444**	.601**	.409**	.362**	0.168
		Sig. (2-tailed)		0.038	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.086
		N	105	105	105	105	105	105	105	105	105	105	105
	INS2	Correlation Coefficient	.202*	1.000	0.084	0.138	-0.055	-0.018	-0.018	0.111	0.143	0.092	0.132
		Sig. (2-tailed)	0.038		0.394	0.160	0.577	0.856	0.858	0.260	0.145	0.353	0.179
		N	105	105	105	105	105	105	105	105	105	105	105
	INS3	Correlation Coefficient	.314**	0.084	1.000	0.176	.364**	0.180	0.148	.238*	.199*	.414**	0.079
		Sig. (2-tailed)	0.001	0.394		0.073	0.000	0.066	0.133	0.014	0.042	0.000	0.423
		N	105	105	105	105	105	105	105	105	105	105	105
	INS4	Correlation Coefficient	.456**	0.138	0.176	1.000	.281**	.324**	.660**	.326**	.373**	.395**	.366**
		Sig. (2-tailed)	0.000	0.160	0.073		0.004	0.001	0.000	0.001	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105	105	105	105
	INS5	Correlation Coefficient	.313**	-0.055	.364**	.281**	1.000	.245*	.300**	0.137	0.166	.205*	0.041
		Sig. (2-tailed)	0.001	0.577	0.000	0.004		0.012	0.002	0.163	0.090	0.036	0.678
		N	105	105	105	105	105	105	105	105	105	105	105
	INS6	Correlation Coefficient	.313**	-0.018	0.180	.324**	.245*	1.000	.527**	.426**	.360**	.335**	.428**
		Sig. (2-tailed)	0.001	0.856	0.066	0.001	0.012		0.000	0.000	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105	105	105	105
	INS7	Correlation Coefficient	.444**	-0.018	0.148	.660**	.300**	.527**	1.000	.440**	.484**	.453**	.307**
		Sig. (2-tailed)	0.000	0.858	0.133	0.000	0.002	0.000		0.000	0.000	0.000	0.001
		N	105	105	105	105	105	105	105	105	105	105	105
	INS8	Correlation Coefficient	.601**	0.111	.238*	.326**	0.137	.426**	.440**	1.000	.428**	.423**	.309**
		Sig. (2-tailed)	0.000	0.260	0.014	0.001	0.163	0.000	0.000		0.000	0.000	0.001
		N	105	105	105	105	105	105	105	105	105	105	105
	INS9	Correlation Coefficient	.409**	0.143	.199*	.373**	0.166	.360**	.484**	.428**	1.000	.485**	.331**
		Sig. (2-tailed)	0.000	0.145	0.042	0.000	0.090	0.000	0.000	0.000		0.000	0.001
		N	105	105	105	105	105	105	105	105	105	105	105
	INS10	Correlation Coefficient	.362**	0.092	.414**	.395**	.205*	.335**	.453**	.423**	.485**	1.000	.270**
		Sig. (2-tailed)	0.000	0.353	0.000	0.000	0.036	0.000	0.000	0.000	0.000		0.005
		N	105	105	105	105	105	105	105	105	105	105	105
	INS11	Correlation Coefficient	0.168	0.132	0.079	.366**	0.041	.428**	.307**	.309**	.331**	.270**	1.000
		Sig. (2-tailed)	0.086	0.179	0.423	0.000	0.678	0.000	0.001	0.001	0.001	0.005	
		N	105	105	105	105	105	105	105	105	105	105	105

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The outcome of the analysis shows that the highest correlation coefficient is found between INS7 and INS4 (i.e. transparent governance and productivity) and the correlation coefficient between the two factors is positive calculated at rs=.660. The second highest positive correlation coefficient is found between INS1 and INS8 (i.e. entrepreneurship & sustainable development and international accessibility) which is calculated at rs=.601. The third highest positive correlation is found between INS7 and INS6 (i.e. transparent governance and Open Data and Big Data), which is calculated at rs=.527, whilst the fourth strongest correlation is found between INS9 and INS10 (i.e. innovative & proactive systems and social cohesion) and calculated at rs-.485. The fifth strongest correlation is found between INS7 and INS9 (i.e. transparent governance, and innovative & proactive systems), which is calculated at rs=.484, and the sixth is found between INS4 and INS1 (i.e. productivity, and entrepreneurship & sustainable development) and calculated at rs=.456. Finally, the seventh is found between INS7 and INS10 (i.e. transparent governance and social cohesion) and calculated at rs=.453.

Drawing from the results in Table 7.19, the correlation analysis of the CSFs for a Smart Institution tends to suggest that the most predominant is INS7. From all indications, transparent governance positively influences the productivity of the city, entrepreneurship and sustainable development, social cohesion, and Open Data and Big Data initiatives (namely, INS4, INS6, INS9, and ISN10 respectively). Similarly, to achieve entrepreneurship and sustainable development in a city, there must be adequate international accessibility. Another interesting finding from this analysis was that entrepreneurship and sustainable development positively influence productivity which indicates that, for a city to be productive, the institutional arrangements to encourage vibrant innovation for entrepreneurial growth need to be in place. Overall, the factor of transparent governance, entrepreneurship & sustainable development, social cohesion, productivity, innovative & proactive systems, international accessibility, and public & social services are considered critical in deploying Smart Institutions for Smart City development.

7.3.3 Analysis of the Critical Success Factors (CSFs) for Smart People

This section analyses the perception of Smart City stakeholders on KPIs for Smart People, in line with research question-d and objective four of this study. In their conceptual framework, Nam and Pardo (2011a) concluded that creativity is an important driver of Smart City innovation. They recognised that people, education, learning and knowledge have critical roles to play in Smart Cities. These assertions were further explored in this study by asking the respondents about their perceptions of some KPIs to measure the Smart People component in

Smart Cities. For consistency, the same five-point Likert scale was adopted for the list of factors extracted from academic journals, industry based Smart City standards, and the interviews with experts.

7.3.3.1 Reliability Test for Factors of People

Following the same procedures described in 7.3.1.1, the reliability assessment for the CSF of Smart People was carried out to validate the data. Table 7.21 presents the results of the reliability test.

Table 7.21: Reliability Statistics: Smart People CSFs

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N. of Items
0.802	0.811	8

Table 7.22: Item Total Statistics: Smart People CSFs

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Peo1	30.5	12.772	0.704	0.547	0.757
Peo2	30.98	11.596	0.607	0.421	0.764
Peo3	31.03	13.74	0.315	0.312	0.811
Peo4	30.62	12.353	0.648	0.51	0.759
Peo5	30.86	12.97	0.419	0.221	0.796
Peo6	30.66	13.439	0.438	0.292	0.79
Peo7	30.67	13.417	0.479	0.46	0.784
Peo8	30.56	12.999	0.585	0.476	0.77

As shown in Table 7.22, Cronbach’s Alpha coefficient for the Smart People factors is 0.802. This indicates that the internal consistency of the dataset for this study is also within the acceptable limit. Furthermore, the item-total statistical correlation values for all items were greater than the 0.3 threshold, which suggests a satisfactory outcome.

Again, in this part of the analysis, descriptive statistics were used to assess the views of the stakeholders on the priority factors for Smart People. This was achieved through an eight-item question on a five-point Likert scale that respondents could rank accordingly. The results are summarised in Table 7.23.

Table 7.23: Mean Score and Descriptive Statistics of Smart People CSFs

		Quality of Life	Social Awareness	Unity	Flexibility	Participation in Public Life	Quality Education	Creativity	Env that Support Productivity
N	Valid	105	105	105	105	105	105	105	105
	Missing	0	0	0	0	0	0	0	0
Mean		**4.63**	**4.14**	**4.1**	**4.5**	**4.27**	**4.47**	**4.46**	**4.56**
Median		5	4	4	5	5	5	5	5
Mode		5	5	4	5	5	5	5	5
Std. Deviation		0.639	0.945	0.838	0.761	0.88	0.748	0.707	0.692
Variance		0.409	0.893	0.702	0.579	0.774	0.559	0.501	0.479
Skewness		-1.734	-0.78	-0.782	-1.55	-0.984	-1.573	-0.925	-1.29
Std. Error of Skewness		0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236

Here, the item statistics for Smart People revealed that 'quality of life' with the highest mean score of 4.63 is the priority factor amongst respondents. The next priority factor is an 'environment that supports productivity' with a mean score of 4.56; this was closely followed by the of 'flexibility' factor with a mean score of 4.5. The 'quality education' factor, with a mean score of 4.47, and 'creativity', with mean score of 4.46, were also seen as priorities for assessing the people component of Smart Cities. As can be seen from Table 7.23, 'unity', 'social awareness', and 'participation in public life' with mean scores of 4.10, 4.14, and 4.27 respectively were scored by respondents as the lowest priority factors. Again, it is important to note that all the items were negatively skewed to the right.

7.3.3.2 The Kruskal-Wallis Test for the Smart People CSFs

In order to compare the variables across the categories of respondents based on the area of specialisation, the sector in which they work and their educational qualification, a further inferential test was conducted. Therefore, a non-parametric test for the independent samples was carried out using the Kruskal-Wallis test; this followed the same procedures as described in the previous sections, whilst Tables 7.24 and 7.25 present the results.

Table 7.24: The Kruskal-Wallis Test for the People Factors Based on Areas of Specialisation

Test Statistics^{a,b}

	Quality of Life	Social Awareness	Unity	Flexibility	Participation in Public Life	Quality Education	Creativity	Env that Support Productivity
Chi-Square	1.29	1.058	1.245	1.644	3.497	4.748	2.651	6.757
df	3	3	3	3	3	3	3	3
Asymp. Sig.	0.732	0.787	0.742	0.649	0.321	0.191	0.449	0.08

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' area of specialisation

As shown in Table 7.24, the p-values for all the items were above the recommended 0.05, indicating that there is no significant difference in the response pattern among the group (based on their area of specialisation) for the variables; this therefore demonstrated a 95% level of confidence. Again, all of the items have a very small Chi-square, which was as low as 1.0158.

The Kruskal-Wallis test for the factors of Smart People was repeated for the same data based on the educational qualification of the respondents. Table 7.25 presents the summary of the results.

Table 7.25: The Kruskal-Wallis Test for the Factors of People Based on Educational Qualifications

Test Statistics^{a,b}

	Quality of Life	Social Awareness	Unity	Flexibility	Participation in Public Life	Quality Education	Creativity	Environment that Support Productivity
Chi-Square	1.035	2.848	1.115	1.493	4.358	2.297	4.346	9.536
df	3	3	3	3	3	3	3	3
Asymp. Sig.	0.793	0.416	0.773	0.684	0.225	0.513	0.226	0.023

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' educational qualification

Here, the p-values for all the factors (quality of life, social awareness, unity, flexibility, participation in public life, quality education, and creativity) were above the 0.05 threshold, indicating that there is no significant difference in the responses among the group; this again, demonstrated a 95% level of confidence. However, the p-value for an ‘environment that supports productivity’ (0.023) was less than 0.05 and had a larger Chi-square of 9.536; this suggests that there is significant difference among the group’s responses based on their educational qualifications. Again, to confirm where the differences arose amongst the groups, a post-hoc test was run to examine the statistically significant differences. Figure 7.5 is the result of the post-hoc, independent-sample Kruskal-Wallis test, based on respondents’ educational qualifications.

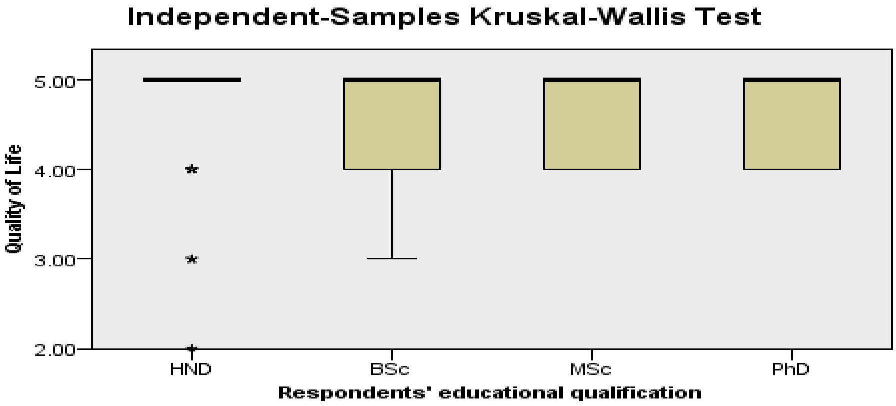


Figure 7-5: The Kruskal-Wallis Post-Hoc Test for People Factors Based on Respondents Education Qualification

Based on a visual inspection of Figure 7.5, it is sufficient to assume a difference in responses amongst the post-hoc analysis of the group. Although the median ranks for HND, BSc, MSc, and PhD respondents were the same at 5.0, the plots were different. In particular, the plot shows a double asterisks (*) sign for HND with respect to the ‘quality of life’. This indicates that there are underlying facts about the distribution of the median ranking by the stakeholders with HND qualifications concerning the quality of life as a core factor for assessing the people component of Smart Cities.

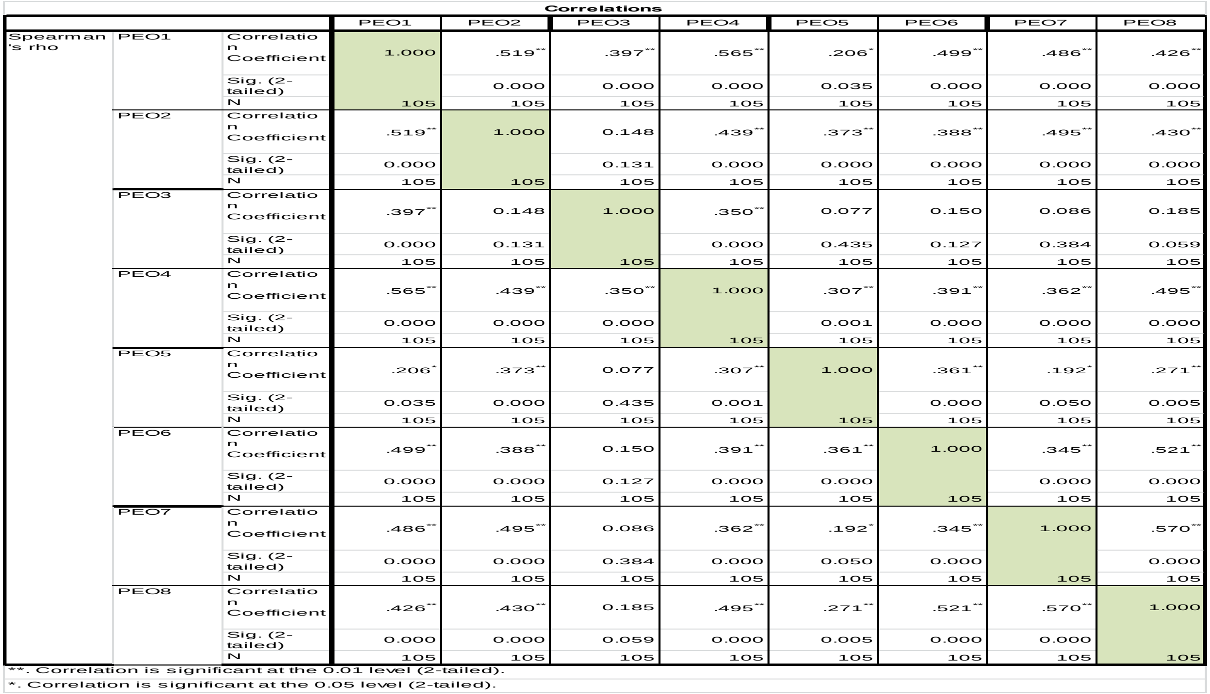
As noted in Table 7.21, the survey results emphasised the quality of life, an environment that supports productivity, quality education, creativity, and flexibility as core factors of Smart People. Although the flexibility factor was mentioned by interviewees, the degree of emphasis was comparitively low. It is, however, important to note that the factors of increased productivity, creativity, and quality education were emphasised during the interviews with experts. This is an indication, that there is strong agreement on these three factors between the survey respondents and the interviewees.

7.3.3.3 Spearman (rho) Correlation Analysis of the CSF for Smart People

In order to assess the relationship among the CSFs of Smart People, the same procedure described in 7.3.1.3 and 7.3.2.3 was also followed using the Spearman's Rank Order Correlation (rho) analysis. Table 7.26 presents the detailed correlation analysis of the CSFs of Smart People.

From Table 7.26, the highest correlation coefficient is found between PEO8 and PEO7 (i.e. an environment that supports productivity, and creativity); the correlation coefficient between the two factors is positive calculated at rs=.570. The second highest positive correlation coefficient is found between PEO1 and PEO4 (i.e. quality of life and flexibility), which is calculated at rs=.565. The third highest positive correlation is found between PEO6 and PEO8 (i.e. quality education, and an environment that supports productivity); this was calculated at rs=.521. The fourth strongest correlation is found between PEO2 and PEO1 (i.e. social awareness and quality of life), which was calculated at rs-.519. In addition, a strong positive correlation was also found between: PEO6 and PEO1 at rs=.499, PEO7 and PEO2 at rs=.495, PEO8 and PEO4 at rs=.495, and PEO8 and PEO1 at .486.

Table 7.26: Spearman's Correlation Analysis of the CSFs for Smart People



Correlations

			PEO1	PEO2	PEO3	PEO4	PEO5	PEO6	PEO7	PEO8
Spearman's rho	PEO1	Correlation Coefficient	1.000	$.519^{**}$	$.397^{**}$	$.565^{**}$	$.206^{*}$	$.499^{**}$	$.486^{**}$	$.426^{**}$
		Sig. (2-tailed)		0.000	0.000	0.000	0.035	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105
	PEO2	Correlation Coefficient	$.519^{**}$	1.000	0.148	$.439^{**}$	$.373^{**}$	$.388^{**}$	$.495^{**}$	$.430^{**}$
		Sig. (2-tailed)	0.000		0.131	0.000	0.000	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105
	PEO3	Correlation Coefficient	$.397^{**}$	0.148	1.000	$.350^{**}$	0.077	0.150	0.086	0.185
		Sig. (2-tailed)	0.000	0.131		0.000	0.435	0.127	0.384	0.059
		N	105	105	105	105	105	105	105	105
	PEO4	Correlation Coefficient	$.565^{**}$	$.439^{**}$	$.350^{**}$	1.000	$.307^{**}$	$.391^{**}$	$.362^{**}$	$.495^{**}$
		Sig. (2-tailed)	0.000	0.000	0.000		0.001	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105
	PEO5	Correlation Coefficient	$.206^{*}$	$.373^{**}$	0.077	$.307^{**}$	1.000	$.361^{**}$	$.192^{*}$	$.271^{**}$
		Sig. (2-tailed)	0.035	0.000	0.435	0.001		0.000	0.050	0.005
		N	105	105	105	105	105	105	105	105
	PEO6	Correlation Coefficient	$.499^{**}$	$.388^{**}$	0.150	$.391^{**}$	$.361^{**}$	1.000	$.345^{**}$	$.521^{**}$
		Sig. (2-tailed)	0.000	0.000	0.127	0.000	0.000		0.000	0.000
		N	105	105	105	105	105	105	105	105
	PEO7	Correlation Coefficient	$.486^{**}$	$.495^{**}$	0.086	$.362^{**}$	$.192^{*}$	$.345^{**}$	1.000	$.570^{**}$
		Sig. (2-tailed)	0.000	0.000	0.384	0.000	0.050	0.000		0.000
		N	105	105	105	105	105	105	105	105
	PEO8	Correlation Coefficient	$.426^{**}$	$.430^{**}$	0.185	$.495^{**}$	$.271^{**}$	$.521^{**}$	$.570^{**}$	1.000
		Sig. (2-tailed)	0.000	0.000	0.059	0.000	0.005	0.000	0.000	
		N	105	105	105	105	105	105	105	105

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Based on the evidence from the correlation analysis, it is sufficient to assume that the most predominant CSF for Smart People is PEO1. This is an indication that the quality of life factor in a Smart City positively influences a number of factors, including flexibility, social awareness, quality of education, and creativity. In addition, an environment that supports productivity can positively impact on creativity just as it positively impacts on the flexibility of people in the city. An interesting finding is that all the CSFs are positively related, which means all the factors contribute positively to the improvement of the characteristics of Smart People. The correlation analysis establishes that four factors, namely quality of life, creativity, quality of education, and an environment that supports productivity, are the core factors for Smart People. The next section discusses the core indicators of Smart Cities.

7.4 Analysis of Smart City's Key Performance Indicators

The stakeholders' perceptions on the metrics for measuring the Smartness of cities are reviewed in this section in line with research question-d and objective four. As established in Smart City journals, a number of core indicators were already used to measure the Smartness and performance of medium size cities in Europe (Giffinger et al., 2007). In addition, ISO 37120 Standard for Sustainable Development and the Resilience of Communities identified 100 measurement areas, which were classified into core and supporting indicators to measure the performance of cities. These metrics were explored by asking the survey participants to rate these indicators on a five-point Likert scale. The indicators were extracted from Smart City standards, journals, and the interviews with experts. The questions were also structured in a similar way to the pilot study discussed in Chapter 5.

7.4.1 Evaluation of the Smart Infrastructure Core Indicators

This section evaluates the core indicators of Smart People outlined in question three, section D of the survey instrument. These indicators are in line with existing knowledge established in the literature and the interviews with experts. Following the same procedure in the previous section, the reliability test of the data from the survey was assessed to establish the reliability of the research instrument. This was followed by descriptive statistics to compare the mean score of the indicators based on respondents' perceptions. In order to assess the difference among the groups, a non-parametric analysis was employed using Kruskal-Wallis H test. The details are summarised in the following sections.

7.4.1.1 Reliability Test for the Indicators of the Smart City Infrastructure

Again, the reliability assessment for the indicators was deemed fit to establish the extent to which the individual items related to one another, as discussed in the preceding sections. Because the questions that form the scales for the survey were also in multiple Likert questions, Cronbach's Alpha was used. Table 7.27 presents the results of the reliability test for the infrastructure indicators.

Table 7.27: Reliability Statistics: Smart Infrastructure Indicators

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N. of Items
0.841	0.82	15

It can be seen from Table 7.28, that the Cronbach's Alpha coefficient for the infrastructure indicators was 0.841. This indicates that the internal consistency of the dataset is within the acceptable limit. In addition, the item-total statistical correlation values for the majority of the items in Table 7.29 were greater than the 0.3 threshold, and the overall alpha value was more than the .7 limit.

Table 7.28: Item Total Statistics for the Infrastructure Indicators

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Infi1	57.03	47.528	0.181	0.973	0.844
Infi2	57.97	38.086	0.799	0.91	0.807
Infi3	58.07	39.447	0.663	0.76	0.817
Infi4	57.82	39.111	0.708	0.765	0.814
Infi5	57.01	47.356	0.206	0.924	0.843
Infi6	57.82	42.111	0.507	0.503	0.829
Infi7	57.02	47.519	0.183	0.979	0.844
Infi8	57.64	41.329	0.567	0.496	0.825
Infi9	57.95	38.969	0.75	0.813	0.811
Infi10	57.39	47.875	0.08	0.408	0.851
Infi11	57.3	46.887	0.22	0.469	0.843
Infi12	57.46	43.712	0.486	0.597	0.83
Infi13	57.55	45.307	0.268	0.333	0.843
Infi14	58.01	38.413	0.765	0.889	0.81
Infi15	56.9	47.229	0.258	0.373	0.841

7.4.1.2 Mean Score and Descriptive Statistics of the Indicators of Smart Infrastructure

It is important to note that question one to three in section D of the survey instrument sought to investigate the views of the stakeholders on the priority indicators for a Smart Infrastructure, Institution, and People. This was addressed through a 14-item question on a five-point Likert scale that the respondents could rank according to their own priority. The descriptive statistics for the core indicators for Smart Infrastructure are summarised in Table 7.29, which is based on question two in section D. In the table: Infi1 represents ‘no. of green energy sources & MW generated per inhabitant’; Infi2 is ‘no. of hospitals per inhabitant’; Infi3 denotes ‘robbotic mobile ambulance available per inhabitant’; Infi4 represents the ‘ratio of Smart wheelchairs per inhabitant’; Infi5 stands for the ‘no. of mobile phones as a percentage of the city population’; Infi6 denotes the ‘uninteruptible power available per inhabitant’; Infi7 stands for the ‘no. of internet access as a percentage of the city population’; Infi8 represents the ‘use of environmental friendly vehicles’; Infi9 stands for the ‘no. of autonomous vehicles’; Infi10 denotes ‘efficient transport networks & transport systems per inhabitant’; Infi11 represents a ‘reduction in greenhouse gas emissions per capita’; Infi12 stands for ‘improved air quality - CO, SO2, NO2 reduction’; Infi13 denotes the ‘existence of Smart equipment for real-time monitoring and control’; Infi14 represents a ‘reduction in noise pollution’, and Infi15 represents the ‘availability of smart technologies and broadband access’.

Table 7.29: Mean Scores and Descriptive Statistics of the Indicators of Smart Infrastructure

		Infi1	Infi2	Infi3	Infi4	Infi5	Infi6	Infi7	Infi8	Infi9	Infi10	Infi11	Infi12	Infi13	Infi14	Infi15
N	Valid	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		4.61	3.67	3.57	3.82	4.63	3.82	4.62	4.00	3.69	4.25	4.33	4.18	4.09	3.63	4.74
Median		5.00	4.00	4.00	4.00	5.00	4.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	5.00
Mode		5	4	4	4	5	4	5	4	4	4[a]	4	4	4	4	5
Std. Deviation		0.563	1.025	1.046	1.026	0.559	0.948	0.561	0.961	0.993	0.744	0.645	0.769	0.878	1.031	0.501
Variance		0.317	1.051	1.093	1.053	0.313	0.900	0.315	0.923	0.987	0.553	0.417	0.592	0.771	1.063	0.251
Skewness		-1.103	-0.325	-0.193	-0.498	-1.199	-0.524	-1.151	-0.729	-0.410	-0.580	-0.445	-0.582	-0.777	-0.434	-2.275
Std. Error of Skewness		0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236

a. Multiple modes exist. The smallest value is shown

In Table 7.29, Infi15 has the highest mean score at 4.74 and was thus perceived as the highest priority indicator for assessing Smart Infrastructure. In a decending ranked order of importance, this was followed by: Infi5 with a mean score of 4.63; Infi7 with a mean score of 4.62; Infi1 with a mean score of 4.61; Infi11 with a mean score of 4.33; Infi10 with a mean score of 4.25; Infi12 with a mean score of 4.18; Infi13 with a mean score of 4.09, and Infi8 with a mean score of 4.0. However, Infi3 had the lowest mean score of 3.57 and Infi2, Infi4, Infi6, Infi9, and Infi14 were seen as the low priority indicators for assessing a Smart City infrastructure.

7.4.1.3 The Kruskal-Wallis Test for Smart Infrastructure Indicators

This section also conducted inferential tests on the core indicators for assessing Smart City infrastructure using the Kruskal-Wallis H test. The Kruskal-Wallis H test was discussed in the methodology and the preceding sections in this chapter. Again, the test was conducted for the different groups of respondents based on their ‘area of specialisation’ and ‘educational qualification’; Tables 7.30 and 7.31 present the results.

Table 7.30: Kruskal-Wallis Test for Indicators of a Smart Infrastructure Based on Respondents' Area of Specialisation

	Infi1	Infi2	Infi3	Infi4	Infi5	Infi6	Infi7	Infi8	Infi9	Infi10	Infi11	Infi12	Infi13	Infi14	Infi15
Chi-Square	2.276	0.316	1.491	0.266	4.665	0.324	2.163	5.267	2.393	1.122	0.065	1.456	1.873	0.733	1.661
df	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.517	0.957	0.684	0.966	0.198	0.955	0.539	0.153	0.495	0.772	0.996	0.692	0.599	0.865	0.646

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' area of specialisation

As shown in Table 7.30, the p-values for all variables (under 'Asymp. Sig.') were above 0.05, indicating that there is no significant difference in the responses among the group about the variables; this indicates a 95% level of confidence based on the respondents' areas of specialisation. The test for the Smart Infrastructure indicators was repeated for the same set of variables based on the education qualification of the respondents (i.e. using the sector of the participants as a dependent variable). Table 7.31 presents the summary of the results.

Table 7.31: Kruskal-Wallis Test for Indicators of Smart Infrastructure Based on Respondents' Education Qualification

	Infi1	Infi2	Infi3	Infi4	Infi5	Infi6	Infi7	Infi8	Infi9	Infi10	Infi11	Infi12	Infi13	Infi14	Infi15
Chi-Square	13.925	11.448	3.065	6.419	12.216	3.751	13.030	7.387	6.564	0.558	1.738	5.872	2.588	10.035	3.046
df	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.003	0.010	0.382	0.093	0.007	0.290	0.005	0.061	0.087	0.906	0.628	0.118	0.460	0.018	0.385

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' educational qualification

As shown in Table 7.31, five items recorded a p-value of less than 0.05, and these are: Infi1, Infi2, Infi5, Infi7, and Infi14. This indicates that there is significant difference among the groups' responses based on their educational qualification. Again, to confirm where the differences occurred among the groups, a post-hoc test was run to examine the statistically significant differences. Figure 7.6 illustrates the results of post-hoc independent-sample Kruskal-Wallis test, based on education qualification.

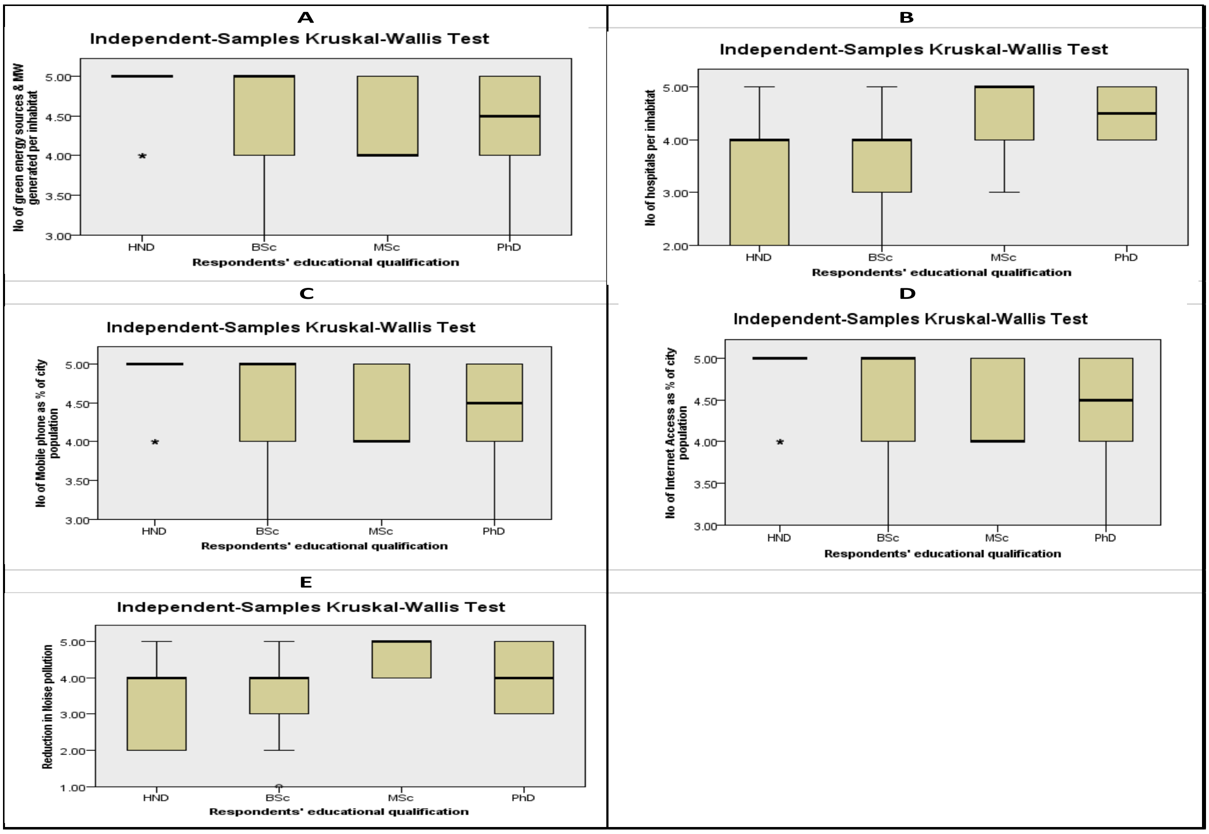


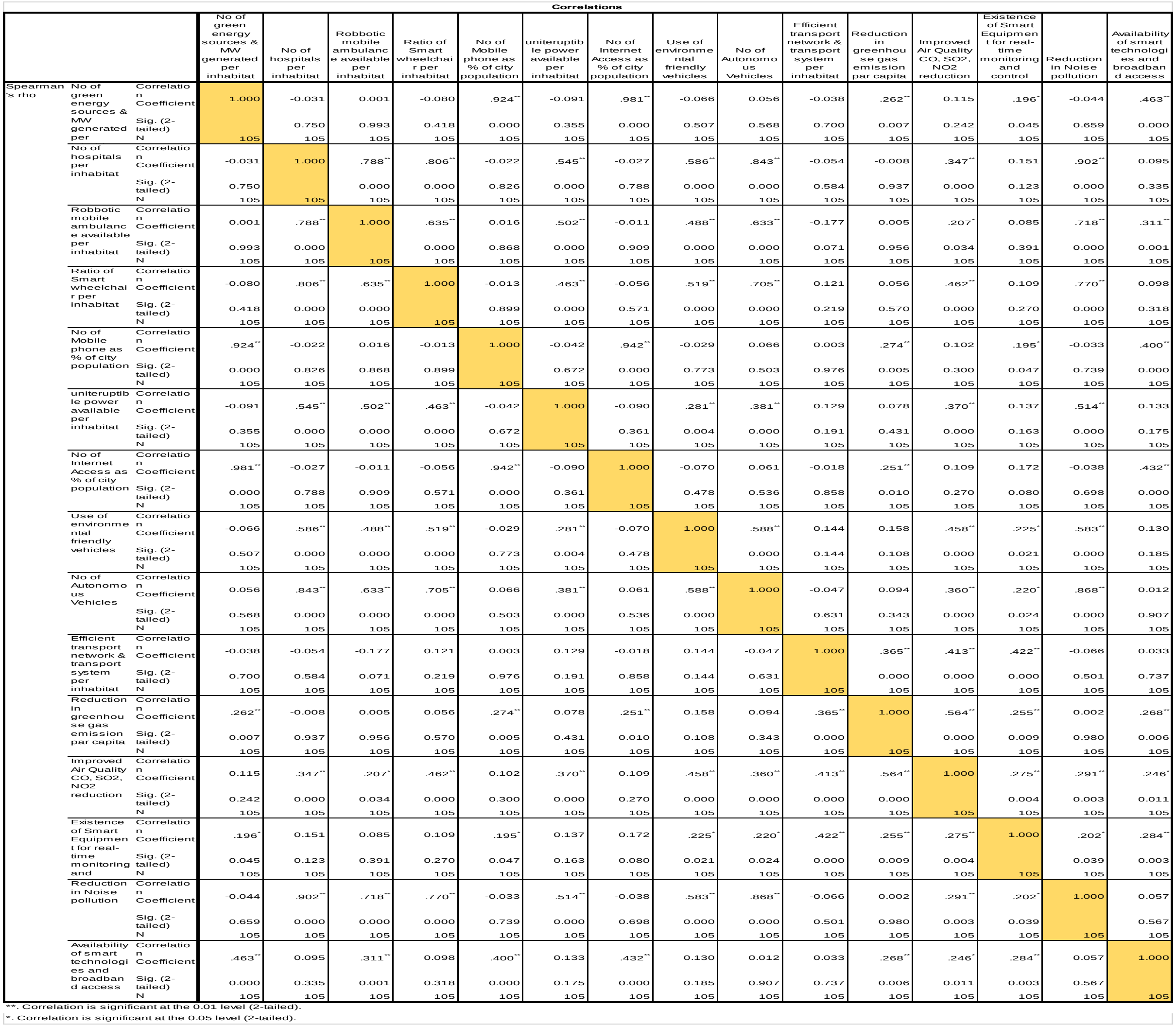
Figure 7-6: Kruskal-Wallis Post-Hoc Test for Institution Factors Based on Education Qualification

Based on a visual inspection of Figure 7.6, it is sufficient to assume difference responses in the post-hoc analysis in A, B, C, D, and E. In A, C, and D, the plots for the HND respondents are significantly different from the other groups, which relates to the: ‘number of green energy sources generated per inhabitant’, ‘number of Internet access as a percentage of the city population’, and a ‘reduction in noise pollution’. The median ranks for the groups also differ significantly across the variables, based on their education qualification; this relates to the five indicators where the disparities arose.

7.4.1.4 Spearman (rho) Correlation Analysis of the Smart Infrastructure Indicators

In this section, the Spearman’s Rank Order Correlation (rho) was also employed to assess the relationship among the KPIs of the Smart Infrastructure. This followed the same procedure as the preceding section for the correlation analysis of CSFs. Table 7.32 presents the detailed correlation analysis of the Smart Infrastructure indicators.

Table 7.32: Spearman's Correlation Analysis of the Indicators for a Smart Infrastructure



Correlations

			No of green energy sources & MW generated per inhabitat	No of hospitals per inhabitat	Robbotic mobile ambulance available per inhabitat	Ratio of Smart wheelchair per inhabitat	No of Mobile phone as % of city population	uniteruptible power available per inhabitat	No of Internet Access as % of city population	Use of environmental friendly vehicles	No of Autonomous Vehicles	Efficient transport network & transport system per inhabitat	Reduction in greenhouse gas emission par capita	Improved Air Quality CO, SO2, NO2 reduction	Existence of Smart Equipment for real-time monitoring and control	Reduction in Noise pollution	Availability of smart technologies and broadband access
Spearman's rho	No of green energy sources & MW generated per	Correlation Coefficient	1.000	-0.031	0.001	-0.080	.924**	-0.091	.981**	-0.066	0.056	-0.038	.262**	0.115	.196*	-0.044	.463**
		Sig. (2-tailed)		0.750	0.993	0.418	0.000	0.355	0.000	0.507	0.568	0.700	0.007	0.242	0.045	0.659	0.000
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	No of hospitals per inhabitat	Correlation Coefficient	-0.031	1.000	.788**	.806**	-0.022	.545**	-0.027	.586**	.843**	-0.054	-0.008	.347**	0.151	.902**	0.095
		Sig. (2-tailed)	0.750		0.000	0.000	0.826	0.000	0.788	0.000	0.000	0.584	0.937	0.000	0.123	0.000	0.335
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Robbotic mobile ambulance available per inhabitat	Correlation Coefficient	0.001	.788**	1.000	.635**	0.016	.502**	-0.011	.488**	.633**	-0.177	0.005	.207*	0.085	.718**	.311**
		Sig. (2-tailed)	0.993	0.000		0.000	0.868	0.000	0.909	0.000	0.000	0.071	0.956	0.034	0.391	0.000	0.001
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Ratio of Smart wheelchair per inhabitat	Correlation Coefficient	-0.080	.806**	.635**	1.000	-0.013	.463**	-0.056	.519**	.705**	0.121	0.056	.462**	0.109	.770**	0.098
		Sig. (2-tailed)	0.418	0.000	0.000		0.899	0.000	0.571	0.000	0.000	0.219	0.570	0.000	0.270	0.000	0.318
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	No of Mobile phone as % of city population	Correlation Coefficient	.924**	-0.022	0.016	-0.013	1.000	-0.042	.942**	-0.029	0.066	0.003	.274**	0.102	.195*	-0.033	.400**
		Sig. (2-tailed)	0.000	0.826	0.868	0.899		0.672	0.000	0.773	0.503	0.976	0.005	0.300	0.047	0.739	0.000
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	uniteruptible power available per inhabitat	Correlation Coefficient	-0.091	.545**	.502**	.463**	-0.042	1.000	-0.090	.281**	.381**	0.129	0.078	.370**	0.137	.514**	0.133
		Sig. (2-tailed)	0.355	0.000	0.000	0.000	0.672		0.361	0.004	0.000	0.191	0.431	0.000	0.163	0.000	0.175
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	No of Internet Access as % of city population	Correlation Coefficient	.981**	-0.027	-0.011	-0.056	.942**	-0.090	1.000	-0.070	0.061	-0.018	.251**	0.109	0.172	-0.038	.432**
		Sig. (2-tailed)	0.000	0.788	0.909	0.571	0.000	0.361		0.478	0.536	0.858	0.010	0.270	0.080	0.698	0.000
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Use of environmental friendly vehicles	Correlation Coefficient	-0.066	.586**	.488**	.519**	-0.029	.281**	-0.070	1.000	.588**	0.144	0.158	.458**	.225*	.583**	0.130
		Sig. (2-tailed)	0.507	0.000	0.000	0.000	0.773	0.004	0.478		0.000	0.144	0.108	0.000	0.021	0.000	0.185
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	No of Autonomous Vehicles	Correlation Coefficient	0.056	.843**	.633**	.705**	0.066	.381**	0.061	.588**	1.000	-0.047	0.094	.360**	.220*	.868**	0.012
		Sig. (2-tailed)	0.568	0.000	0.000	0.000	0.503	0.000	0.536	0.000		0.631	0.343	0.000	0.024	0.000	0.907
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Efficient transport network & transport system per inhabitat	Correlation Coefficient	-0.038	-0.054	-0.177	0.121	0.003	0.129	-0.018	0.144	-0.047	1.000	.365**	.413**	.422**	-0.066	0.033
		Sig. (2-tailed)	0.700	0.584	0.071	0.219	0.976	0.191	0.858	0.144	0.631		0.000	0.000	0.000	0.501	0.737
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Reduction in greenhouse gas emission par capita	Correlation Coefficient	.262**	-0.008	0.005	0.056	.274**	0.078	.251**	0.158	0.094	.365**	1.000	.564**	.255**	0.002	.268**
		Sig. (2-tailed)	0.007	0.937	0.956	0.570	0.005	0.431	0.010	0.108	0.343	0.000		0.000	0.009	0.980	0.006
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Improved Air Quality CO, SO2, NO2 reduction	Correlation Coefficient	0.115	.347**	.207*	.462**	0.102	.370**	0.109	.458**	.360**	.413**	.564**	1.000	.275**	.291**	.246*
		Sig. (2-tailed)	0.242	0.000	0.034	0.000	0.300	0.000	0.270	0.000	0.000	0.000	0.000		0.004	0.003	0.011
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Existence of Smart Equipment for real-time monitoring and	Correlation Coefficient	.196*	0.151	0.085	0.109	.195*	0.137	0.172	.225*	.220*	.422**	.255**	.275**	1.000	.202*	.284**
		Sig. (2-tailed)	0.045	0.123	0.391	0.270	0.047	0.163	0.080	0.021	0.024	0.000	0.009	0.004		0.039	0.003
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Reduction in Noise pollution	Correlation Coefficient	-0.044	.902**	.718**	.770**	-0.033	.514**	-0.038	.583**	.868**	-0.066	0.002	.291**	.202*	1.000	0.057
		Sig. (2-tailed)	0.659	0.000	0.000	0.000	0.739	0.000	0.698	0.000	0.000	0.501	0.980	0.003	0.039		0.567
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
	Availability of smart technologies and broadband access	Correlation Coefficient	.463**	0.095	.311**	0.098	.400**	0.133	.432**	0.130	0.012	0.033	.268**	.246*	.284**	0.057	1.000
		Sig. (2-tailed)	0.000	0.335	0.001	0.318	0.000	0.175	0.000	0.185	0.907	0.737	0.006	0.011	0.003	0.567	
		N	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Here, the most significant, or highest, correlation coefficient is found between INFi1 and INFi7 (i.e. the 'no. of green energy sources & MW generated per inhabitant' and the 'no. of Internet access as a percentage of the city population') and the correlation coefficient between the two factors is positive calculated at rs=.981. The second highest positive correlation coefficient is found between INFi7 and INFi5 (i.e. the 'no. of Internet access as a percentage of the city population' and the 'no. of mobile phones as a percentage of the city population'), which was calculated at rs=.942. The third highest positive correlation coefficient is found between INFi1 and INFi5 (i.e. the 'no. of green energy sources & MW generated per inhabitant' and the 'no. of mobile phone as a percentage of the city population'), which was calculated at rs=.924. The other high positive correlations were found between: INFi2 and INFi14 (rs=.902); INFi9 and INFi14; INFi2 and INFi9; INFi2 and INFi4; INFi2 and INFi3; INFi4 and INFi14; INFi3 and INFi14; INFi4 and INFi9; INFi3 and INFi4; INFi3 and INFi9; INFi8 and INFi9; INFi2 and

INFi8; INFi11 and INFi12; INFi2 and INFi6; INFI4 and INFi8; INFi6 and INFi14, and INFi3 and INFi6. Therefore, based on the results of the correlation analysis of the KPIs, it is sufficient to suggest that the predominant indicators of a Smart City infrastructure are INFi4, INFi2, INFi3, and INFi8.

7.4.2 Evaluation of the Smart Institution Core Indicators

As discussed in 7.4.1, the same analysis was conducted for the Smart Institution component. These analyses included the reliability test of the data from the survey to establish the reliability of the research instrument. This was followed by descriptive statistics to compare the mean score of the indicators based on respondents' perceptions and the non-parametric analysis using the Kruskal-Wallis H test. The details are summarised in the following sections.

7.4.2.1 Reliability Test for Smart Institution Core Indicators

In establishing the reliability of the data used for the Smart Institution indicators in this study, the internal consistency of the items were assessed using Cronbach's Alpha, as analysed in the previous section for the Smart Infrastructure Indicators. Table 7.33 presents the results of the reliability test for the indicators.

Table 7.33: Reliability Statistics: Smart Institution Indicators

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N. of Items
0.903	0.912	11

The results in Tables 7.33 and 7.34 shows that Cronbach's Alpha coefficient for the Smart Institution indicators is 0.903. This indicates that the internal consistency of the dataset is within the acceptable limit. In addition, the item-total statistical correlation values for all the items were greater than the 0.3 threshold. The overall alpha value is 0.903, which is greater than .7 limit, which confirms the reliability of the data.

Table 7.34: Item Total Statistics for the Institution Indicators

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Insi1	44.70	24.575	0.814	0.778	0.883
Insi2	44.29	27.764	0.696	0.684	0.892
Insi3	44.47	25.655	0.807	0.760	0.884
Insi4	44.46	25.577	0.743	0.810	0.888
Insi5	44.44	27.556	0.635	0.548	0.894
Insi6	44.36	27.099	0.741	0.643	0.890
Insi7	44.48	28.925	0.497	0.543	0.901
Insi8	44.76	27.549	0.332	0.364	0.921
Insi9	44.62	25.700	0.806	0.731	0.884
Insi10	44.54	26.635	0.699	0.716	0.891
Insi11	44.50	28.637	0.495	0.653	0.901

7.4.2.2 Mean Score and Descriptive Statistics of the Smart Institution Indicators

As noted in the preceding section, question two in section D of the survey instrument sought to investigate the views of stakeholders on the priority indicators for a Smart Institution. This was addressed through an 11-item question in a five-point Likert scale format which enabled the respondents to rank according to their own priority. The descriptive statistics for the core indicators for Smart Institution are summarised in Table 7.35. In the table: Insi1 represents ‘percentage increase in the self-employment rate’; Insi2 stands for the ‘satisfaction with the quality of healthcare delivery’; Insi3 denotes the ‘satisfaction with the quality of schools and key public institutions’; Insi4 represents the ‘no. of qualified doctors, nurses, and health attendants per inhabitant’; Insi5 stands for a ‘reduction in the crime rate’; Insi6 denotes ‘satisfaction with the safety of life and properties’; Insi7 represents an ‘increased number of innovation hubs’; Insi8 stands for the ‘no. of visitors to tourist centres’; Insi9 denotes the ‘number of crimes profiled in real-time’; Insi10 represents the ‘revenue generated in tourism as a percentage of the total revenue’, and Insi11 represents an ‘increased number of new registered businesses’.

Table 7.35: Mean Score and Descriptive Statistics of the Smart Institution Indicators

		Insi1	Insi2	Insi3	Insi4	Insi5	Insi6	Insi7	Insi8	Insi9	Insi10	Insi11
N	Valid	105	105	105	105	105	105	105	105	105	105	105
	Missing	0	0	0	0	0	0	0	0	0	0	0
Mean		**4.26**	**4.68**	**4.50**	**4.50**	**4.52**	**4.60**	**4.49**	**4.20**	**4.34**	**4.42**	**4.46**
Median		4.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.00	5.00	5.00
Mode		5	5	5	5	5	5	5	5	5	5	5
Std. Deviation		0.855	0.563	0.735	0.798	0.637	0.614	0.557	1.032	0.732	0.704	0.605
Variance		0.731	0.317	0.541	0.637	0.406	0.377	0.310	1.065	0.535	0.496	0.366
Skewness		-0.901	-1.557	-1.092	-1.520	-1.001	-1.281	-0.454	-1.001	-1.089	-0.970	-0.630
Std. Error of Skewness		0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236

As shown in Table 7.35, Insi2 has the highest mean score of 4.68, which was the highest priority. This is followed by the priority indicators for assessing Smart Institution, in decending rated order of importance: Insi6 with a mean score of 4.60; Insi5 with a mean score of 4.52; Insi3 and Insi4 each had a mean score of 4.50; Insi7 had a mean score of 4.49, and Insi11 had a mean score of 4.46. However, Insi8 had the lowest mean score of 4.20 and Insi1, Insi9, and Insi10 were seen by these respondents as low priority indicators for assessing a Smart City institution.

7.4.2.3 The Kruskal-Wallis Test for Smart Institution Indicators

This section also outlines the results from the Kruskal-Wallis H test which assessed disparities among the different groups of respondents based on their ‘area of specialisation’ and ‘educational qualification’. Tables 7.36 and 7.37 present the results.

Table 7.36: Kruskal-Wallis Test for Smart Institution Indicators Based on Respondents’ Areas of Specialisation

	Insi1	Insi2	Insi3	Insi4	Insi5	Insi6	Insi7	Insi8	Insi9	Insi10	Insi11
Chi-Square	4.755	1.286	0.666	3.015	3.420	2.546	5.579	1.009	2.115	3.410	2.048
df	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.191	0.733	0.881	0.389	0.331	0.467	0.134	0.799	0.549	0.333	0.563

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' area of specialisation

As shown in Table 7.37, the p-values for all the variables (listed as 'Asymp. Sig.') were above 0.05. This indicated that there was no significant difference in the responses among the group concerning the variables; this demonstrated a 95% level of confidence based on the respondents' area of specialisation. The test for Smart Institution indicators was repeated for the same set of variables based on the education qualification of the respondents (i.e. using the sector of participants as a dependent variable). Table 7.37 presents a summary of the results.

Table 7.37: The Kruskal-Wallis Test for Smart Institution Indicators Based on Education Qualification

	Insi1	Insi2	Insi3	Insi4	Insi5	Insi6	Insi7	Insi8	Insi9	Insi10	Insi11
Chi-Square	5.484	12.441	8.929	17.025	13.270	13.232	3.639	12.912	12.180	4.873	1.416
df	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.140	0.006	0.030	0.001	0.004	0.004	0.303	0.005	0.007	0.181	0.702

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' educational qualification

As shown in Table 7.37, seven items recorded a p-value of less than 0.05, namely: Insi2, Insi3, Insi4, Insi5, Insi6, Insi8, and Insi9. This indicates that there was a significant difference among the responses based on their education qualification. Again, to confirm where the differences occurred, a post-hoc test was run to examine the statistically significant differences. Figure 7.7 illustrates the results of post-hoc independent-sample from the Kruskal-Wallis test, based on education qualifications.

Based on a visual inspection of Figure 7.7, it can be assumed that the different responses in the post-hoc analysis are shown in A, B, C, D, E, F and G. In A, the HND and BSc groups have the same median ranks at 5.0 but with different plots, while the MSc and PhD groups have the same median ranks of 4.0 and similar plots for 'satisfaction with the quality of healthcare delivery'. The patterns were similar in B with respect to 'satisfaction with the quality of schools and key public institutions'. In C, the median ranks for HND and BSc were also the same, which was similarly the case for the median ranks for the MSc and PhD respondents ; however, there were different plots across the groups with respect to the 'no. of qualified doctors, nurses, and health attendants per inhabitant'. In D, the HND and BSc groups had the same median ranks at 5.0 but with different plots while the MSc and PhD groups had the same median ranks of 4.0, and again with different plots in relation to the indicator ‘a reduction in the crime rate’. The patterns were also similar in E with respect to the ‘satisfaction with the safety of life and property’. Furthermore, in F, the BSc, MSc, and PhD groups had the same median ranks but with different plots, while the HND group had the highest median rank of 5.0 with double asterisks against the ‘no. of visitors to tourist centres’. Finally in G, the BSc, MSc, and PhD groups had the same median ranks but with different plots, while, the HND group had the highest median rank at 5.0 showing that there were significant differences among the groups in relation to the ‘number of crimes profiled in real-time’. Overall, the post-hoc analysis revealed that there are statistically significant differences among the groups based on their education qualification in relation to the seven indicators where the disparities arose.

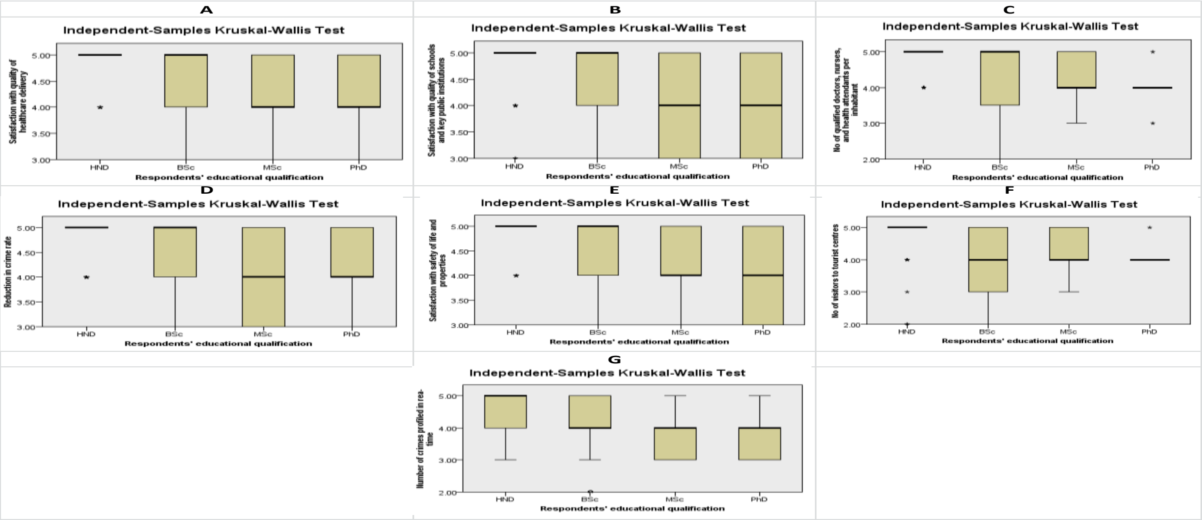


Figure 7-7: Kruskal-Wallis Post-Hoc Test for Smart Institution Indicators Based on Education Qualification

7.4.2.4 Spearman (rho) Correlation Analysis of the Indicators for Smart Institution

This section uses Table 7.38 to explain the relationship among the core indicators of the Smart Institution component. Again, the Spearman’s Rank Order Correlation (rho) was adopted as a tool for this analysis.

Table 7.38: Spearman's Correlation Analysis of the Indicators for a Smart Institution

Correlations

			INSi1	INSi2	INSi3	INSi4	INSi5	INSi6	INSi7	INSi8	INSi9	INSi10	INSi11
Spearman's rho	INSi1	Correlation Coefficient	1.000	.638**	.682**	.689**	.739**	.491**	.456**	.322**	.630**	.539**	.415**
		Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi2	Correlation Coefficient	.638**	1.000	.766**	.764**	.489**	.637**	.337**	.452**	.495**	.579**	.395**
		Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi3	Correlation Coefficient	.682**	.766**	1.000	.723**	.650**	.595**	.363**	.414**	.644**	.480**	.318**
		Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi4	Correlation Coefficient	.689**	.764**	.723**	1.000	.619**	.498**	0.147	.632**	.512**	.361**	0.133
		Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000	0.135	0.000	0.000	0.000	0.177
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi5	Correlation Coefficient	.739**	.489**	.650**	.619**	1.000	.531**	.441**	.320**	.613**	.438**	.291**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000	0.000	0.001	0.000	0.000	0.003
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi6	Correlation Coefficient	.491**	.637**	.595**	.498**	.531**	1.000	.509**	.309**	.590**	.548**	.354**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000	0.001	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi7	Correlation Coefficient	.456**	.337**	.363**	0.147	.441**	.509**	1.000	-0.012	.563**	.507**	.550**
		Sig. (2-tailed)	0.000	0.000	0.000	0.135	0.000	0.000		0.900	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi8	Correlation Coefficient	.322**	.452**	.414**	.632**	.320**	.309**	-0.012	1.000	.285**	0.164	0.007
		Sig. (2-tailed)	0.001	0.000	0.000	0.000	0.001	0.001	0.900		0.003	0.094	0.940
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi9	Correlation Coefficient	.630**	.495**	.644**	.512**	.613**	.590**	.563**	.285**	1.000	.586**	.452**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003		0.000	0.000
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi10	Correlation Coefficient	.539**	.579**	.480**	.361**	.438**	.548**	.507**	0.164	.586**	1.000	.706**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.094	0.000		0.000
		N	105	105	105	105	105	105	105	105	105	105	105
	INSi11	Correlation Coefficient	.415**	.395**	.318**	0.133	.291**	.354**	.550**	0.007	.452**	.706**	1.000
		Sig. (2-tailed)	0.000	0.000	0.001	0.177	0.003	0.000	0.000	0.940	0.000	0.000	
		N	105	105	105	105	105	105	105	105	105	105	105

**. Correlation is significant at the 0.01 level (2-tailed).

The highest positive correlation coefficient was found between INSi2 and INSi3 (i.e. 'satisfaction with the quality of healthcare delivery' and 'satisfaction with the quality of schools/key public institutions' and the correlation coefficient between the two indicators is calculated at rs=.766. The second highest positive correlation coefficient was found between INSi2 and INSi4 (i.e. 'satisfaction with the quality of healthcare delivery' and the 'no. of qualified doctors, nurses, and health attendants per inhabitant'), which was calculated at rs=.764. The third highest positive correlation was found between INSi1 and INSi5 (i.e. 'the percentage increase in the self-employment rate' and 'reduction in the crime rate'), which was calculated at rs=.739. The other strong positive correlations included: INSi3 and INSi4; INSi10 and INSi11; INSi1 and INSi4; INSi1 and INSi3; INSi3 and INSi5; INSi3 and INSi9; INSi1 and INSi2; INSi2 and INSi6; INSi4 and INSi8; INSi1 and INSi9; INSi4 and INSi5 and INSi5 and INSi9. It is important to note that the relationships among the indicators of a Smart Institution are all positive; this infers that an improvement in any of the indicators will impact positively on all other variables.

Based on the results from the correlation analysis of the Smart Institution, it is possible to suggest that the most predominant indicator for assessing a Smart City institution is INSi9. This is an indication that Smart City stakeholders view the issue of crime management or the real-time profiling of criminal activities as an important issue in Smart Cities. Interestingly, this indicator has a strong positive relationship with every other indicator except INSi8 (i.e. the 'no. of visitors to tourist centres'). Contrary to the common belief that cities with less crimes should attract more tourists, this is not the case with this survey's respondents. Another important assumption is that satisfaction with number of qualified doctors, nurses, and healthcare attendants enhances the quality of healthcare delivery. Overall, satisfaction with safety, life, and property, an increase in self-employment, and satisfaction with the quality of healthcare delivery are key performance indicators for assessing a Smart Institution in a Smart City.

7.4.3 Evaluation of the Smart People Core Indicators

This section evaluates the core indicators of Smart People outlined in question three in section D of the survey instrument. This reflects existing knowledge observed in the literature and findings from the interviews with experts. The reliability test of the data from the survey was conducted to establish the reliability of the research instrument; this was followed by the descriptive statistics to compare the mean scores of the indicators based on respondents' perceptions. In order to assess the differences among the groups, a non-parametric analysis was employed using the Kruskal-Wallis H test. The details are summarised in the following sections.

7.4.3.1 Reliability Test for Smart People Core Indicators

In establishing the reliability of the data used for the Smart People indicators in this study, the internal consistency of the items were assessed using Cronbach's Alpha, as analysed in the previous section for the Smart Infrastructure and Smart Institution indicators. Table 7.39 presents the results of the reliability test for the people indicators.

Table 7.39: Reliability Statistics: Smart People Indicators

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N. of Items
0.854	0.841	9

Table 7.40: Item Total Statistics for the Smart People Indicators

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Peoi1	30.95	39.392	-0.174	0.365	0.894
Peoi2	31.42	27.803	0.848	0.766	0.809
Peoi3	31.70	28.806	0.669	0.635	0.828
Peoi4	31.49	29.791	0.642	0.601	0.832
Peoi5	31.47	29.309	0.711	0.745	0.825
Peoi6	31.40	31.531	0.467	0.455	0.850
Peoi7	31.45	29.846	0.695	0.655	0.827
Peoi8	31.21	31.898	0.538	0.438	0.842
Peoi9	31.35	28.884	0.752	0.638	0.820

Tables 7.39 and 7.40 above show that the Cronbach’s Alpha coefficient for the Smart People indicator is 0.854; this indicates that the internal consistency of the dataset is within the acceptable limit. In addition, the item-total statistical correlation values for all items were greater than the 0.3 threshold, with the exception of Peoi1, which had a negative correlation (-0.174). The overall alpha value was 0.854 which was more than the .7 limits; this confirms the reliability of the data.

7.4.3.2 Mean Score and Descriptive Statistics of Smart People Indicators

Here, question three in section D of the survey instrument sought to investigate the ranking of the stakeholders on the priority indicators for Smart People. This was addressed through a 9-item question on a five-point Likert scale that enabled respondents to rank according to their own priority. The descriptive statistics and the mean score for Smart People are summarised in Table 7.41. In the table: Peoi1 represents ‘the percentage of educated citizens at different levels of education’;, Peoi2 denotes the ‘no. of skilled citizens as a percentage of the city population’; Peoi3 stands for ‘increased life expectancy’; Peoi4 represents the ‘no. of voter turnout as a percentage of the city population’; Peoi5 denotes the ‘no. of healthy citizens as a percentage of the city population’; Peoi6 stands for the ‘material living conditions’; Peoi7 represents the ‘GDP as a percentage of employed citizens in the city’; Peoi8 denotes the ‘ratio of employed to unemployed citizens’, and Peoi9 stands for the ‘no. of entrepreneurs as a percentage of the city population’.

Table 7.41: Mean Score and Descriptive Statistics of the Smart People Indicators

		Peoi1	Peoi2	Peoi3	Peoi4	Peoi5	Peoi6	Peoi7	Peoi8	Peoi9
N	Valid	105	105	105	105	105	105	105	105	105
	Missing	0	0	0	0	0	0	0	0	0
Mean		4.35	3.89	3.60	3.82	3.84	3.90	3.86	4.10	3.95
Median		5.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Mode		5	4	4	4	4	4[a]	4	4	5
Std. Deviation		0.796	1.050	1.140	1.054	1.030	1.070	0.985	0.915	1.032
Variance		0.634	1.102	1.300	1.111	1.060	1.145	0.970	0.837	1.065
Skewness		-1.190	-0.581	-0.232	-0.482	-0.530	-0.768	-0.569	-0.883	-0.653
Std. Error of Skewness		0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236

a. Multiple modes exist. The smallest value is shown

As shown in Table 7.41, Peoi1 had the highest mean score of 4.35, and thus was perceived as the highest priority. This was followed by: Peoi8 with a mean score of 4.10, Peoi9 with a mean score of 3.95, Peoi6 with a mean score of 3.90, and Peoi2 with a mean score of 3.89 which were also perceived as priority indicators for assessing Smart People. However, Peoi3 with the lowest mean score of 3.60 and Peoi4, Peoi5, and Peoi7 were seen as the low priority indicators for assessing the Smart People component.

7.4.3.3 The Kruskal-Wallis Test for the Smart People Indicators

Following the non-parametric test described in the previous section, this section also conducted a Kruskal-Wallis H test to assess for disparities among the different groups of respondents based on their 'area of specialisation' and 'educational qualification'. Tables 7.42 and 7.43 present the results.

Table 7.42: Kruskal-Wallis Test for Smart People Indicators Based on Respondents' Area of Specialisation

	Peoi1	Peoi2	Peoi3	Peoi4	Peoi5	Peoi6	Peoi7	Peoi8	Peoi9
Chi-Square	0.299	2.971	2.591	1.855	1.723	1.941	2.806	5.577	0.680
df	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.960	0.396	0.459	0.603	0.632	0.585	0.423	0.134	0.878

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' area of specialisation

As shown in Table 7.42, the p-values for all variables (listed against 'Asymp. Sig.') were above 0.05, indicating that there was no significant difference in the responses among the group for the variables; This demonstrated a 95% level of confidence based on the respondents' areas of specialisation. The test for the Smart People indicators was repeated for the same set of variables based on respondents' educational qualifications (i.e. using the sector of participants as a dependent variable). Table 7.43 presents the summary of the results.

Table 7.43: The Kruskal-Wallis Test for the Smart Institution Indicators Based on Respondents' Education Qualification

	Peoi1	Peoi2	Peoi3	Peoi4	Peoi5	Peoi6	Peoi7	Peoi8	Peoi9
Chi-Square	8.319	14.351	18.415	15.946	8.102	11.335	5.052	8.120	8.394
df	3	3	3	3	3	3	3	3	3
Asymp. Sig.	0.040	0.002	0.000	0.001	0.044	0.010	0.168	0.044	0.039

a. Kruskal Wallis Test

b. Grouping Variable: Respondents' educational qualification

As shown in Table 7.43, most items recorded a p-value of less than 0.05, except for Peoi7 which recorded a p-value of 0.158. The items with a p-value of less than 0.05, which includes Peoi1, Peoi2, Peoi3, Peoi4, Peoi5, Peoi6, Peoi8, and Peoi9, indicated that there was a significant difference among the groups' responses based on their educational qualifications. To confirm where the differences occurred among the groups, a post-hoc test was run to examine the statistically significant differences. Figure 7.8 ilustrates the results of the post-hoc independent-sample Kruskal-Wallis test, based on educational qualification.

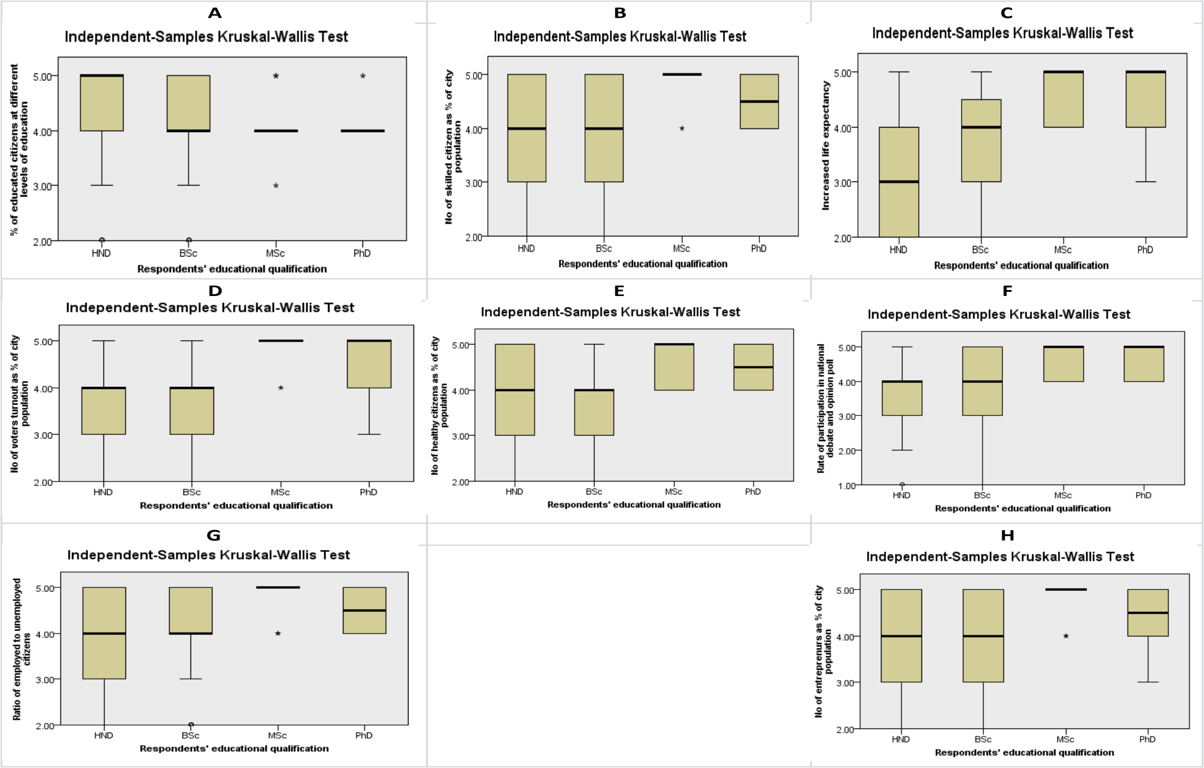


Figure 7-8: The Kruskal-Wallis Post-Hoc Test for the Smart People Indicators Based on Respondents' Education Qualifications

Based on a visual inspection (Figure 7.8), it is sufficient to assume a difference in responses in the post-hoc analysis (shown in A, B, C, D, E, F, and H). While respondents with HND and BSc backgrounds tended to have similar views on certain indicators, as reflected in B, D, and H, respondents with MSc and PhD backgrounds tended to have divergent views on various issues, with the exception of the 'percentage of educated citizens at different levels of education' (as shown in A) and the 'material living conditions' (as shown in F). Overall, the post-hoc analysis clearly revealed that there were statistically significant differences among the groups based on their education qualification, which relates to the eight indicators that recorded less than 0.05 under 'Asymp. Sig' (shown in Table 7.43).

7.4.3.4 Spearman (rho) Correlation Analysis of the CSF for Smart Institution

In this section, Table 7.44 is used to explain the relationship among the core indicators of Smart People. Again, the procedures for the Spearman's Rank Order Correlation (rho) described in the preceding sections was adopted for this analysis.

Table 7.44: Spearman's Correlation Analysis of the Indicators for Smart People

Correlations

			PEOi1	PEOi2	PEOi3	PEOi4	PEOi5	PEOi6	PEOi7	PEOi8	PEOi9
Spearman's rho	PEOi1	Correlation Coefficient	1.000	-0.188	-.274**	-.282**	0.123	-.325**	-.206*	-0.106	-0.071
		Sig. (2-tailed)		0.055	0.005	0.004	0.213	0.001	0.035	0.280	0.474
		N	105	105	105	105	105	105	105	105	105
	PEOi2	Correlation Coefficient	-0.188	1.000	.559**	.612**	.656**	.512**	.625**	.589**	.714**
		Sig. (2-tailed)	0.055		0.000	0.000	0.000	0.000	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105	105
	PEOi3	Correlation Coefficient	-.274**	.559**	1.000	.710**	.432**	.517**	.362**	.267**	.431**
		Sig. (2-tailed)	0.005	0.000		0.000	0.000	0.000	0.000	0.006	0.000
		N	105	105	105	105	105	105	105	105	105
	PEOi4	Correlation Coefficient	-.282**	.612**	.710**	1.000	.361**	.533**	.419**	.396**	.520**
		Sig. (2-tailed)	0.004	0.000	0.000		0.000	0.000	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105	105
	PEOi5	Correlation Coefficient	0.123	.656**	.432**	.361**	1.000	.202*	.608**	.385**	.645**
		Sig. (2-tailed)	0.213	0.000	0.000	0.000		0.039	0.000	0.000	0.000
		N	105	105	105	105	105	105	105	105	105
	PEOi6	Correlation Coefficient	-.325**	.512**	.517**	.533**	.202*	1.000	.409**	.261**	.378**
		Sig. (2-tailed)	0.001	0.000	0.000	0.000	0.039		0.000	0.007	0.000
		N	105	105	105	105	105	105	105	105	105
	PEOi7	Correlation Coefficient	-.206*	.625**	.362**	.419**	.608**	.409**	1.000	.444**	.614**
		Sig. (2-tailed)	0.035	0.000	0.000	0.000	0.000	0.000		0.000	0.000
		N	105	105	105	105	105	105	105	105	105
	PEOi8	Correlation Coefficient	-0.106	.589**	.267**	.396**	.385**	.261**	.444**	1.000	.570**
		Sig. (2-tailed)	0.280	0.000	0.006	0.000	0.000	0.007	0.000		0.000
		N	105	105	105	105	105	105	105	105	105
	PEOi9	Correlation Coefficient	-0.071	.714**	.431**	.520**	.645**	.378**	.614**	.570**	1.000
		Sig. (2-tailed)	0.474	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
		N	105	105	105	105	105	105	105	105	105

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

In Table 7.44, the highest positive correlation coefficient was found between PEOi2 and PEOi9 (i.e. the 'no. of skilled citizen as a percentage of the city population' and the 'no. of entrepreneurs as a percentage of the city population'). The correlation coefficient between the two indicators was calculated at rs=.714. The second highest positive correlation coefficient was found between PEOi3 and PEOi4 (i.e. 'increased life expectancy' and the 'no. of voter turnout as a percentage of the city population'), which was calculated at rs=.710. The third highest positive correlation was found between PEOi2 and PEOi5 (i.e. the 'no. of skilled citizens as a percentage of the city population' and the 'no. of healthy citizens as a percentage of city population'), which was calculated at rs=.656. The other strong positive correlations were between: PEOi5 and PEO9; PEOi2 and PEOi7; PEOi7 and PEOi9; PEOi2 and PEOi4; PEOi5 and PEOi7; PEOi2 and PEOi8; PEOi8 and PEOi9; PEOi2 and PEOi3; PEOi4 and PEOi6; PEOi4 and PEOi9; PEOi3 and PEOi6, and between PEOi2 and PEOi6.

Based on the results in Table 7.44, it is sufficient to suggest that the most predominant indicator for assessing Smart People is PEOi2. This indicates that Smart City stakeholders view the issue of skilled citizens as important for Smart Cities. Interestingly, this indicator has a strong positive relationship with the majority of the variables, except the ‘percentage of educated citizens at different level of education’ which had a negative correlation at -0.188 indicating that formal education may not necessarily determine the skills needed for Smart City innovation. Again, the analysis revealed that, as the number of skilled citizens increase, this impacts positively on the entrepreneureal status of the city. Another important assumption is that life expectancy influences the amount of voter turn-out in the city. Thus, as people continue to live longer, it increases the rate of voter participation in elections.

7.5 Smart City KPI Model: A System Dynamic Model

This chapter discusses the analysis of the causal relationships of the core Smart City KPIs and relates them to the complex structure of emerging innovation in cities, which is part of the objectives and aim of this study. Using the concept of System Dynamics, the chapter establishes a foundation to assess the dynamics of Smart City innovation based on the core components and factors of Smart and Sustainable Cities. Building on the initial efforts to develop a conceptual framework model to measure the Smartness of cities, the KPIs established in the literature, from the interviews with experts, and the survey responses were used to develop a foundational model for Smart Cities that focused on the three core components of Smart Infrastructure, Smart Institution, and Smart People. Thus, each of the core components were identified with their core factors that influence the development of a Smart and Sustainable City.

7.5.1 Modelling Process and Technology for Simulation

In System Dynamics, the primary concern and an important step in modelling is the articulation of the problem (Sterman, 2000). Systems scientists refer to this phase of modelling processes as ‘boundary selection’. Thus, the modelling process involves the elicitation of information needed to dynamically define the problem (Sterman, 2000). According to this Sterman, there are two useful processes through which to explicitly establish reference modes and a time horizon for modelling.

7.5.1.1 Reference Modes

The reference modes relate to the historical behaviour of the key concepts and variables as well as their future behaviour. It helps a modeller to break out of the short-term ‘event-oriented’ world-view to identify the time horizon. This includes defining the variables and concept considered imperative for understanding the problem. They are called reference modes because the modeller repeatedly refers back to them throughout the modelling processes. The model in this study is characterised by the impacts of the core components of Smart Cities and a number of factors and indicators that interact dynamically with graphs and descriptive data indicating the development of the issues over time.

7.5.1.2 Time Horizon

The time horizon defines the extent to which the future should be considered. According to Sterman (2000), the time horizon needs to be extended well enough into the past (history) to show how the problem emerged and to describe its symptoms. It also needs to extend far enough into the future to capture the delays and indirect effects of the potential policies. Sterman criticised the tendency of modellers to think of the cause and effects in any system as local and immediate, suggesting that, in dynamic complex systems, the cause and effects are distant in time and space.

7.5.1.3 Technology for Simulation

In this study, the System Dynamics approach mainly shows the causal relationships among the core factors of Smart Cities and the KPIs. The technology (software) deployed for modelling in this study is Vensim with a text-based system of equations to provide a graphical expression of the modelling structure, which include stock and flow diagrams as well as causal loop flows. Vensim is an interactive software/simulation environment that allows for exploration, development, analysis, and the optimisation of simulation models (Eberlein & Peterson, 1992). Vensim was developed to help system scientists improve the quality and understanding of models. It was introduced to assist in solving problems from a systems perspective. The modelling environment with Vesnsim includes the provision for defining qualitative and quantitative tests, and the automatic execution of a test on a simulation model, called the reality check (Peterson & Eberlein, 1994). It also includes a method for the interactive tracing of behaviour in a model structure through causal links (Peterson & Eberlein 1994). According to Eberlein and Peterson (1992), a reality check allows users to automatically perform validity tests. The test in this case takes the following form: ‘if test input A is imposed on a valid model, then behaviour B will result’. However, this only refers to the behaviour and not the structure.

Prior to these procedures, the exogenous variables that constitute the core factors of Smart Cities in this study were realised through various statistical procedures and techniques, as discussed in the previous sections of this chapter. It is important to note that System Dynamics seek endogenous explanations for a phenomenon (Sterman, 2000). The first steps, namely formulating the problem and establishing key classifications, were achieved through the pilot study with Smart City stakeholders. The data was improved through the literature review, interviews with experts, and the case study investigation in the selected cities in Europe, North America and Africa.

7.5.2 Causal Loop Diagram and Stock and Flow Maps

As the systems scientist Sterman (2000) argued, model boundary charts and sub-system diagrams show the boundary and architecture of the model; however, they do not show how the variables are related. Thus, causal loop diagrams are flexible and useful tools for diagrammatically representing the feedback structure of systems in any given domain. They are simply maps that indicate the causal links that exist amongst the variables. The arrows of the causal links point from a cause point to an effect. Figure 7.9 depicts a feedback flow map for a typical Smart City initiative.

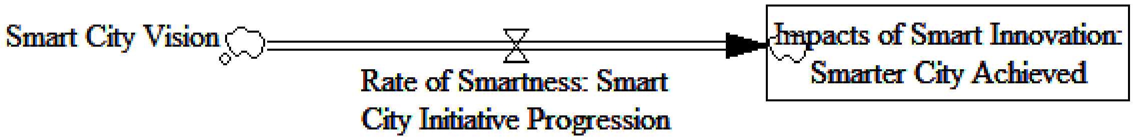


Figure 7-9: Feedback Flow Map for a Smart City Initiative.

7.5.2.1 Designing the Model Structure and Stating the Assumptions

Models can be classified in different ways and according to different criteria, which includes physical or symbolic, dynamic or static, deterministic or stochastic, and so on (Barlas, 1996). With respect to validity, Barlas emphasised that a choice must be made between the 'causal-descriptive' models that are purely theory-like ('White-Box') and the correlational models that are purely data-driven ('Black-Box'). On one hand, the concern of the correlation model is the aggregate output behaviour and the model is assessed for validity based on the matches between its output and the 'real' output within some specified range of accuracy. In such cases there is no recourse to the validity of the individual relationship that exists in the model. A good example of this type of model is the regression model. A causal-descriptive model, on the other hand, refers to statements on how the real system actually operates in some aspects.

As emphasised by (Sterman, 2002), most of the critical assumptions in any model, whether mental or formal, are the implicit ones buried deeply in the system. These assumptions are usually not known to the modellers and they are not in the model equation nor its documentation. In any case, it is important to make clear assumptions about the variables in order to clearly define their boundaries and provide the required information about them. Figure 7.10 represents some simplified assumptions, as follows:

- The smartness of the city as a result of innovation depends on the rate of Smart initiatives
- A Smart City vision flows to process/progress and/or the rate of Smart initiatives
- A Smart City (final Smarter city) improves by the rate of Smartness, and
- The rate of Smartness is a function of the Smart City vision or goal and the final Smarter City achievements.

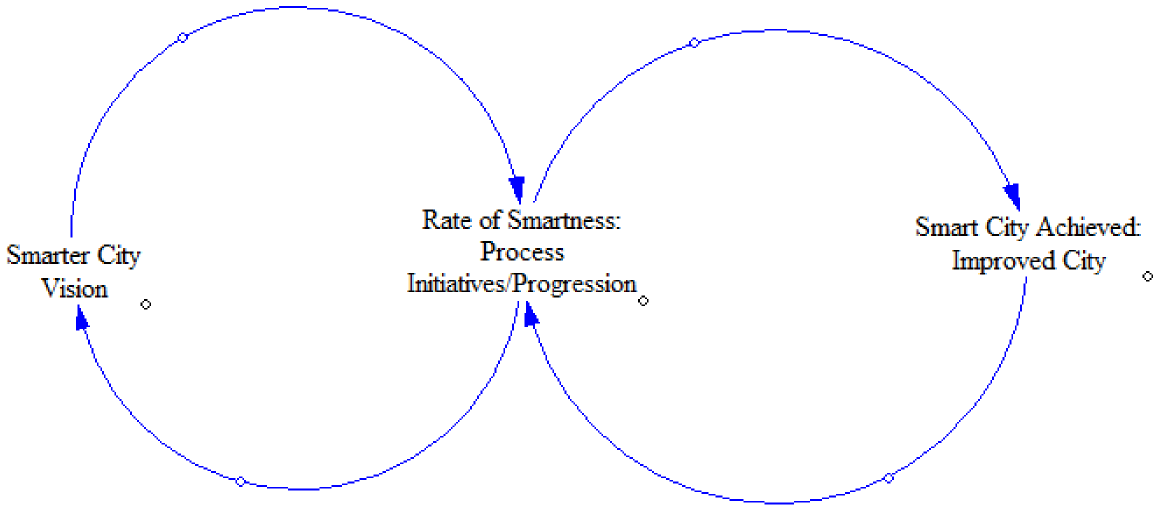


Figure 7-10: Causal Loop Diagram for a Smart City Initiative

As captured in the model boundary, the first and most important assumption is the model’s scope and the focus. Thus, it will place more emphasis and research focus on the working mechanism of the core components, namely Infrastructure, Institution, and People, within Smart City innovation. An enabling environment for Smart City innovation is another key important boundary assumption. The third important assumption involves the units described as factors and the indicators in the model. In order to explain the causal relationship among the components, the hypothetical model developed for the simulation was continually revised to examine the effects.

7.5.2.2 Model Testing and Validation

In order to establish confidence in the accuracy, soundness, and usefulness of a model, it is imperative to conduct validation and testing. The techniques commonly used for model testing and validation include tests of a model's structure and behaviour. The tests, according to Senge and Forrester (1980), are further classified into the model structure verification test, model parameter verification test, model extreme-condition test, model adequacy test, model dimensional consistency test, and model behaviour prediction test. Model testing is considered an essential part of modelling process in System Dynamics in terms of its validation, which aims to uncover errors and improve the model, and to understand its limitations in order to assist in decision-making (Sternman, 2000). The tests conducted in this study using Vensim are summarised as follows:

a) Model Structure Verification Test

The model structure verification test must not contradict knowledge about the structure of the real system. The verification may include comparisons of the model's assumptions with descriptions of decision-making and the relationships found in relevant literature (Senge & Forrester, 1980). It is important to note that the Vensim application used for the model and simulation in this study has an in-built mechanisms for model testing and validation. Thus, all the models were properly checked and verified 'OK' in showing the causal relationships and influence of the variables on one another in the diagrams. The relationships were guided by the results of the correlation analysis conducted for the variable which eliminated a number of factors with weak correlations (relationships) in the models. The tests for the model's structure were confirmed 'OK' in all the diagrams, as included in the screen shots.

b) The Model Dimensional Consistency Test

Again, Senge and Forrester (1980) suggested that parameters in a System Dynamics model must have real-world meaning, as in the case of the structure verification test. As system scientists asserted, many models fail the dimension consistency test. It is considered mundane but quite revealing and can be useful when applied in conjunction with the parameter verification test. Here, the unit of measurement is defined in ‘Month’ and expressed in ‘%’; moreover, this assessment has real-world meaning. The test was conducted by clicking a drop-down menu for the dimensional consistency function in Vensim to confirm that the variables on both sides of the equation match with equal units of measurement.

c) The Model Parameter Verification Test

In System Dynamics, a parameter verification is mainly concerned with determining whether the parameters of the model correspond conceptually with real life by comparing the model parameters to the knowledge of the real system (Senge & Forrester, 1980). The parameter verification and structure verification tests are interrelated. (Sterman, 2000) suggested a wide range of methods, such as the use of statistical methods for System Dynamics parameter verification. The other methods include ‘judgemental’, which is based on interviews, focus groups experience, retrieval, experts’ opinion, and a host of other methods. In this study, a number of these methods were employed to establish the core factors and indicators for Smart City assessment metrics, starting with the literature established by renowned Smart Cities scholars, Smart City standards, a pilot study, and interviews with experts who were key Smart City stakeholders in Boston, FCT Abuja (with survey component), and Manchester City. The outcome of the field investigation was properly analysed using the appropriate statistical tools and techniques.

d) The Model Extreme-Condition Verification Test

As noted by Senge and Forrester (1980), structures in System Dynamics models should permit consistency in performance, even in unusual and extreme cases. Sterman (2000), suggested the need to test whether the model responds plausibly to extreme policies, shocks, and parameters. Following the established procedures, the model equations and the simulations in this study were tested at extremely low and high levels. Based on the outcomes, the models performed very well.

7.5.3 The Stock and Flow Diagram for the Smart City KPI Model

This section discusses the stock and flow diagram for the proposed Smart City KPI model. The discussion covers the model diagrams for the Smart Infrastructure, Smart Institution, and Smart People components. According to Sterman (2000), the two fundamental concepts of System

Dynamics theory are the stocks and flows, and the feedback. The causal relationships among the elements of a System Dynamics model are represented in a stock and flow diagram with the algebraic representation for simulation in order to enhance the analysis of the relationships among the elements of the model.

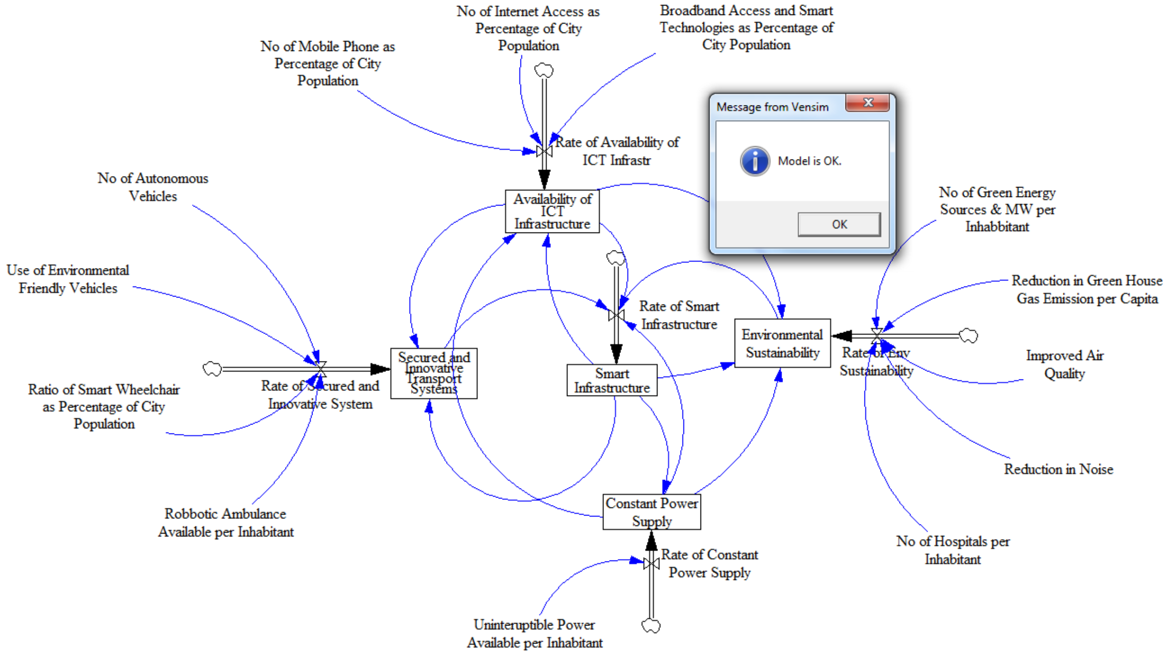
In the previous chapters (Chapters 6 and 7), the core factors and indicators of the Smart City KPIs were established using a correlation analysis and the outcome of the content analysis. Thus, to simulate the relationship among the core factors and indicators, the stock and flow diagram for a Smart City was developed using Vensim software as a modelling tool (see Figures 7.11 to 7.14). It is important to note that the variables included in the stock and flow diagram for the model are variables established from the correlation analysis with strong correlation coefficients; these are also confirmed by the interviews with experts. The factors and indicators with weak correlation coefficients (those not mentioned or apparent from the interviews with experts) were not included in the stock and flow diagrams. To assess the impacts of one variable on other parts of the model, simulations were run to determine the criticality of a particular variable over another and the entire model. The next section discusses the stock and flow diagrams from the three core components of Smart Infrastructure, Smart Institution, Smart People, and the overall Smart City KPI model diagram. Subsequently, the proposed dynamics model for a Smart City will be evaluated in line with the fourth objective of this study.

7.5.3.1 Smart Infrastructure Variables and SD Model

Smart Infrastructure was earlier established in this study as one of the core components of Smart Cities for building intelligent assets for a future city infrastructure. Furthermore, the study established the four critical factors of Smart Infrastructure, which are: the availability of ICT infrastructure, environmental sustainability, a constant power supply, and secured and innovative transport systems. The first critical factor, the availability of ICT infrastructure, was established with three core indicator measures, which were: the no. of internet access as a percentage of the city population, the no. of mobile phones as a percentage of the city population, and the availability of Smart technologies and broadband access. All these measures are crucial to the success of any Smart City vision. They underpin the IoT technologies that drive Smart City innovation across the globe. The measures are all interrelated and critical because a Smart City environment requires every citizen to have unhindered access to services. Internet access, the ownership of a mobile phone, and broadband facilities are at the core of the underlying technologies and networks that power Smart City initiatives. Without mobile phones, broadband and Internet access, there is no possibility for Smart City innovation.

The second critical factor ‘environmental sustainability’ was established with five core indicator measures, which include: the number of green energy sources and MW generated per inhabitant, a reduction in greenhouse gas emissions per capita, improved air quality through CO, SO2, NO2 reduction, and the number of hospitals per inhabitant. Building a Smart Infrastructure for a Smart and Sustainable City requires adequate attention to critical health hazards emanating from the deployment of the physical infrastructure of cities. Again, these measures are interrelated and critical to environmental sustainability. These core indicator measures suggest that, as a city infrastructure becomes Smarter, they depend more on renewable energy sources; therefore, reducing gas emissions and pollution has direct implications for the air quality condition of the city.

The third critical factor, ‘secured and innovative transport systems’ was established with four core indicator measures, which are: the no. of autonomous vehicles, the use of environmentally friendly vehicles, the ratio of smart wheelchairs per inhabitant, and robotic mobile ambulances available per inhabitant. Again, the four measures of innovative transport systems are interrelated. These measures suggest that deploying a secure and innovative transport infrastructure for Smart Cities needs to consider the exploration of emerging areas of mobility innovation with environmentally friendly models and robotic options for emergency interventions. The measures also considered the satisfaction of citizens with special needs in mobility choices. Finally, the fourth critical factor, a ‘constant power supply’ was established with one core indicator measure, namely the availability of uninterruptible power for every inhabitant. A constant power supply serves as the central hub of all Smart City innovation. The measure of uninterrupted power is key in that power outages are not envisaged in Smart Cities. All the established variables were accordingly modelled for Smart Infrastructure and tested ‘OK’, as depicted in Figure 7.11.



Model is OK.

Figure 7-11: System Dynamics Model of a Smart Infrastructure with the Model Checked

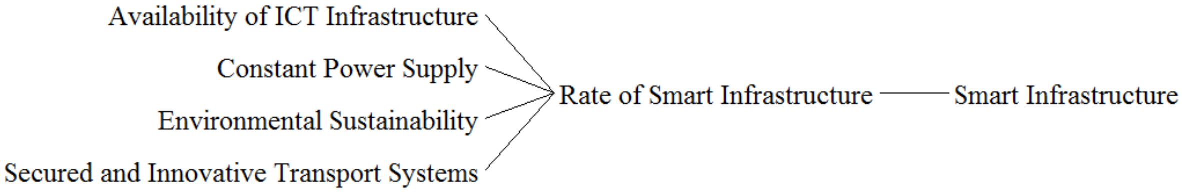


Figure 7-12: Tree Diagram of the System Dynamics Model for Smart Infrastructure

The Tree Diagram in Figure 7.12 shows the variables that drive the performance of the rate of Smart Infrastructure, from the causal loop diagram of the stock and flow in Figure 7.11. The equation for the model is given as;

Smart Infrastructure = INTEG (Smart Infrastructure^0.5+Rate of Smart Infrastructure).

The unit is given by;

Units: “per cent” [0, 100].

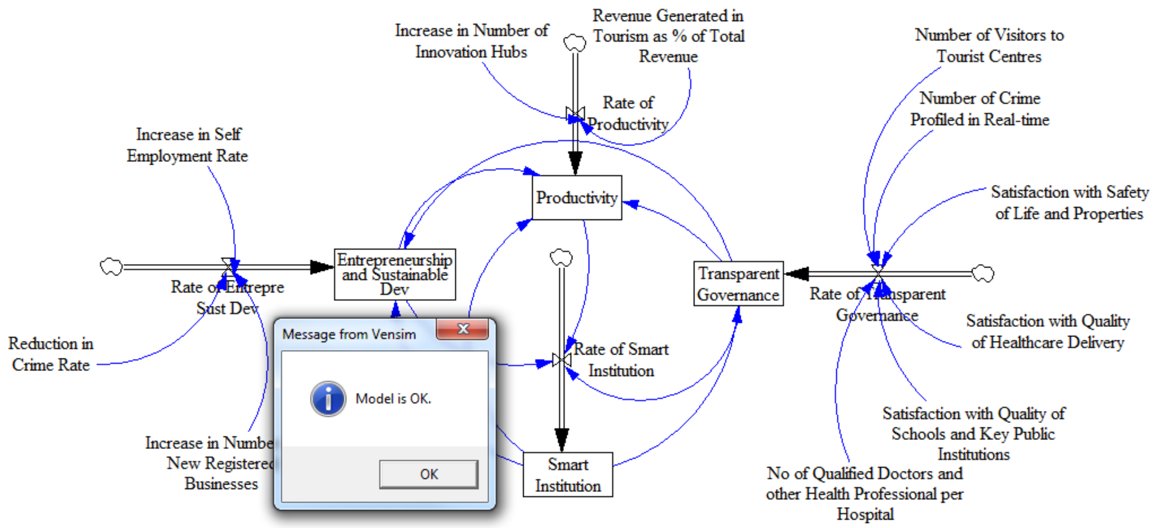
7.5.3.2 Smart Institution Variables and SD Model

Another important component of Smart Cities established in this study is the Smart Institution for the governance of Smart City innovation. This component is primarily concerned with building context-sensitive institutions for unified social, political and economic consideration with a richer e-approach. In this study, three critical factors were established under the Smart Institution component, namely: transparent governance, entrepreneurship and sustainable development, and productivity.

The first critical factor, ‘transparent governance’ was established with six core indicator measures which were: satisfaction with the quality of schools and key public institutions, satisfaction with the quality of healthcare delivery, the number of visitors to tourist centres, the number of qualified doctors and other health professionals per hospital, the number of crimes profiled in real-time, and satisfaction with the safety of life and properties. The critical factor suggests that achieving transparent governance systems requires a combination of effort to build institutional capacity in key public sector institutions to drive smart growth and services in core sectors, such as healthcare, education, security, and the safety of citizens through social and technological innovation.

The second critical factor ‘entrepreneurship and sustainable development’ was established with three core indicator measures, which were: the prcentage increase in the self-employment rate, an increased number of new registered businesses, and a reduction in the crime rate. Here, the core indicator measures that comprised the factor suggested that building a Smart City that encourages entrepreneurial and sustainable growth requires a particular level of openness that connects with the people and an ease in doing business that attracts new businesses. Thus, as citizens become fully engaged, realising the potential with access to venture capital and job opportunities, vulnerability to crime and the crime rate reduces to the minimum.

Lastly, the third critical factor, ‘productivity’, was established with two core indicator measures, which were: the increased number of innovation hubs, and revenue generated in tourism as a percentage of the total revenue. Both measures that comprised this factor suggest that building a productive city requires the creation of innovation hubs in the form of social communities and research centres that encourage ideation and knowledge transfer in order for the city to stay ahead of the competition and create new revenue streams while promoting tourism development. Both the established variables were accordingly modelled for the Smart Institution and tested ‘OK’. as depicted in Figure 7.13.



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Model is OK.

Figure 7-13: System Dynamics Model of Smart Institution with Model Checked

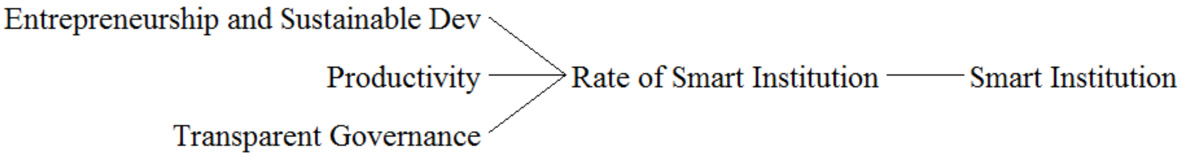


Figure 7-14: Tree Diagram of the System Dynamics Model for Smart Institution

The Tree Diagram in Figure 7.14 shows the variables that drive the performance of the rate of the Smart Institution from the causal loop diagram of the stock and flow in Figure 7.13. The equation for the model is given as;

Smart Institution = INTEG (Smart Institution^0.5+Rate of Smart Institution).

The unit is given by;

Units: “per cent” [0, 100].

7.5.3.3 Smart People Variables and SD Model

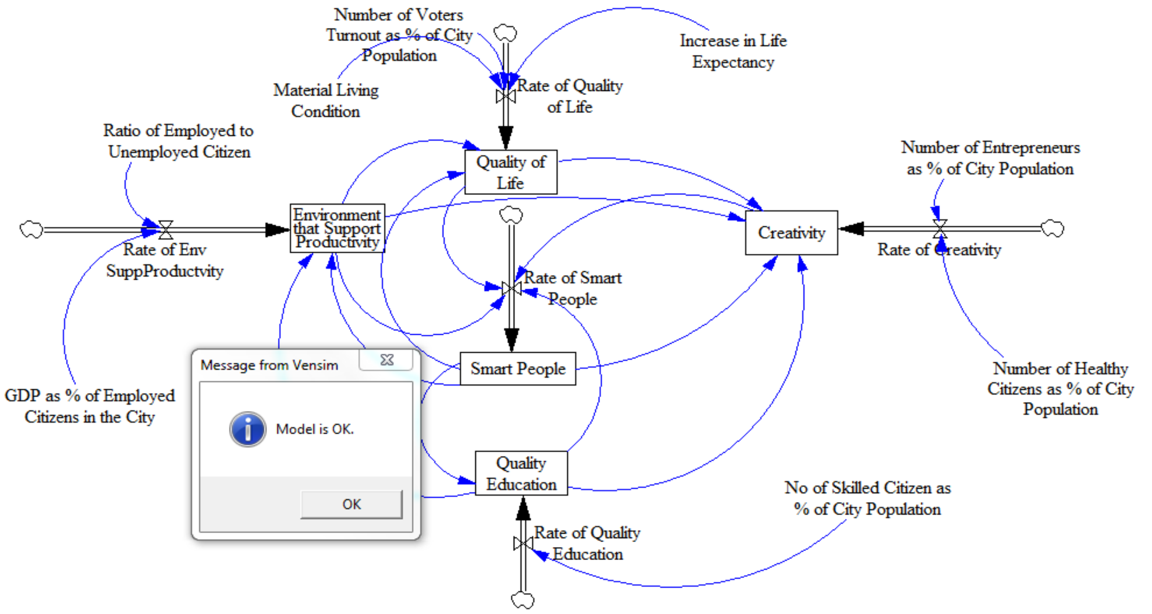
In order to achieve the overall vision of a Smart City in any city region, adequate attention must be paid to certain factors in relation to the component of Smart People. According to Giffinger et al. (2010), these factors relate to the social and human capital development of a city which includes: the level of qualification, an affinity to lifelong learning, flexibility, creativity, and participation in public life. This is corroborated by the findings of Lombardi et al. (2011) which listed similar measures for the human capital component of Smart Cities, including the employment rate in knowledge-intensive sectors, city representatives per resident, participation in life-long learning (as a percentage), and patent applications per inhabitant.

This study established four critical factors for the component of Smart People, which were: the quality of life, productivity, quality education, and an environment that supports productivity. The first factor highly emphasised in Smart Cities research is the ‘quality of life’ and is established with three core indicators, which are: an increase in life expectancy, material living conditions, and the level of voter turnout as a percentage of the city population. Here, the two core indicator measures concerning the quality of life suggests that, as Smart City innovation focuses on improving the quality of life for people, the risk factors in Smart Cities reduces with lifestyle choices that translate into an increased life expectancy for the people. As people live longer with an improved quality of life, this also impacts directly on the city population and on the voting power of the city. Again, the indicators tend to expose the hidden correlations between the quality of life and population growth in a society.

The second factor also emphasised in the literature is ‘creativity’; this is established with two core indicators, which include the number of entrepreneurs as a percentage of the city population and the number of healthy citizens as a percentage of the city population. These core indicator measures that comprise the creativity factor suggest that building a Smart City with creative people requires skills development as a platform and model for managing place-based urban innovation ecosystem. In this context, the social tolerance and economic performance associated with creative people can be assessed on the number of entrepreneurs attracted to the city. In addition, the health condition of citizens is considered crucial to their level of creativity. The third factor is ‘quality education’; this is established with one core indicator measure, namely the number of skilled citizens as a percentage of the city population.

The core indicator for the factor of quality education suggests that building a Smart City with educated people requires that adequate attention must be paid to their skills (the quality of the educated individuals) and not necessary the level of education acquired by citizens. For instance, addressing some challenges in the sub-systems of a city may require certain professional skills and capabilities not available through formal education but rather through special training. In this regard, quality education for Smart People in a Smart City cannot be taken in abstract.

Finally, the fourth factor is an ‘environment that supports productivity’, which is established with two core indicator measures; this includes the rate of employed to unemployed citizens, and the GDP as a percentage of the employed citizens in the city. Thus, the core indicators for the factor ‘an environment that supports productivity’ suggests that building a Smart City requires adequate attention to an enabling environment that encourages citizens to realise their full potential to become more productive. Within an enabling environment, Smart People create job opportunities which, on one hand, increases the employment rate of the city and, on the other hand, reduces unemployment while contributing to the GDP of the city. Again, all the established variables were accordingly modelled for Smart People and tested ‘OK’, as depicted in Figure 7.15.



Model is OK.

Figure 7-15: System Dynamics Model of Smart People with Model Checked

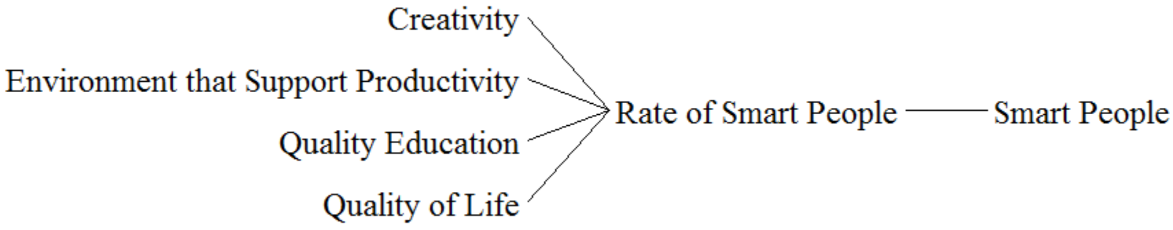


Figure 7-16: Tree Diagram of the System Dynamics Model for Smart People

The Tree Diagram in Figure 7.16 shows the variables that drive the performance of the rate of Smart People from the causal loop diagram of the stock and flow in Figure 7.15. The equation for the model is given as;

Smart People = INTEG (Smart People^0.5+Rate of Smart People).
The unit is given by;
Units: “per cent” [0, 100].

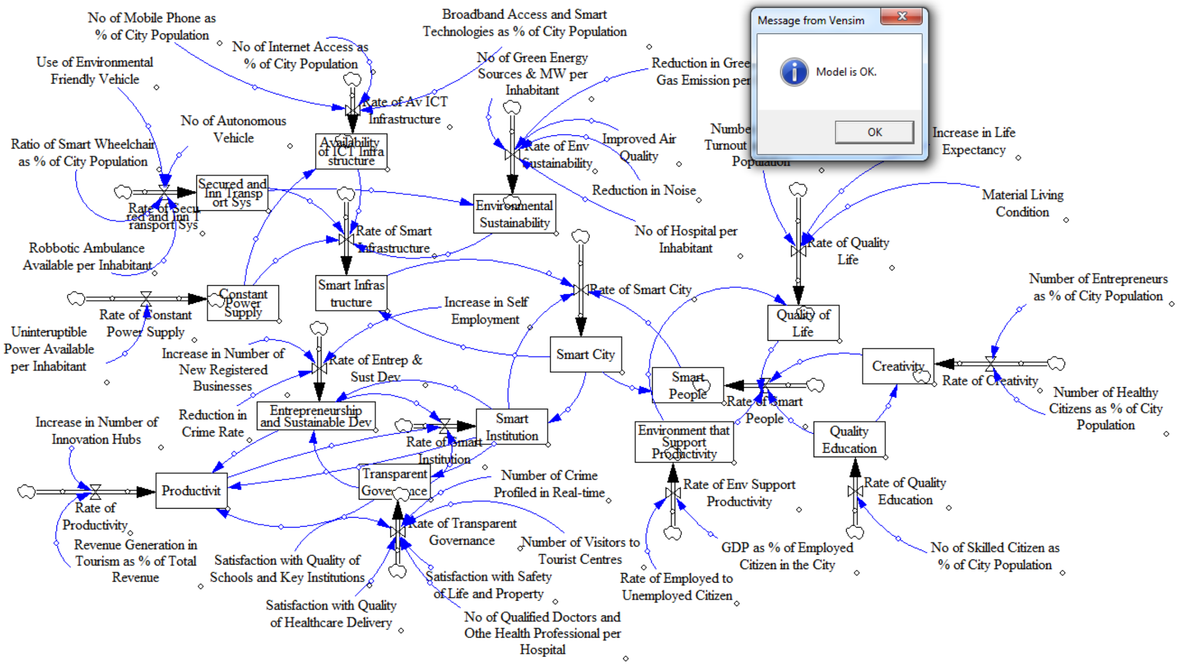
The modelling of the dynamic workings of the endogenous variables and their causal relationship, which is built on the established correlations among the variables to show the dynamic interactions of the factors. The three models in the stock and flow feedback system with their dynamic interactions were tested and confirmed OK. Thus, this confirms the suitability of modelling all variables for a Smart City KPI model. The next section presents the overall dynamic KPI model to assess the impacts of Smart Cities.

7.5.4 Dynamic KPI Model of the Three Core Components of Smart Cities

The previous sections have considered the dynamic models for the individual Smart City components for Smart Infrastructure, Smart Institution, and Smart People. This section presents the comprehensive modelling of all the core factors and the indicators measures for the three core components as a single dynamic KPI model for Smart Cities.

As outlined in the individual models, a Smart Infrastructure was established with the four critical factors of: availability of ICT infrastructure, environmental sustainability, constant power supply, and secured and innovative transport systems. Each of the factors was further established with core indicator measures. Similarly, Smart Institution was established with three critical factors, which include: transparent governance, entrepreneurship and sustainable development, and productivity, which also had core indicator measures. Finally, Smart People was also established with four critical factors, which were: the quality of life, productivity, quality education, and an environment that supports productivity. These were established alongside their respective indicator measures. All the different factors from the three distinct components and their corresponding variables (indicators) were used to model the dynamic

KPI model to assess Smart Cities. The overall model was also tested ‘OK’, as depicted in Figure 7.17.



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Model is OK.

Figure 7-17: Dynamic KPI Model for Assessing Smart Cities

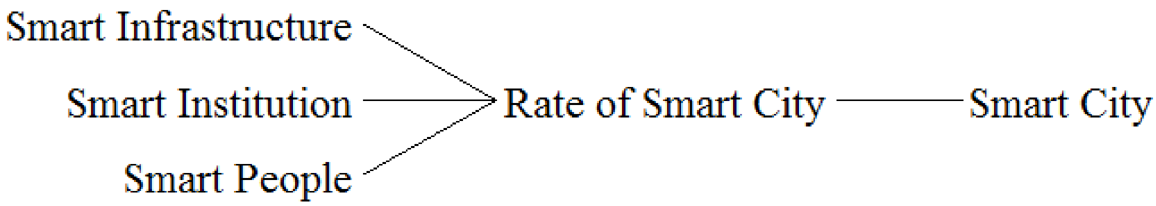

Figure 7-18: Tree Diagram of the Dynamics Model for Smart Cities

The Tree Diagram in Figure 7.18 shows the variables that drive the performance of the rate of the Smart City from the causal loop diagram of the stock and flow in Figure 7.17. The equation for the model is given as;

Smart City = INTEG (Smart City^0.5+Rate of Smart City).

The unit is given by;

Units: “per cent” [0, 100].

7.5.5 Extreme Condition Tests for the Dynamic KPI Model

The dynamic KPI model was tested at extremely low (0%) and extremely high (100%) values to observe the consistency of the performance when subjected to unusual conditions. The results are shown in Figures 7.19 to 7.22.

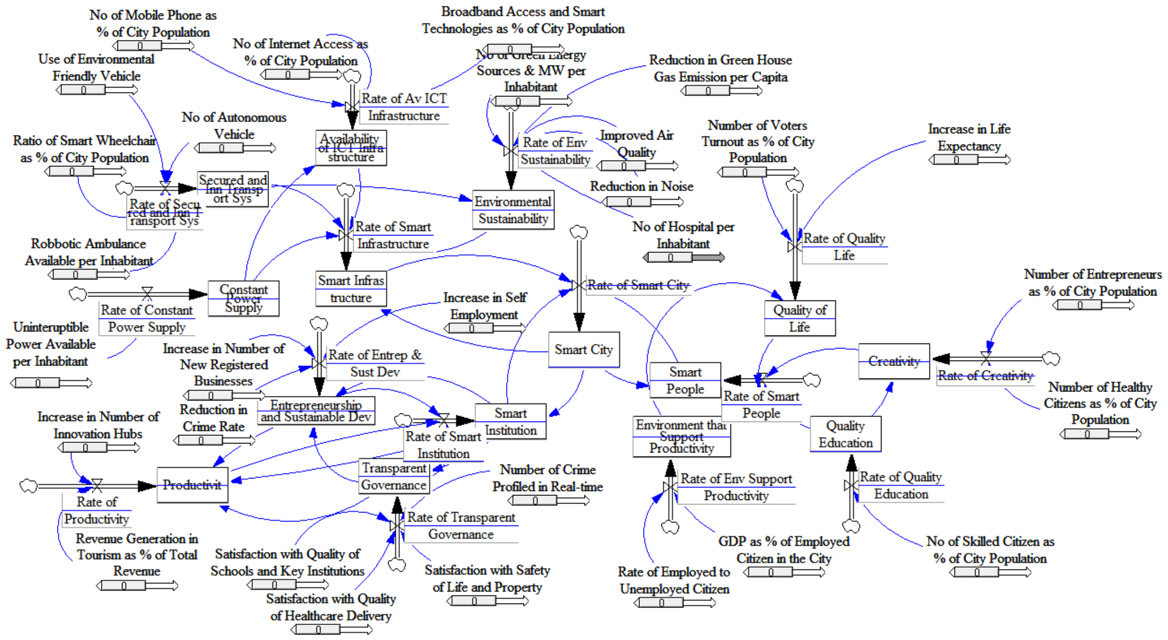

Figure 7-19: Simulation of a Dynamic SC KPI Model Run at a 0% Extreme Test

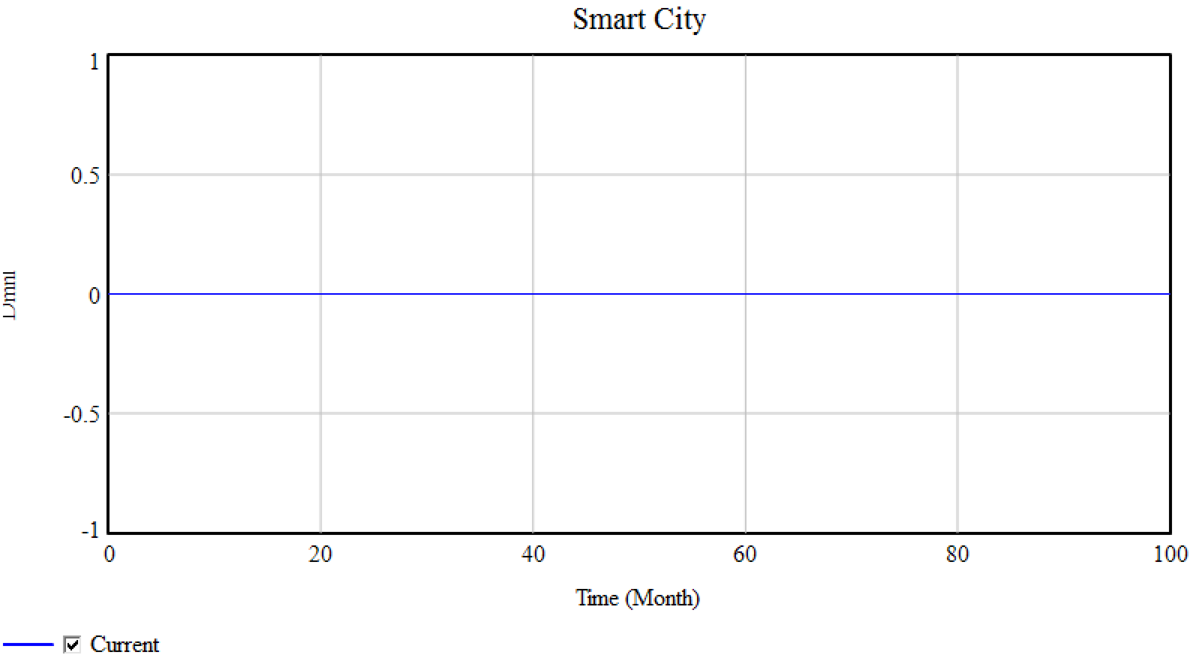

Figure 7-20: Graph of the Simulation for the Model Run at a 0% Extreme Test

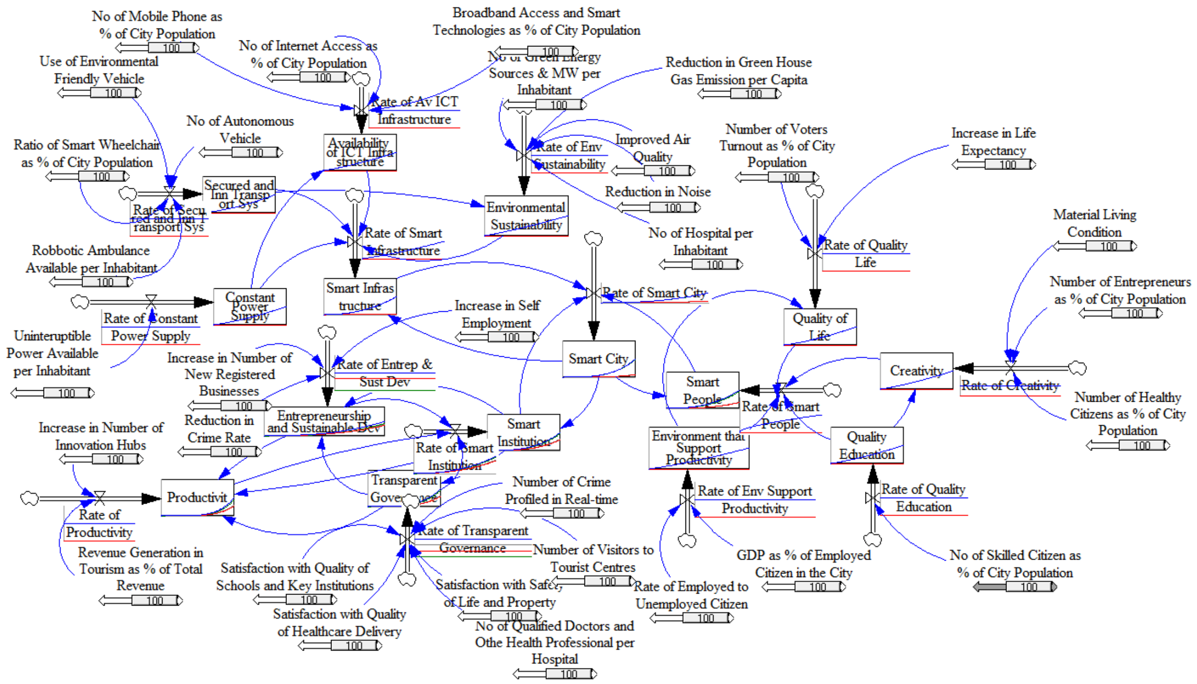

Figure 7-21: Simulation of Dynamic SC KPI Model Run at a 100% Extreme Test

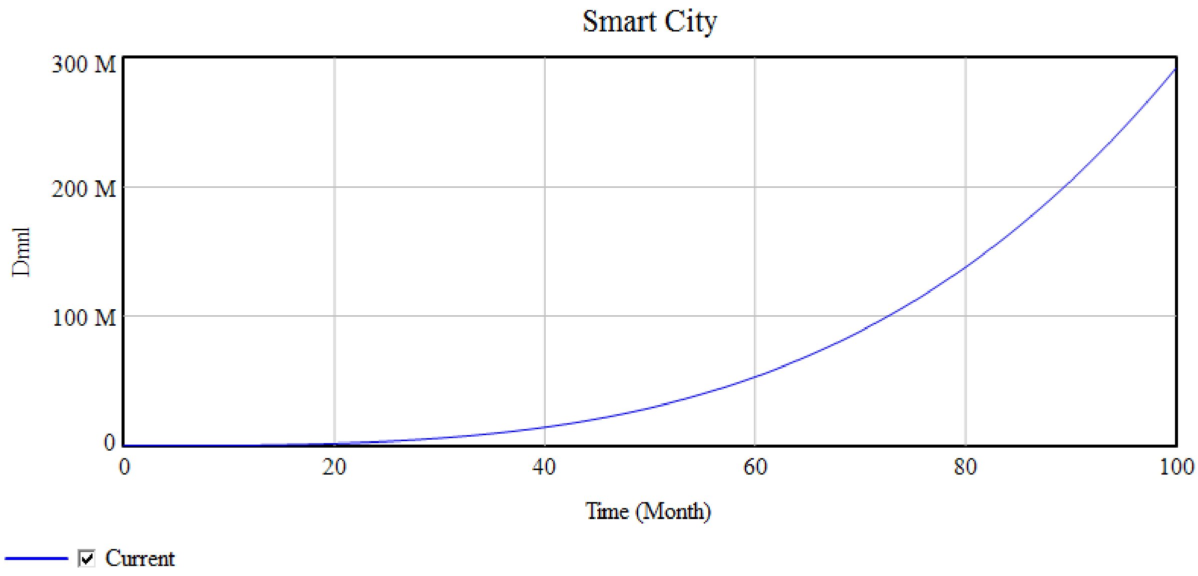

Figure 7-22: Graph of the Simulation for the Model Run at a 100% Extreme Test

7.5.6 Running the Simulations and Evaluation of the Causal Influences (Dynamic Impacts) of the KPIs

In order to determine the model equation for the three core components established in this study, and to ascertain the overall performance of the Smart City model, the correlation coefficients of the core indicators were loaded on to the model for simulation. Following the successful loading of the model with all the indicator values, the simulation was tested at two extreme scenarios of 0% and 100%. The performances of the individual components were compared across the system by adjusting the values for each variable of a particular component while keeping others unchanged. For instance, to check the influence of Smart Infrastructure on the model, all the variables of the Smart Infrastructure component were decreased to 0% while others were kept at 100%; the results were subsequently compared, and vice versa.

The same process was repeated for Smart Institution and Smart People to compare the dynamic impacts of the individual components on the overall performance of the model. The results of the simulations at different scenarios are presented in Figures 7.23 to 7.26.

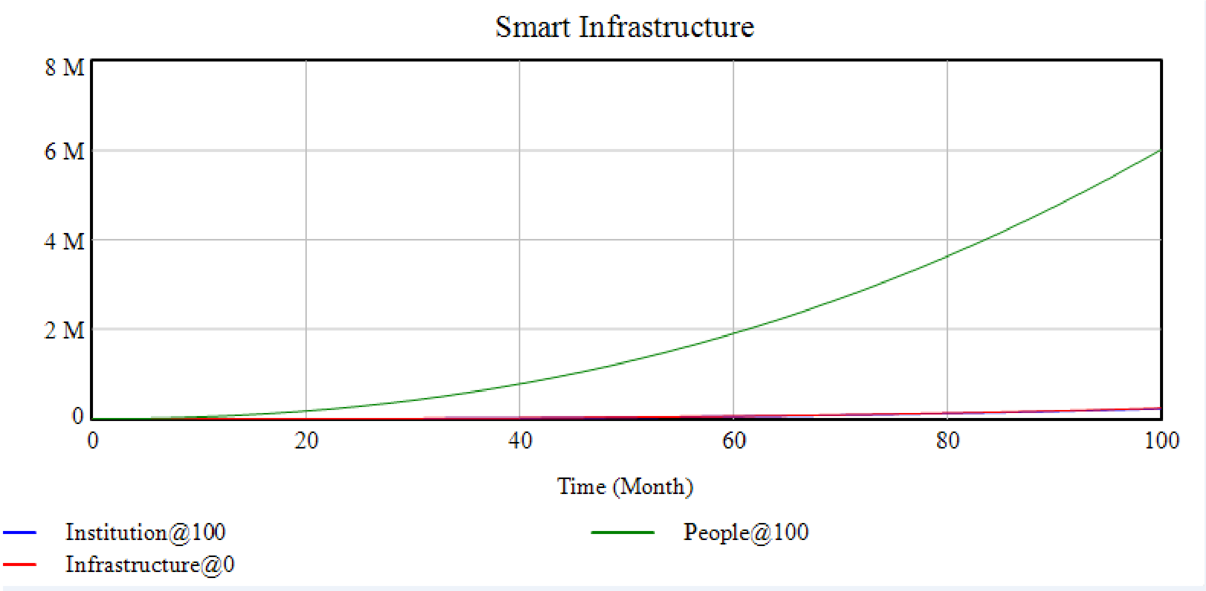

Figure 7-23: Graph of the Dynamic Impact of the Smart Infrastructure at 0%, Smart Institution at 100%, and Smart People at 100%.

Figure 7.23 shows the simulation results, comparing the performance of components with the Smart Infrastructure component decreased to 0% while maintaining the Smart Institution and the Smart People components at 100%. Based on the dynamic interrelationship, the result indicates the strong influence of the Smart Infrastructure on the institution component. The performance of the institution component is worst for Smart Infrastructure@0. This suggests that, when city infrastructure is poor, it invariably has an adverse effect on the performance of institutions. However, the people component still performs optimally, indicating that the performance of the people is not necessarily tied to a Smarter city infrastructure. The blue line represents institution@100, the red line represents infrastructure@0 while the green line represents people@100. A visual inspection of Figure 7.23 shows that Smart Infrastructure decreases in line with the institution. Using the examples of initiatives cited in Chapter 6 across the cities investigated, forward-thinking (Smart) institutions seeking to deliver Smarter services in cities naturally influence the need for an infrastructure to deliver such services. For instance, the air quality monitoring initiative by CityVerve in Manchester (cited in Chapter 6) can be seen as a typical example of a forward-thinking institution to deliver Smart services which require infrastructure (e.g. sensors) for the delivery of such services. Thus, delivering such an initiative must first ensure that the right infrastructure is in place, which explains the negative impact of infrastructure@0 on the institution component.

The simulation process was repeated for the Smart Institution@0 and the result is shown in Figure 7.24.

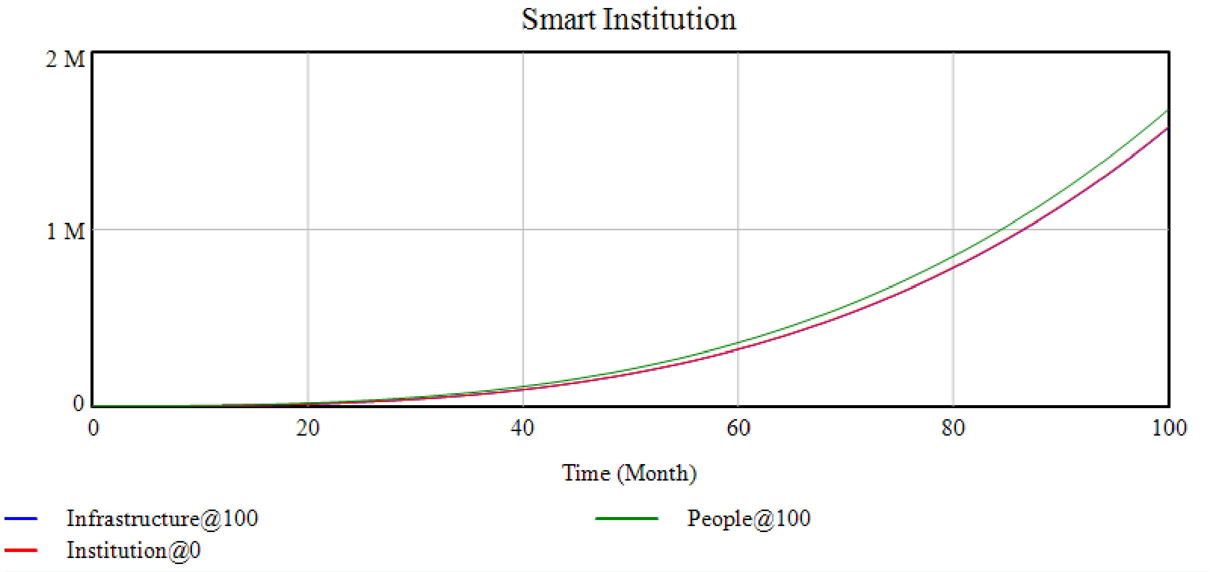

Figure 7-24: Graph of the Dynamic Impact of Smart Institution at 0%, Smart Infrastructure at 100%, and Smart People at 100%.

Figure 7.24 shows the simulation results that compare the performance of the Smart Institution @0%, while keeping the infrastructure and the people components at 100%. This provides an interesting result in that the development of the infrastructure component strongly influences the performance of the institution component. Here, the blue represents infrastructure@100, the red line represents institution@0, while the green line represents people@100. It can be seen that the blue and red lines are tied together, which results from the strong influence of the infrastructure component. The dynamic influence explains the need to build Smart Institutions with the foresight to deploy Smart Infrastructures to deliver smart services.

The simulation process was repeated for the Smart People@0 and the result is shown in Figure 7.25.

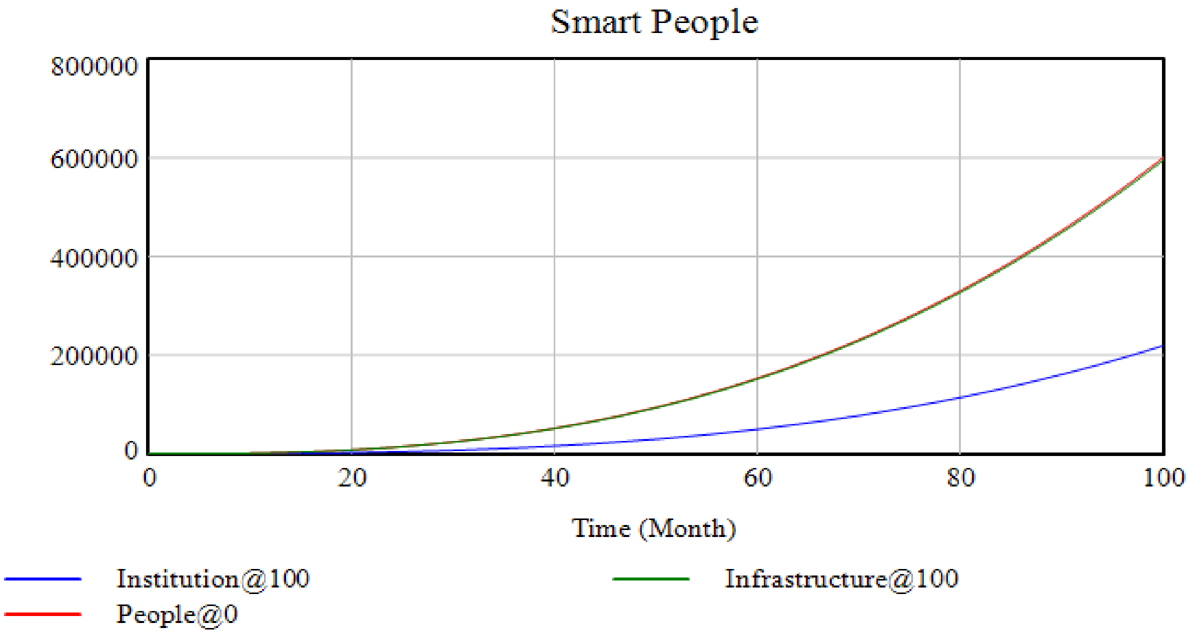

Figure 7-25: Graph of the Dynamic Impact of Smart People at 0%, Smart Infrastructure at 100%, and Smart Institution at 100%.

Figure 7.25 shows the simulation results comparing the performance of Smart People decreased to @0% while the infrastructure and the institution components are maintained at 100%. The performance of people@0 is strongly influenced by the infrastructure@100 while impacting negatively on the performance of the institution. Again, the blue line represents institution@100, whilst the red line represents infrastructure@100, and the green line represents people@0. This suggests that the development of a Smart Institution requires adequate human capacity to sustain it. Thus, the under-performance of the people component can be an impediment to the institution component. This could equate to building institutions to develop skilled human capacities, such as universities, without adequate or competent individuals to deliver the content. The result also demonstrates that Smart Infrastructure has the potential to impact positively on cities with unskilled citizens. For instance, this includes ongoing innovations to deploy intelligent devices (Smart Infrastructure) in the form of drones by forward-looking organisations, such as Amazon, to deliver services (parcels). In this instance, the delivery of a parcel by an un-manned drone to individuals does not necessarily require the recipient to be ‘Smart’ to enjoy such services as the intelligent device may not require any instruction from the delivery process that is already remotely programmed.

Overall, to assess the influence of all the components of a Smart City, the simulation process was repeated for the Smart City with all the components @100. The result is shown in Figure 7.26.

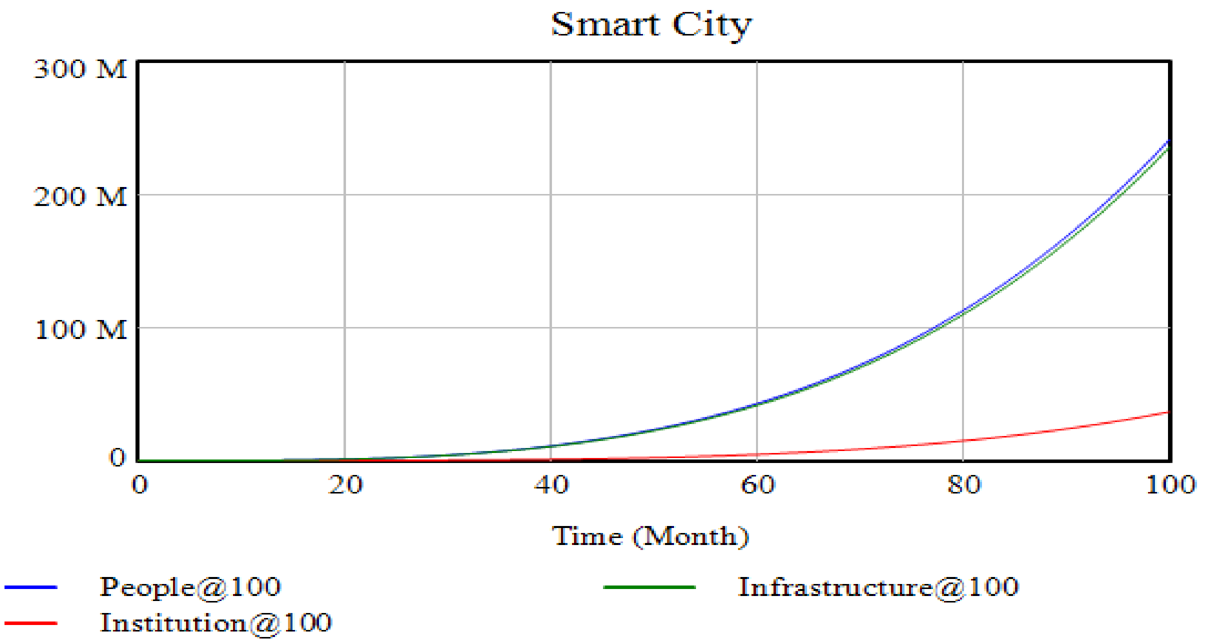

Figure 7-26: Graph of the Dynamic Impact of Smart Infrastructure at 100%, and Smart Institution at 100%, and the Smart People at 100%.

Figure 7.26 shows the overall performance of the Smart City initiatives at the extreme level of 100% for all the components. The influence of the individual components at 100% shows that each of the KPI components impact on the level of Smartness of the city. The result suggests that the dynamic influence of the institution component reduces significantly as development infrastructure for Smart Cities improves. This result demonstrates that a Smarter city environment at a reasonable maturity level with Smart Infrastructure and Smart People performing well at an optimum level do not necessarily require much influence from the institution component. This finding also agrees with the views expressed in existing literature regarding how Smart Cities risk purely catering for smaller stakeholders, which include rich, mobile, and creative businesspeople. The next section presents the chapter summary.

7.6 Chapter Summary

The chapter analysed the CSFs of the Smart City components, focusing on the core components of Infrastructure, Institution, and the People. It also assessed the KPIs established in the literature and existing standards for Smart Cities. The chapter began with a comprehensive review/analysis of demographic information using descriptive statistics. The key findings from the analysis are summarised as follows:

- From the demographics, it was observed that participation was skewed towards ICT professionals who dominate the space of ongoing Smart City innovations in FCTA. The skewness was attributed to the fact that the level of awareness was higher among key stakeholders who view the concept of Smart City innovation as technocratic in nature.
- The deployment of sustainable transport systems was highly emphasised by survey respondents in assessing the CSFs of a Smart City infrastructure. This was followed by the availability of an ICT infrastructure, secured and innovative technologies, a power supply, and environmental protection. This compares well with the outcome of the interviews with experts that also emphasised these factors as crucial in Smart City innovation. Interestingly, the correlation analysis also found strong correlations among these factors.
- On the institutional arrangements for the governance of Smart City innovation, through an eleven item, five-point Likert scale question, the chapter sought to investigate the perceptions of respondents. The results indicated that transparent governance was crucial to the development of a Smart Institution. The correlation analysis also found that transparent governance played a crucial role in Smart City deployment as it positively influences key issues, such as productivity, social cohesion, and entrepreneurship.
- Regarding the component of Smart People, the results demonstrated that the quality of life was crucial in Smart City innovation. Based on the results of the correlation analysis, the quality of life factor plays a dominant role among the CSFs of Smart People. Moreover, the quality of life positively influences a number of other factors, such as creativity, flexibility, and social awareness.

- The KPIs established in the literature, ISO37120, and other Smart City standards were explored further through a five-point Likert scale question for the infrastructure, institution and people components. The results demonstrated that Smart technologies and broadband access were the most crucial measurement area for Smart City Infrastructure. This was followed by the number of mobile phones as a percentage of the city population, Internet access, green energy sources, a reduction in greenhouse gas emissions, an efficient transport systems, improved air quality and the existence of Smart equipment for real-time monitoring and control as crucial measurement areas for Smart City infrastructure. The same analysis was repeated for institution and the people accordingly.

CHAPTER 8

8.1 Discussion of Findings and Framework Refinement

This chapter discusses the findings in line with the research aim and objectives outlined at the beginning of the study. In the early stages, a comprehensive review of the Smart City and its contexts was carried out. The review examined how technologies focus on social innovation, emerging technologies, and the existing architectures for Smart Cities. Based on the literature review (Chapters 2 and 3) and the pilot study (Chapter 5), the core factors and indicators were identified which formed the basis for a further qualitative field investigation of Smart City innovation to capture any evidence of these factors and indicators as they relate to Smart innovation across three different city regions. In a mixed method approach, the study deployed survey instruments targeted at Abuja Smart City stakeholders, which aimed to improve the quality of the research outcome and validate the findings. Based on the findings from both the qualitative and quantitative analysis, the conceptual framework proposed in Chapter 5 was refined and its presentation will be examined in this chapter. The chapter presents the refined KPI framework for assessing the impacts of Smart Cities based on the core factors and indicators established from qualitative and quantitative data, and the system dynamics simulations.

8.2 Discussion of the Findings

The importance of Smart and Sustainable Cities was highlighted in the literature review. However, despite the importance of Smart City innovation, it would appear from the literature that there are gaps associated with the understanding of the concept among stakeholders and the absence of a summarised KPI model to assess the impacts of Smartness. These problems, if not addressed, could lead to complex planning challenges and policy failures in the introduction of new technologies to cities with the possible consequential risk of building disconnected islands of Smartness.

The main aim of this study, as outlined in the introductory chapter, was to develop a framework to promote social and economic development in Smart and Sustainable Cities. To achieve this aim, a number of research objectives were outlined with strategies for achieving the stated objectives. In addition, efforts were also made to articulate the research questions that helped in shaping the research activities, from the broad perspective of a research interest to the specific research focus. This section, however, discusses findings based on empirical evidence from three world cities, namely Boston in the USA, Abuja in Nigeria, and Manchester in the UK. In doing so, it focuses on how technologies are introduced to cities and summarises the existing models for an assessment of Smart impacts. In addition, the discussion touches on the incorporation of a Smart City into wider economic strategy of cities. This section, therefore, helps to sufficiently justify how the stated research objectives were met.

8.3 Findings from the Literature Review and the Investigation of Current Smart City Frameworks

The comprehensive literature review helped to develop a full understanding of existing Smart City frameworks under implementation in different city regions, which is one of the objectives of this study, and outlined in Chapter 1. Thus, as outlined in Chapter 1, the questions underpinning this objective are: ‘what gaps need to be filled in the current Smart Cities models in order to make them capable of promoting *smartness* of cities in Nigeria?’ and ‘How can cities in Nigeria, especially the Abuja city region, leverage the concept of social innovation and emerging technologies in Smart Cities for sustainable social and economic development?’ Based on evidence from literature, Smart City innovation is seen as the solution to sustainability challenges, an improved quality of life, and better efficiency in cities. Smart City studies, such as the those by Bătăgan (2011), Paroutis et al. (2014), and Schaffers et al. (2011a) support this finding. However, it would appear that the potential benefits of introducing technologies into cities through Smart City innovation is somewhat weakened by a host of challenges established in the literature and identified through the interviews with experts in this study.

Shapiro (2006) looked at Smart Cities from the perspectives of quality of life, productivity, and the growth effects of human capital. Using data on growth in wages, rent, and house values, Shapiro calibrated a neoclassical city growth model to illustrate the relationship between growth and human capital that considers the equilibrium between the conditions of production, wages, and other factors held equally in a dynamic context for a city endowed with location-specific productivity and quality of life. In relying on secondary data from IPUMS, Shapiro

(2006) proposed a model that estimates the underlying relationship between human capital growth in productivity and quality of life. In another framework, Lombardi et al. (2012) established a triple-helix model that emerged as a reference framework for analysing knowledge-based innovation systems. The research led to a framework for classifying Smart City performance indicators and restructuring an analytics network process (ANP) for investigating the relationships between Smart City components, actors, and strategies. The proposed model was based on quantitative indicators and experts' views and had innovative features for the measurement of a Smart City policy vision; however, it still requires further improvement.

Chourabi et al. (2012) explored the understanding of Smart Cities in an integrated framework to examine how local authorities envision Smart City initiatives. Their framework identified eight critical success factors for Smart City initiatives, which include: people and communities, policy context, management and organisation, technology, governance, built infrastructure, natural environment, and the economy. Chourabi et al. (2012) concluded that each of the factors in their framework was important in assessing the extent of their Smartness when examining Smart City initiatives. This placed emphasis on the possibility that the factor of technology heavily influenced all other factors. Other studies, such as that by Nam and Pardo (2011a) proposed a framework for Smart Cities from the dimension of People, Technology, and Institution. Moreover, Schaffers et al. (2011a) proposed a framework based on the future Internet and Open Innovation, whilst the framework developed by Jin, Gubbi, Marusic, and Palaniswami (2014) was based on an urban information system through the Internet of Things (IoTs).

As noted in the literature review, cities are 'easy' locations where the world's creative and innovative activities shape the nature of global economies using technology and social innovation. Social innovation is diverse and is becoming attractive to critical fields, such as social entrepreneurship, technology, and cities and urban development (Mulgan et al., 2007). Although the primary concerns of this study are how the concept of social innovation makes the promising ideas of Smart Cities useful, not necessarily by analysing the different dimensions of innovations that are social, but rather to highlight Smarter ways of managing the challenges of the unprecedented rate of urban growth. The imperative is that Smart Cities are contextualised with a variety of creative talents that are capable of offering novel and sustainable solutions in modern urban constellations by promising a mix of human capital, high-tech infrastructure, and social capital within a creative entrepreneurial environment (Kourtit & Nijkamp, 2012). As highlighted in the review, further insights in critical areas, such as the potential of Big Data analytics for real-time information about entire city sub-systems, decentralised cloud-based platforms for Smart Cities, and testing a number of these Smart solutions in core sectors of the city. With innovative solutions in the web of things, the IoT, social media, and crowdsourcing, emerging technologies are now adopting critical roles in a wide range of applications in the key city services, such as health, education, transportation, and professional services.

In terms of the proposed architectures for Smart City deployment, this research recognises various contributions from different perspectives in this area. It is important to acknowledge that a number of authors have recognised internet technologies - especially the IoT - as a critical component in various designs, including sensor networks and cloud computing. Although some of the authors approached the issue of architecture for SCs in a particular pattern based on technologies for SOA, EDA, the IoT and the IoE, a few architectures referenced in the literature have adopted the techniques of combining more technologies for managing advanced applications. For instance, Rong et al. (2014) have designed a simple layered architecture that integrates the functionalities of the IoT, SOA and EDA for the better management of data intensive technologies in Smart Cities. In view of some of the weaknesses noted with respect to many of the discussed technologies, a comprehensive integration of technologies and architectures for SOA, EDA, the IoT and the emerging IoE will create cross-domain solutions to handle the data processing challenges of future cities, especially with respect to sensor systems and the ‘cloud of things’.

The current study has contributed significantly by examining the core components of Smart Cities, their critical success factors and indicators by using the outcome of a systematic literature review, a pilot study, interviews with experts, and a survey to contribute to existing knowledge and the summarisation of a Smart City KPI model, as detailed in the subsequent sections.

8.4 Finding of the Pilot Study

At the preliminary phase of this study, a pilot investigation was considered imperative to streamline the scope of the research and obtain expert opinion on the importance of the different perspectives and components of Smart Cities identified in the literature. Thus, Smart City stakeholders were identified in FCT-Abuja from diverse professions and sectors, such as urban planning, the ICT industry, transportation, and academia. The pilot study was conducted in the form of a focus-group with the pilot instruments employing an aspect of Q-methodology ranking with a small group of professionals. This was later expanded to cover more professionals, in line with experts' opinions. The data analysis of the pilot study, as presented in Chapter 5, established the criticality of three components, which were also referred to as the core components of Smart Cities from the initial list of the 19 components used for the pilot study. On the basis of the pilot study and the factor analysis these three components were retained for further analysis as core components of Smart Cities.

8.5 Critical Success Factor Associated with Smart City Impacts Assessment

This section discusses the critical success factors of the core components of Smart Cities which were initially identified through the literature, then subjected to interviews with experts/empirical testing, statistical analysis and system dynamic simulations. Building on the outcome of the field investigation, as analysed in Chapters 6 and 7, the critical factors of Smart Cities were grouped into three distinct groups within the core components established from the pilot study. The critical factors and the results of each group (component) will be discussed in this section.

8.5.1 Smart Infrastructure

The first and most important component is the Smart Infrastructure. This component is considered the driving force of all Smart innovation in a city (Chourabi et al., 2012; Giffinger et al., 2007; Lombardi et al., 2012) . It serves as the platform for both social and technological innovation in any city. After the content analysis of the interviews with experts and the correlation analysis, the obsolete and/or weak variables were removed (in this instance INF1, INF5, INF8, INF11, and INF12) to establish the list of critical factors for a Smart Infrastructure.

The removal of the weak variables was strictly based on weak correlations and a consensus with the content analysis of the qualitative phase of this study.

I. Availability of ICT Infrastructure: The role of ICT infrastructure in driving sustainable Smart City developments in future cities for innovative solutions in the management of complex urban systems, and improvements in sustainability and livability, has been validated as one of the highly critical factors of a Smart Infrastructure. This is supported by previous studies that proposed framework models for Smart City deployment. The framework developed by Chourabi et al. (2012) asserted that ICTs are key drivers of innovation in Smart and Sustainable cities. They emphasised that the integration of ICT technologies with development initiatives are capable of changing the urban landscape since they offer potential opportunities to enhance the management and function of a city. Furthermore, Lombardi et al. (2012) proposed a framework for Smart City performance assessment which emphasised the need for a special emphasis on ICT-based solutions that offer various opportunities for new urban design and management. The model also identified the planning and policy implications for new initiatives to ensure an efficient, effective and reliable infrastructure in the six core areas in which the ICT infrastructure was emphasised. These literature findings corroborate the empirical findings in Chapter 6 and the survey analysis in Chapter 7.

A number of Smart City frameworks and standards, including ISO37120 Standard on City Indicators – Sustainable Development of Communities, emphasised ICT infrastructure as most critical factor of a Smart Infrastructure for Smart Cities. The ISO37120 standard proposed 100 indicators to help cities assess their performance, measure progress over time, and ultimately improve sustainability and their citizens' quality of life. In this standard, the ICT infrastructure was among the 18 areas of measurement as telecommunication innovation (see also Lee et al., 2013; Martinez-Balleste et al., 2013 ; Neirotti et al., 2014; Paskaleva (2009).

II. Environmental Sustainability: The importance of leveraging Smart City innovation to enhance environmental sustainability is one of the critical factors of a Smart Infrastructure for Smart Cities that has been validated in this study. In theory, a number of Smart City studies have discussed environmental sustainability from different perspectives. For instance, Chourabi et al. (2012) identified the factor of environmental sustainability from the perspective of the natural environment. Their framework recognised the need for environmental sustainability and technology that helps to increase sustainability and better manage natural resources, confirming that these were critical to examining the impacts of Smart Cities. The deployment of intelligent technologies in Smart City infrastructure ultimately aims to improve the environmental sustainability of services to make cities more agile and capable of responding to a variety of urban problems (Lee et al., 2014). Moreover, through a real-time city, Big Data, and Smart urbanism, Kitchin (2014) identified that Smart Infrastructure (such as sensors networks) can be deployed to monitor the general environmental condition of cities. Malhotra et al. (2013) identified the challenges related to climate change and the substantial risks to people and the environment. A major emphasis in their study was on the criticality of deploying information systems (IS) for environmental sustainability that will economically and environmentally benefit society. They cited the use case example of large technology companies launching Smart City online simulations for climate awareness.

The importance of environmental sustainability is thus one of the critical factors of Smart Cities relevant to the Smart Infrastructure component; this view is also supported by Anttiroiko, Velkama and Bailey (2014), and Viitanen and Kingston (2014). Viitanen and Kingston, for instance, established that the digitisation of urban systems and infrastructures backed by the World Bank, OECD, EU, and the World Economic Forum, is a viable proposition in securing environmental sustainability. These findings from the literature were also confirmed by the empirical results in Chapter 6 and the survey analysis in Chapter 7.

III. Secured and Innovative Transport Systems: The importance of leveraging Smart City innovation to build sustainable transport systems for efficiency, improved livability, and a better quality of life for citizens is one of the critical factors of a Smart Infrastructure for Smart City innovation that has been validated in this study. This has been supported by several other studies (Ashim, 2013; Coutard, 2005; Kyriazis et al., 2013). Giffinger and Gudrun (2010) established six charateristics of Smart Cities, 31 critical factors, and 71 indicators, which formed an effective instrument for ranking and positioning cities where sustainable, innovative and safe transport systems were identified as critical factors of Smart Mobility (Transport and ICT). Moreover, Caragliu et al. (2011) established an urban audit data set to analyse the factors and determine the performance of Smart Cities. A major emphasis in their audit was the need for a collection of comparable statistics and indicators for European Cities. Their work identified 250 indicators across nine domains in which 'travel and transport' was emphasised as one of the critical domains.

In addition, sustainable transport systems are considered a major focus in many Smart City innovations as cities find ways to manage new challenges (Albino et al., 2015). As Albino et al. revealed, cities world-wide have started looking for solutions and harnessing technologies that enable transportation linkages, mixed land use, and high-quality urban services that can lead to long-term positive effects on their economies. It is also important to note that sustainable transport systems, as a critical factor of a Smart Infrastructure, are also supported by use case examples of Smart City initiatives cited during the interviews with experts. These citations related integrated transport systems and autonomous vehicle across cases.

IV. Constant Power Supply: A constant power supply as a critical factor of a Smart Infrastructure is perhaps less extensively elaborated in previous research. It would appear from the survey outcome in Chapter 7 that the availability of a constant power supply is identified as one of the critical factors of a Smart Infrastructure for Smart Cities. This factor demonstrates that the deployment of Smart City solutions, or the implementation of any Smart City initiative, especially in cities across developing countries and in particular, FCT Abuja, requires the existence of a stable power supply to sustain Smart services, such as mobility systems, water, emergency, and security. A constant power supply has, so far as previous studies relating to Smart Cities were concerned, focused on the environmental impacts of power generation, efficiency, and the general management of energy resources for the cities, with several studies proposing models for energy storage and renewable sources of energy generation.

The study by Brenna, et al. (2012) identified some key indicators for customer satisfaction concerning the continuity of energy supply, reliability, safety, and feelings in an emergency situation. A major emphasis in their study was on factors relating to environmental sustainability and energy saving. Moreover, Karnouskos (2011) investigated demand via consumer interactions in the Smart City Energy marketplace, whilst Angelidou (2014) adopted a spatial approach to Smart City policy. In comparison, Yamagata and Seya (2013) explored the potential for an integrated land use-energy model through the simulation of a future Smart City, and, Lazaroiu and Roscia (2012) defined a methodology for a Smart Cities model. A number of these studies treated a constant power supply as a given, whereas many cities in developing countries are still faced with the challenges of an adequate power supply required to support the sustainability of Smart innovation within their cities. However, the findings of this study showed a certain level of agreement between the interviews with experts, especially in CASE-2, and the correlation analysis in Chapter 7 which confirmed that a constant power supply strongly influences many variables of the infrastructure component.

Based on the result of the correlation analysis and the interviews with experts, four core factors and 13 core measurement areas (indicators) were established for the Smart infrastructure component, as shown in Figure 8.1. Interestingly, the Smart Grid factor, which was significantly emphasised in Smart City literature, was only confirmed as a critical factor by the survey respondents. Most stakeholders, especially in CASE-2, viewed the factor of a Smart Grid as a management issue, whereas their major concern was the availability of resources - for example, a constant power supply - to support their city's innovation eco-system.

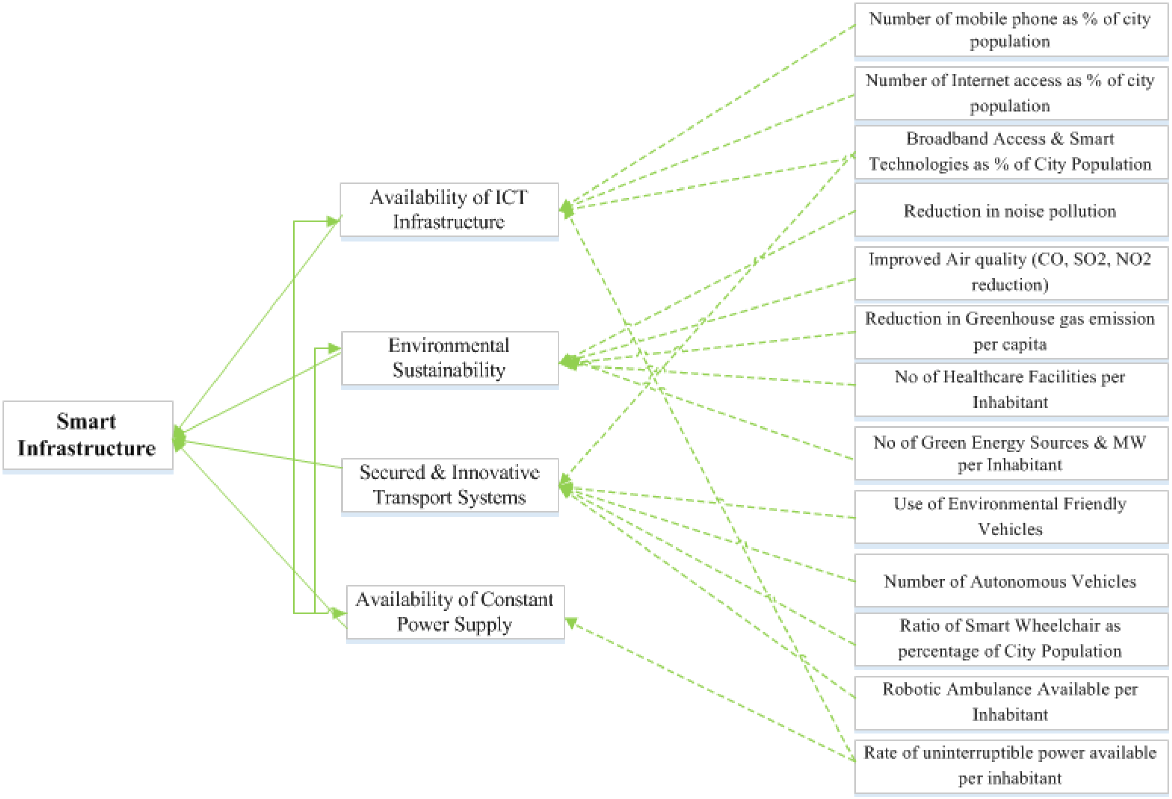

Figure 8-1: Theoretical Model of the Smart Infrastructure KPIs

8.5.2 Smart Institution

The second important component considered in this study is Smart Institution. This component is considered important for the design and implementation of Smart City initiatives, in fostering cooperation among the stakeholders, mainly for smooth governance and policy direction (Cocchia, 2014). As Nam and Pardo (2011a) suggest, urban planning based on governance with multiple stakeholders is important for Smart growth. Thus, Smart City initiatives require governance to enable their success. A number of previous studies also support this finding, including the work of Chourabi et al. (2012) and (Berardi, 2013); these identified institutional sustainability as one of the core components of an assessment of sustainable communities, through the application of the following three factors: local authority services, community activity, and local leadership. Again, after the content analysis of the interviews with experts and the correlation analysis, the obsolete and/or weak variables were removed (in this instance INS2, INS3, INS5, and INS11) to establish the list of critical factors for a Smart Institution. Similar to the procedures in section 8.3.1, the removal of the weak variables was also based on weak correlations and a consensus with content analysis of the qualitative phase of this study.

I. Transparent Governance: Based on the evidence obtained from the survey analysis, it is sufficient to suggest that the factor of transparent governance is perceived as the most critical factor of a Smart Institution for Smart Cities since it strongly influences many other institutional variables. Moreover, the findings of the qualitative analysis (in Chapter 6) also show a strong consensus across the three cases in which stakeholders are aware that transparent governance is a critical factor of a Smart Institution. Again, this is supported by previous studies that proposed framework models for Smart Cities in the dimensions of institution and governance.

The strong consensus on transparent governance among the different categories of interview participants and survey respondents is perhaps unsurprising when also considering evidence from the literature review and the analysis phase of this study. ISO37120 on the Sustainable Development of Communities, for instance, identified governance as one of the critical factors with six measurement areas. Similarly, Giffinger et al. (2010) identified transparent governance as one of the critical factors in the dimension of Smart governance in their framework. Other previous studies that support transparent governance as a critical factor of the Smart Institution include Goldsmith and Crawford (2014), and Nam and Pardo (2011a) . Nam and Pardo, who conceptualised the Smart City through the dimensions of technology, people, and institutions, identified transparent governance as one of the critical factors of an institution that relates to the fundamental components of a Smart City. A major emphasis in their study was the need to create an enabling environment, in terms of initiatives, structure, and engagement, to support a Smart City. Furthermore, they cited institutional readiness as a cornerstone for successful Smart City development, especially in minimising legal and regulatory barriers.

II. Entrepreneurship and Sustainable Development: The importance of leveraging Smart City innovation to improve entrepreneurial growth in cities is one of the critical factors of the Smart Institution, as validated in this study. From the findings of the content analysis of the interviews in Chapter 6, it is sufficient to suggest that entrepreneurship and sustainable development is at the core of institutional (governance and policy) concerns for Smart Cities. This finding is strongly corroborated by the outcome of the survey results in Chapter 7. After the correlation analysis, entrepreneurship and sustainable development were confirmed to have strong positive correlations with a number of other factors. The consensus among the stakeholders promoting entrepreneurship and sustainable development is perhaps unsurprising given that previous a number of previous studies have also emphasised that entrepreneurship and sustainable development are at the core of Smart City development. For example, in a case study of three European cities (Barcelona, Amsterdam, and Helsinki), Boes, Buhalis and Inversini (2015) identified four fundamental constructs of Smart City innovation, which include leadership, entrepreneurship and innovation, social capital, and human capital. From these, the factor of entrepreneurship and innovation was found to be the core construct of Smart City innovation across the three cities. This study recognised the importance of entrepreneurship innovation, social capital and their interrelated factors.

Entrepreneurship and sustainable development, as a critical factor, was also supported by other studies that specifically investigated the emergence of the Smart City as an urban development strategy. For instance, Giffinger et al. (2010) identified entrepreneurship as a critical factor under their component of Smart Economy. Morover, Chourabi et al. (2012) noted that the operational definition of Smart Economy in Giffinger et al. (2010) identified factors around the economic competitiveness of cities which included innovation, entrepreneurship, productivity, trademark, and the flexibility of the labour market. The current study, therefore, established that entrepreneurship and sustainable development form one of the most important factors of Smart Cities; this was well referenced by stakeholders in the exploratory phase of this research.

III. Productivity: Attracting the human capital-rich worker who will raise productivity and wealth as the nexus between academia and the real economy in future cities has been validated as one of the critical factors of the Smart Institution. Based on evidence obtained from the survey analysis, it is sufficient to suggest that the factor of productivity is one of the critical factors of the Smart Institution for Smart Cities since it strongly influences other institutional variables. Here, the findings of the qualitative analysis in Chapter 6 also shows a strong consensus across the three cases investigated where the factor of productivity was portrayed as one of the critical factors of the Smart Institution.

Again, a number of Smart City frameworks and standards, including UN – Habitat's (2013) "State of the World Cities 2012/2013 - Prosperity of Cities", emphasised productivity as the most critical factor of a Smart Institution for Smart Cities. Increasing productivity and enhancing efficiency are major concerns of Smart City interventions, especially in relation to ensuring urban management and regulation (Gabrys, 2014). As Chourabi et al. (2012) asserted, the economic outcomes of Smart City initiatives relate to business creation, workforce development and most importantly, an improvement in productivity. Similarly, Giffinger et al. (2010) identified productivity as a critical factor of the Smart Economy. (Habitat, 2013) identified productivity as one of the five key dimensions of cities' prosperity factors, which include urban infrastructure, productivity and prosperity, quality of life and urban prosperity, environmental sustainability, and equity.

Regarding the Smart Institution, using the results of the correlation analysis and the interviews with experts, three core factors and 11 core measurement areas (indicators) were established for the Smart Institution component, as shown in Figure 8.2.

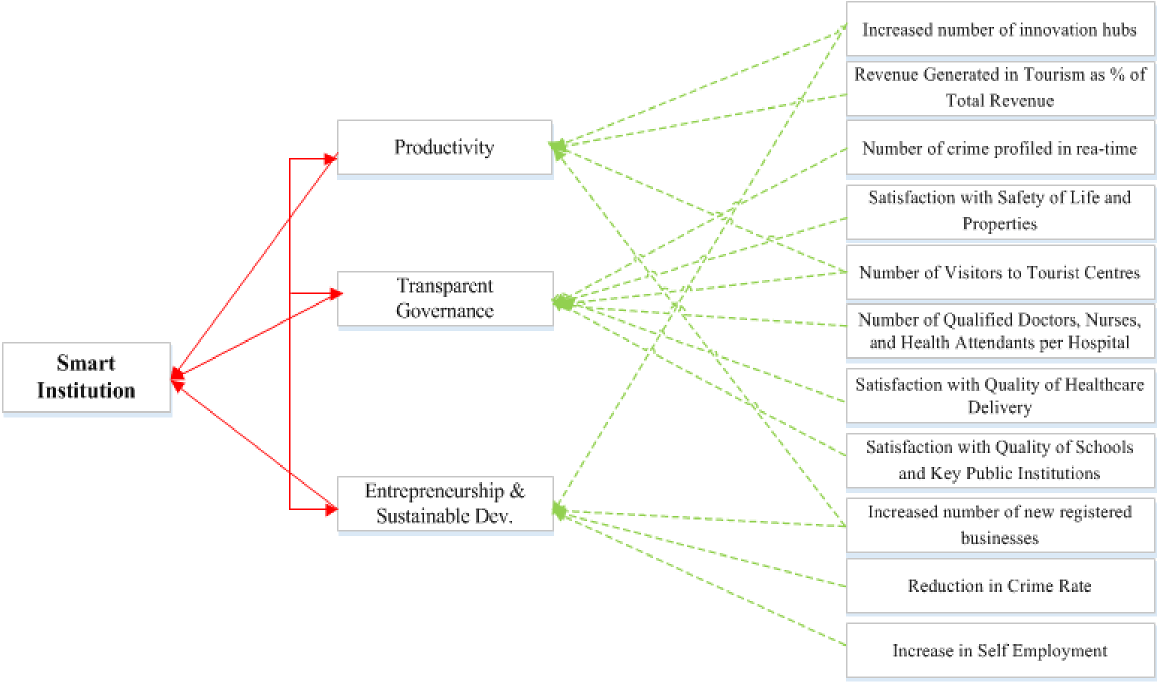

Figure 8-2: Theoretical Model of the Smart Institution KPIs

8.5.3 Smart People

The third important component considered in this study is Smart People. The dimension of Smart People is well elaborated in several existing studies (for instance, Chourabi et al. (2012), Giffinger et al. (2010), and Nam and Pardo (2011a). This component is considered important from the humane perspective of Smart Cities. Smart Cities are expected to be endowed with the intellectual and social capital of their people to enable a creative life. As regards the critical factors of Smart People, after the content analysis of the interviews with experts and the correlation analysis, the weak variables were removed (in this instance PEO2, PEO3, PEO4, and PEO5) to establish a list of critical factors for Smart People. Similar to sections 8.3.1 and 8.3.2, the removal of weak variables was also based on weak correlations and a consensus with the content analysis of the qualitative phase of this study. In total, four factors were successfully finalised following the content analysis of the interviews in Chapter 6 and the correlation analysis in Chapter 7. These factors include: the quality of life, quality education, creativity, and an environment that supports productivity.

I. Quality of Life: The current study establishes that the quality of life is one of the critical factors of the Smart People component. This factor is identified asa major focus of Smart living in existing models that assess Smart Cities; this includes the work of Giffinger et al. (2010) and Lombardi et al. (2012). In addition, the quality of life is emphasised in several

Smart City studies as one of the core objectives of Smart Cities. Falconer & Mitchell, (2012) definition of the Smart City also emphasised the mitigation of urban challenges through the adoption of scalable solutions that leverage ICTs to improve efficiency, reduce cost, and enhance the quality of life . The evidence obtained from the survey analysis suggests that the quality of life factor strongly influences the other Smart People variables. In addition, the findings of the qualitative analysis in Chapter 6 shows a strong consensus across the three cases investigated where the quality of life factor was portrayed as one of the critical factors of Smart People. This study establishes that the efforts to build human capital for Smart Cities needs to focus on citizens' quality of life.

In theory, the quality of life as a critical factor of Smart People has been supported by other studies that have specifically looked at Smart City innovation from the perspectives of sustainability, efficiency, and quality of life. For example, Bakici et al. (2013) revealed that the Barcelona Smart City Standard established eight critical factors, namely: economics, green infrastructure, inclusiveness, science and technology, housing, mobility, quality of life, and the identity to drive the 22@Barcelona Smart City plan. A framework by J.-H. Lee and Hancock (2012) and a white paper by Achaerandio Bigliani, Curto and Gallotti (2012) also emphasised the quality of life as critical factor of a Smart City assessment. Indeed, in their analysis of Spanish Smart Cities, Achaerandio et al. noted that Bilbao's Smart City strategy was based on the following six main areas: economy, citizenship, governance, mobility, environment, and quality of life.

II. Creativity: The central importance of creativity to the economic performance of cities, their cultural diversity, and social cohesion has been validated in this study. This study establishes that, to drive Smart City innovation, the creative workforce, knowledge network, and organisations are crucial. Based on the correlation analysis in Chapter 7, creativity is confirmed to have strong positive correlations with a number of other Smart People factors. In addition, the findings of the qualitative analysis in Chapter 6 reached a strong consensus across the three cases investigated, where the factor of creativity was also portrayed as one of the critical factors of Smart People.

The consensus among the stakeholders that emphasises the factor of creativity is perhaps unsurprising given that a number of previous studies have recognised creativity as a key driver to Smart City development. A framework by Nam and Pardo (2011b) identified the importance of creativity as a driving force of a Smart City in the dimension of human capital. Similarly, Giffinger et al. (2010) identified creativity among the critical factors of Smart People, which was confirmed in this study by stakeholders at different levels (see also the “Smart City Wheel” (Cohen, 2013b).

III. Quality Education: From the evidence obtained in the correlation analysis in Chapter 7, it is sufficient to suggest that quality education also has a strong positive correlation with other Smart People variables. In addition, the findings of the qualitative analysis in Chapter 6 reached a strong consensus across the three cases investigated, which portrayed quality education as one of the critical factors of Smart People. This study establishes that, to develop adequate human capital and a creative workforce to drive Smart City innovation, the quality of a city’s education for its citizens is crucial.

This is also, perhaps, unsurprising, considering the corroboration of the qualitative analysis and survey results. Furthermore, earlier in the literature review, Washburn and Sindhu (2009) identified that quality education was among the seven critical infrastructure components and service of a Smart City in action. Their critical infrastructure and services were: city administration, education, healthcare, public safety, real estate, transportation and utility. A major emphasis in their study was the criticality of high-quality education at a low cost with increased access, improved quality, and sufficient experience.

IV. Environment that Support Productivity: The importance of an enabling environment that encourages creative and knowledgeable citizens (people) to be highly productive (environment that support productivity) is one of the critical factors of Smart People not examined in previous studies. This particular factor establishes that Smart People recognise the importance of creating an enabling environment that meets the needs of the social infrastructure of a city.

Based on the evidence obtained in the correlation analysis in Chapter 7, it is sufficient to suggest that an environment that supports productivity also has a strong positive correlation with other Smart People variables. In addition, the findings of the qualitative analysis in Chapter 6 reached a strong consensus across the three cases investigated, which clarifies that an environment that supports productivity is one of the critical factors of Smart People.

Again, based on the results of the correlation analysis and the interviews with experts, four core factors and eight core measurement areas (indicators) were established for the Smart People component, as shown in Figure 8.3.

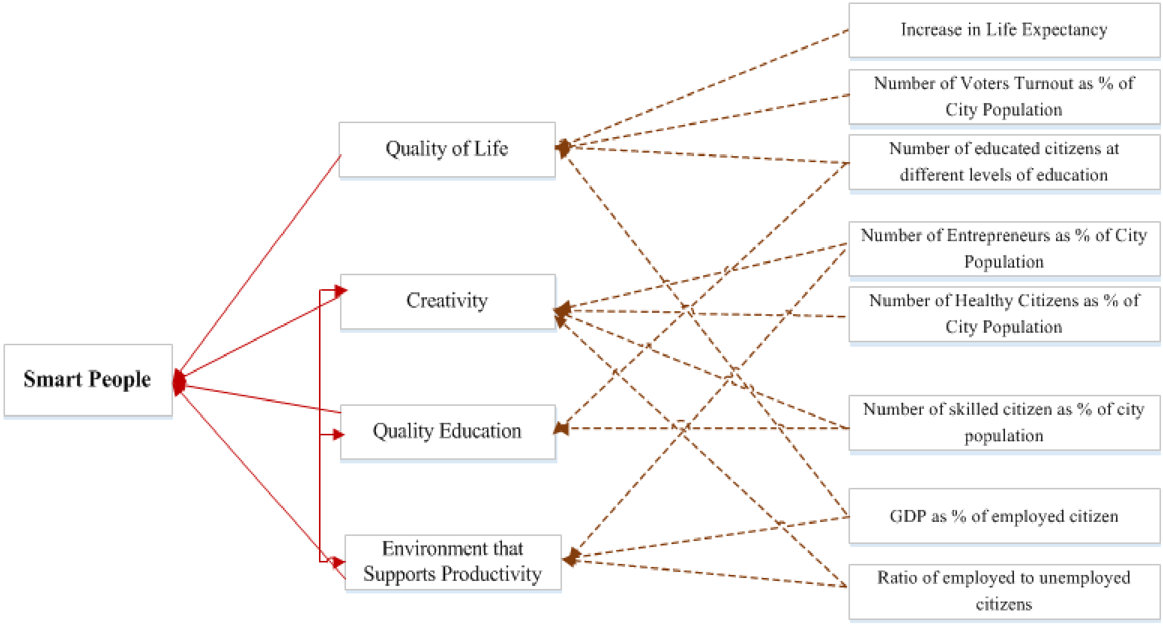

Figure 8-3: Theoretical Model of the Smart People KPIs

8.6 The Proposed Framework

One of the core objectives of this study, as outlined in Chapter 1, is to propose a Smart City framework model based on the core factors and indicators established from the literature and the empirical case study data. In partial fulfilment of the research aim, this section presents the proposed framework for a Smart City development with a KPI model for assessing the impacts of Smartness in the context of FCT-Abuja. It is envisaged that the framework will also serve as guidance for other city regions in Nigeria with a similar history and experience and for other developing countries undertaking Smart City initiatives.

The proposed framework is based on a comprehensive review of the relevant literature and Smart City standards presented in Chapters 1 and 2, and the qualitative/quantitative analysis, including the simulations carried out in Chapters 6 and 7. The key arguments in this study relate to the gap between the theory and practice of Smart City development in which the existing knowledge fails to adequately address the infrastructure provision that remains a challenge among cities in developing countries, and the apparent lack of a summarised KPI model to assess the impacts of Smartness on cities. These gaps can only be understood and addressed through an empirical study that accesses the embedded knowledge of key Smart City stakeholders, and is based on the core components of cities. It is suggested that, by focusing on the core components of cities established in the previous chapters, it is possible to realistically reach the potential for Smart City development, especially amongst cities in developing countries. In addition, the smart dream of cities in both advanced and developing countries can only be realised if the desired impacts of Smartness can be measured, which can be bench-marked on the existing histories, experiences, and challenges of cities.

Furthermore, although the key participants at the qualitative phase of this study were drawn from cities with different histories and experiences, they appear to be approaching the issue of Smart City innovation with similar goals, as shown in Chapter 6. Similarly, the summary of findings from the survey respondents presented in Chapter 7 highlighted the core factors and indicators of Smart Cities which confirmed a number of priority areas. Based on the predominance and importance of the established factors and indicators from the different stages of analysis and the System Dynamics modelling phase, the conceptual framework conceived in Chapter 5 was modified.

Based on the systematic literature review presented in Chapters 2 and 3, the conceptual domains presented in Chapter 5, the comprehensive analysis in Chapters 6 and 7, and the discussion of the findings in this chapter, this study addressed the Smart City development in FCT-Abuja and, by implication, similar cities in developing countries. The findings confirmed that such developments are possible through addressing the three core components of Smart Infrastructure, Smart Institution, and Smart People (as depicted in Figure 8.4).

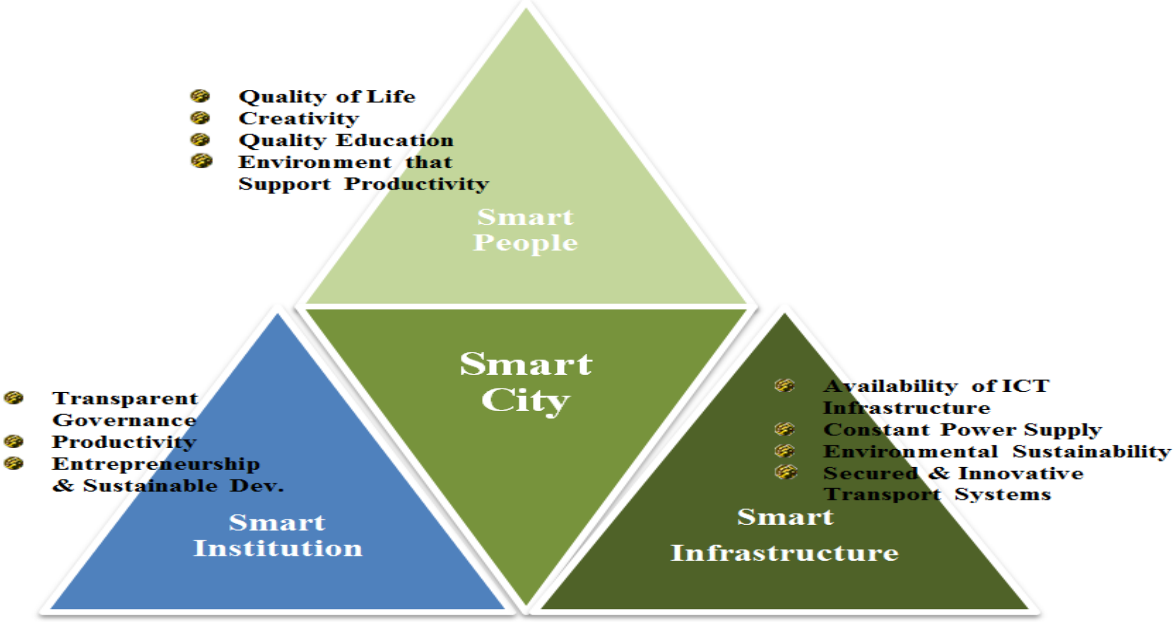

Figure 8-4: Proposed Smart City Framework

8.6.1 Nature of Proposed Framework Model and Further Deductions from the Model Analysis

The proposed framework presented in Figure 8.4 is composed of three sections representing the core components of Smart Cities established in this study. The following sub-sections further highlight the components based on the findings from the literature, the case studies, the correlation analysis, and the modelling phase of the study.

8.6.2 The Smart Infrastructure Component of the Model

Through the literature review, to assess Smart City development, the study highlighted 12 core factors and 15 indicators as measurement areas associated with Smart Infrastructure. Findings from the interview phase of the study corroborated these initial findings through which seven factors with eight indicators were highlighted with differing degrees of emphasis. Furthermore, the correlation analysis confirmed that only four of the factors were critical for a Smart City infrastructure, with thirteen measurement areas forming the core indicators (see also Figure 8.1). Based on the criticality of these four factors (the availability of ICT infrastructure, the availability of a constant power supply, secured and innovative transport systems, and environmental sustainability) and the thirteen indicators, they were included in the modelling structure for the System Dynamics simulation, as shown in Figure 7.11. Thus, using the coefficients of the core indicators as loading values established from the correlation analysis and the System Dynamics modeling, the computation of the mathematical equation for the Smart Infrastructure component is shown as follows:

$$SINF = \int \left(SINF_0^{\frac{1}{2}} \ + SC_{grow}^{\frac{1}{2}} + SINF_{rate} \right) dt \tag{1}$$

$$SINF_{rate} \ = \sum_i^n \left(ICT_{inf} + CP_{sup} + ENV_{sus} + INT_{sys} \right) \tag{2}$$

$$ICT_{inf} = \int \left(ICT_0^{\frac{1}{2}} + CP_{sup}^{\frac{1}{2}} + ICT_{rate} \right) dt \tag{3}$$

$$ICT_{rate} = \sum_i^n \left(BBD_{st} * 0.463 + NINT_{acc} * 0.981 + Mob_{ph} * 0.942 \right) \tag{4}$$

$$CP_{sup} = \int \left(CP_0^{\frac{1}{2}} + CP_{rate} \right) dt \tag{5}$$

$$CP_{rate} = UNP_{av} * 0.545 \tag{6}$$

$$ENV_{sus} = \int \left(ENV_0^{\frac{1}{2}} + INT_{grow}^{\frac{1}{2}} + ENV_{rate} \right) dt \tag{7}$$

$$ENV_{rate} = \sum_i^n \left(IMP_{aql} * 0.564 + GE_{so} * 0.981 + HLT_{no} * 0.843 + RGH_{ge} * 0.564 + NOI_{pe} * 0.902 \right) \tag{8}$$

$$INT_{sys} = \int \left(INT_0^{\frac{1}{2}} + INT_{rate} \right) dt \tag{9}$$

$$INT_{rate} = \sum_i^n (AV_{no} * 0.843 + SW_{ra} * 0.806 + RA_{av} * 0.788 + EF_{reh} * 0.588) \tag{10}$$

Where SINF is the Smart Infrastructure component. $SINF_0$ is the initial Smart Infrastructure. SC_{grow} is Smart City growth. $SINF_{rate}$ is the growth rate of the Smart Infrastructure component. ICT_{inf} is the availability of an ICT infrastructure factor. ICT_{rate} is the growth rate of the ICT infrastructure BBD_{st}, $NINT_{acc}$, $and\ Mob_{ph}$ represent the core indicators of the ICT infrastructure. CP_{sup} is the factor for the availability of a constant power supply and CP_{rate} is the growth rate of a constant power supply. UNP_{av} is the core indicator of the constant power supply. ENV_{sus} is the environmental sustainability factor, while ENV_{rate} represents the growth rate of the environmental sustainability factor, while IMP_{aql} , GE_{so}, HLT_{no}, RGH_{ge}, $and\ NOI_{pe}$ represent the core indicators of environmental sustainability. INT_{sys} is the factor of Secured and Innovative Transport Systems, and INT_{rate} represents the growth rate of the innovative transport systems. AV_{no}, SW_{ra}, RA_{av}, $and\ EF_{reh}$ are the core factors of integrated transport systems.

8.6.3 The Smart Institution Component of the Model

Throughout the literature review, the study also highlighted 11 core factors and 11 indicators as areas of measurement associated with Smart Institution. The interview findings also confirmed some of the initial findings established in literature, from which seven factors with seven indicators were highlighted with differing degrees of emphasis. Furthermore, the correlation analysis confirmed only three of the factors as critical for the Smart City institutions, with 11 measurement areas forming the core indicators (see Figure 8.2). Based on the criticality of these three factors (namely, productivity, transparent governance, and entrepreneurship and sustainable development) and the eleven indicators, these were included in the modelling structure for the System Dynamics simulation, as shown in Figure 7.12a. Again, using the coefficients of the core indicators as loading values established from the correlation analysis, the System Dynamics modeling, the computation of the mathematical equation for the Smart Institution component is shown as follows:

$$SINS = \int \left(SINS_0{}^{\frac{1}{2}} + SC_{grow}{}^{\frac{1}{2}} + SINS_{rate} \right) dt \tag{1}$$

$$SINS_{rate} = \sum_i^n (ES_{dev} + Pro + TG) \tag{2}$$

$$ES_{dev} = \int \left(ES_{dev}{}^{\frac{1}{2}} + SINS_{grow}{}^{\frac{1}{2}} + TG^{\frac{1}{2}} + ES_{rate} \right) dt \tag{3}$$

$$ES_{rate} = \sum_i^n \left(INN_{rb} * 0.706 + IS_{emp} * 0.739 + RC_{ra} * 0.739 \right) \tag{4}$$

$$Pro = \int \left(Pro_0{}^{\frac{1}{2}} + SINS_{grow}{}^{\frac{1}{2}} + TG^{\frac{1}{2}} + Pro_{rate} \right) dt \tag{5}$$

$$Pro_{rate} = \sum_i^n (INI_{hub} * 0.563 + RGT_{tsm} * 0.706) \tag{6}$$

$$TG = \int \left(TG_0{}^{\frac{1}{2}} + SINS_{grow}{}^{\frac{1}{2}} + TG_{rate} \right) dt \tag{7}$$

$$TG_{rate} = \sum_i^n \left(CP_{rt} * 0.644 + SQH_{de} * 0.766 + SQS_{ki} * 0.77 + SS_{lp} * 0.637 + NQD_{hp} * 0.764 + NVT_{cen} * 0.632 \right) \tag{8}$$

Where $SINS$ is the Smart Institution component. SC_{grow} is the Smart City growth. $SINS_0$ is the initial Smart Institution. $SINS_{rate}$ is the growth rate of the Smart Institution component. ES_{dev} is the factor of entrepreneurship and sustainable development. Pro is the productivity factor. TG is the transparent governance factor. ES_{rate} is the growth rate of entrepreneurship and sustainable development, while $INN_{rb}, IS_{emp}, and\ RC_{ra}$ represent the core indicators of entrepreneurship and sustainable development. Pro_{rate} is the growth rate of productivity while $INI_{hub}\ and\ RGT_{tsm}$ represent the core indicators of productivity. TG_{rate} is growth rate of transparent governance $CP_{rt},\ SQH_{de},\ SQS_{ki},\ SS_{lp},\ NQD_{hp},\ and\ NVT_{cen}$ represent the core indicators of transparent governance.

8.6.4 The Smart People Component of the Model

The study highlighted eight core factors and nine indicators, which formed the measurement areas of associated with Smart People; these were adopted from the literature. The interview findings also confirmed some of the initial literature findings from which six factors with five indicators were highlighted with differing degrees of emphasis. Furthermore, the correlation analysis confirmed only four of the factors as critical for Smart People, with eight measurement areas as core indicators (see Figure 8.3). Based on the criticality of these four factors (namely, the quality of life, creativity, quality education, and an environment that supports productivity) and the eight indicators, these were included in the modelling structure for the SD simulation shown in Figure 7.13a. Also, using the coefficients of the core indicators as loading values established from the correlation analysis, the text-based mathematical equation for the System Dynamics simulation modelling was derived for Smart People as follows:

$$SPEO = \int \left({SPEO_0}^{\frac{1}{2}} + {SC_{grow}}^{\frac{1}{2}} + SPEO_{rate} \right) dt \tag{8.1}$$

$$SPEO_{rate} = \sum_i^n \left(CR_{tvy} + ESP_{ro} + QE_{du} + QL_{ve} \right) \tag{8.2}$$

$$CR = \int \left({CR_0}^{\frac{1}{2}} + QE^{\frac{1}{2}} + CR_{rate} \right) dt \tag{3}$$

$$CR_{rate} = \sum_i^n \left(NEN_{cp} * 0.714 + NHC_{cp} * 0.656 \right) \tag{4}$$

$$ESP = \int \left({ESP_0}^{\frac{1}{2}} + ESP_{rate} \right) dt \tag{5}$$

$$ESP_{rate} = \sum_i^n \left(GDP_{empc} * 0.625 + RE_{unmp} * 0.589 \right) \tag{6}$$

$$QE = \int \left({QE_0}^{\frac{1}{2}} + QE_{rate} \right) dt \tag{7}$$

$$QE_{rate} = NSC_{cp} * 0.714 \tag{8}$$

$$QL = \int \left({QL_0}^{\frac{1}{2}} + ESP^{\frac{1}{2}} + QL_{rate} \right) dt \tag{9}$$

$$QL_{rate} = \sum_i^n \left(IL_{exp} * 0.71 + NVT_{cp} * 0.71 + MAT_{liv} * 0.533 \right) \tag{10}$$

Where, $SPEO$ is the Smart People component. SC_{grow} is the Smart City growth. SPEO0 is the initial Smart People component. $SPEO_{rate}$ is the growth rate of the Smart People component. CR is the creativity factor. CR_{rate} is the growth rate of the creativity factor. ESP is the factor of the environment that supports productivity. ESP_{rate} is the growth rate of the environment that support productivity. QE is the quality education factor. QE_{rate} is the growth rate of quality education. QL represents the quality of life factor, while QL_{rate} is the growth rate of quality of life factor.

8.6.5 The General Framework Model

The general equation for the Smart City performance within the confines of the causal relationship among the components and within the model boundary is given as;

Smart City =INTEG ((Smart City^0.5+Rate of Smart City),0)

$$SC_{grow} = \int \left(SC_0^{\frac{1}{2}} + SC_{rate} \right) dt \tag{1}$$

$$SC_{rate} = \sum_i^n (SINF + SINS + SPEO) \tag{2}$$

Where, SC_{grow} is the Smart City growth. SC_0 is the initial Smart City. SC_{rate} is the growth rate of the Smart City. SINF is the Smart Infrastructure component. SINS is the Smart Institution component. SPEO represents the Smart People component.

In summary, the proposed framework captures the key findings from the study and integrates the key elements of the core components of Smart Cities to assess the impact of Smartness. The proposed framework introduces the dimension of the Smart Infrastructure, which, prior to this study, has not been widely emphasised. It is important to note, however, that Smart Infrastructure is an additional contribution as it focuses on the importance of laying the basic foundation for Smart and Sustainable City development, especially in cities where the provision of infrastructure remains a major challenge. It is also important to note that the proposed framework model for Smart City development has a strong scientific basis and adopts tested methods. This study, therefore, provided an opportunity to use tested priority factors/indicators as building blocks to develop a novel framework model as a guide for Smart City stakeholders in Abuja and other cities with similar histories and experiences in developing countries.

8.7 Chapter Summary

This chapter discussed the findings from the systematic review of relevant literature, the interviews from the case studies, the survey component outcomes, and the System Dynamic simulation. The discussion extensively covered findings relating to Smart City development generally, innovations arising from the introduction of emerging technologies to cities, and an in-depth analysis of the core factors/indicators associated with the three core components of Smart Cities which were established in this study. Furthermore, the chapter presented the proposed framework model for assessing the impact of Smartness in cities. The framework model, although not yet validated, has been fully dissected and explained in this chapter, in accordance with the initial aim and objectives for this study. The next chapter presents the conclusions, recommendations, and the direction for the scope of future research undertakings in this area.

CHAPTER 9

9.1 Conclusions and Recommendations

This chapter presents the conclusions and recommendations of the study in accordance with the objectives and draws on the findings discussed in the previous chapters. The chapter further highlights the limitations of the study and suggests areas of further research. The research undertaken was based on the aim to develop a Smart City framework with a KPI model to assess the impacts of socio-technological innovation on the social and economic development of cities in the context of FCT-Abuja, Nigeria. In order to achieve this aim, the objectives were:.

i) To investigate the current Smart City frameworks implemented in different city regions
ii) To identify and document the main social and economic challenges that have the potentials to be addressed through Smart City technologies and innovation.
iii) To review relevant standards and Smart City key performance indicators (KPIs) to identify current development and thinking on Smart City measurement metrics.
iv) To evaluate the dynamic interrelationships among the core factors and indicators of Smart Cities with model flow diagrams, parameter estimation and model validation.
v) To propose and validate a Smart City framework model based on the core factors and indicators established from the empirical case study data.

The research design was based on an integrated approach of triangulation through the conduct of a systematic literature review and the mixed method qualitative and quantitative data collection and analysis; this combination aimed to improve the quality of the evidence derived from the study.

9.2 Summary of the Study

The first objective of this study was to explore the Smart City development in general through an investigation of existing knowledge in literature, and the specific stakeholder experiences in cities across different regions that are currently adopting Smart City development strategies.

To embark on any meaningful study, there is need to develop a well-grounded understanding of the subject and field of study. Therefore, the first objective aimed to provide an opportunity to examine first-hand developments in an emerging field (Smart Cities) and their relevance to cities in developing countries in general and FCT-Abuja in particular. More specifically, it provided the opportunity to understand the different perspectives of Smartness, diverse definitions, the identification of the initial components, key critical success factors and indicators of Smart Cities. These findings from the literature provided the theoretical foundation for the empirical analysis. Thus, the first objective was achieved through a systematic literature review on the Smart City and the case study development in three world cities within North America, Europe, and Africa. This led to the identification of six Smart City wheels and an additional twelve components, which were used as a guide during the pilot study. In addition, the case studies were conducted in the form of in-depth interviews across all three cases, and provided an opportunity to examine cities working towards Smartness and their understanding of the context. This type of empirical investigation also enables the researcher to gain more insight, not only on Smart City development, but on how cities that claim to be smart assess the impact of Smartness on their economies and the relevance of specific factors/indicators to their individual contexts.

The second objective of the study was also achieved through secondary data from the literature. Findings from the initial review were further contextualised by analysing the evidence that related to specific city challenges that were being address through Smart City innovations. The exploration of the secondary data revealed the existence of several Smart City architectures that were proposed in the ongoing social and technological innovations and targeted at specific challenges in several of the cities' sub-systems. Using emerging technologies to address such challenges, these sub-systems included: transportation, security, and the environment. In addition, the comprehensive review seemed to suggest that the introduction of technologies would add further challenges to the complex nature of cities, which indicated that a System Dynamic approach would be required to address them. Thus, a System Dynamic approach was considered for summarising the KPI model to assess the impacts of Smartness in cities.

The third objective was achieved through an investigation into the critical success factors of Smart Cities and the core indicators of smartness; this involved the use of existing Smart City standards and frameworks. This particular objective helped in the identification of 31 critical success factors of Smart Cities and 35 core indicators, which formed the measurement areas that were later grouped and transformed into the survey instrument (questionnaire) for the field investigation. In addition, this objective served as the basis for the development of the conceptual framework for the study. This foundation was laid in Chapter 1, it was rigorously discussed in Chapter 5, and later reinforced in Chapter 6.

The fourth objective was achieved after the correlation analysis was conducted for the three components of Smart Cities. This was achieved by establishing the components of the critical success factors and their underlying relationship with each indicator. The refined core factors/indicators were adopted for the evaluation of the System Dynamics model using stock flows alongside feedback on the central concepts of Systems Dynamics theory. Using 'Vensim PLE for academics', the established factors/indicators were used to simulate the causal relationship among the core components of Smart Cities and their performances. The core factors/indicators of the individual components were modelled, tested, and validated before integrating them into the general model for Smart City KPIs.

Lastly, the fifth objective was to propose a Smart City framework model based on the core factors and indicators established from the empirical case study data; this was achieved through the different stages, including the qualitative analysis which identified the central objectives of Smart City innovation and assessed the core factors/indicators of Smart Cities, and explored through the entire process. In addition, the factors/indicators were investigated in a survey (a quantitative study) and presented in Chapter 7. The established factors/indicators were further refined for System Dynamics modelling in a stock and flow diagram that was developed to simulate causal relationships among the core components of Smart Cities by employing the aforementioned SD tool, Vensim. Thus, the underlying structure of interactions among the core components were established and presented in Chapter 7. Moreover, the conceptual framework was proposed in Chapter 5, as developed from the literature findings and feedback from the pilot study, and was refined based on the findings from case studies and the quantitative analysis discussed in Chapters 6 and 7.

9.3 Main Findings and Conclusions

Based on the findings from the cases investigated, it was found that the conceptualisations of Smartness in cities from Europe to America and Africa are similar. Furthermore, Smart City stakeholders at different levels tend to raise issues of entrepreneurial development and governance in Smart City discourse, arguing that, in order for cities to retain sustainable development, emphasis needs to be placed on an improved quality of life. Although the study acknowledged the views expressed by a number of urbanism scholars opposed to the Smart City concept as ‘technocratic solution’ to city challenges, the findings from the study offer a novel contribution to existing knowledge on Smart Cities, especially as it relates to the KPI model for assessing impact. The study remains exploratory in nature, and, like other empirical studies, provides a significant contribution to the body of knowledge regardless of its limitations. The findings from the sequential methodology adopted for this study were brought together and presented in Chapters 6 and 7, on the basis of which some meaningful conclusions can be drawn, as follows:

1. The literature review revealed interesting themes that support the need for innovation platforms as social, physical or technological starting points for Smart City processes. According to the key participants interviewed, innovation platforms are crucial for knowledge sharing and serve as test-beds for enhancing healthy collaboration and the participation of stakeholders in the development processes of a city. In this regard, the study reveals that the Boston’s New Urban Mechanics partnership with R&D institutions to provide test-beds for Smart solutions, thereby encouraging citizen engagements was highlighted as a good model. In addition, the government at the state level is incentivising R&D results in order to accelerate technology adoption to build robust and Smart healthcare systems using the PULSE/MassChallenge innovation platform. Manchester City is also building similar platforms through their CityVerve initiative and the CityLab collaborative arrangement. Another example cited includes the participatory Chinatown in Boston, where Smart City stakeholders and city administration are experimenting with an approach to collecting data from citizens through the neighbourhood planning processes.
2. This research introduced a different perspective in the way the impacts of Smart Cities can be assessed as different components. They were reported separately in the literature review and reduced to three core components through further research. Smart Infrastructure was introduced as one of the core components and a major priority in the context of cities in developing countries where the provision of a reliable and sufficient infrastructure to support Smart City -- for instance electricity -- is in serious deficit. The literature review established that existing Smart City KPI models focused mainly on the Smart Environment, Smart Economy, Smart Governance, Smart People, Smart

Mobility, and Smart Living, whilst a number of other components were proposed in Smart City KPI models and highlighted in Chapters 2, 3, and 5. This study establishes that the Smart City KPI model needs to focus on the core characteristics and components that are critical to the development of city economies, with core factors and indicators that are closely associated with the different cities' sub-systems. Thus, the critical success factors for the established core components were organised as follows:

   a) The Smart Infrastructure component was established with four CSFs, which were: the availability of an ICT infrastructure, environmental sustainability, secured and innovative transport systems, and a constant power supply. This component had 13 core measures.
   b) The Smart Institution was established with three CSFs, which were: transparent governance, entrepreneurship and sustainable development, and productivity. This component had 11 core measures.
   c) Similarly, the Smart People component was established with four CSFs, which were: the quality of life, creativity, quality education, and an environment that supports productivity. This component had eight core measures.

3. The investigation of the CSFs associated with the Smart Infrastructure revealed some interesting findings. For example, the qualitative analysis revealed that, of the seven CSFs highlighted, the availability of an ICT infrastructure, environmental sustainability, secured and innovative transport systems, and a constant power supply are critical to smart city development. The correlation analysis also confirmed these four CSFs as critical factors (see Chapter 7). However, in the correlation analysis a Smart Grid was selected as one of the critical CSFs of a Smart Infrastructure, but this was not emphasised by the interviewees. Furthermore, the factor of pollution control, secured and innovative technologies, and educational facilities were rarely mentioned by interviewees while the quantitative analysis also identified their weak correlations. Moreover, 13 of the identified indicators for the Smart Infrastructure were confirmed with only two indicators, which demonstrated a very weak correlation, i.e. efficient transport network and transport system per inhabitant, and the existence of Smart equipment for real-time monitoring and control. These were excluded from the final established indicators.
4. The result also revealed that, of the seven Smart Institution CSFs that were highlighted by the interviewees, only three were emphasised as critical success factors for Smart

City development. These were: transparent governance, productivity, and entrepreneurship & sustainable development. Interestingly, the flexibility of the labour market and Open Data and Big Data, which were emphasised in the literature as critical to Smart City development, were not confirmed in this study. Again, the result of the quantitative analysis of the CSFs also indicated that the transparent governance factor had the highest correlation; this was followed by productivity and entrepreneurship and sustainable development. Moreover, although international accessibility and innovative and proactive systems, demonstrate a strong correlation with one or two factors, the two factors were not mentioned by the interviewees. Interestingly, the correlation analysis of the 11 Smart Institution indicators were confirmed as all demonstrated a strong correlation with one or more of the indicators (see Chapter 7).

5. For the Smart People component, the qualitative analysis revealed that four of the five CSFs highlighted by the interviewees were deemed critical success factors. These were: quality of life, creativity, quality education, and an environment that supports productivity. However, the flexibility factor established in literature was not confirmed in this study as one of the critical CSFs for Smart People. Again, the result of the correlation analysis also supported these four factors with quality of life demonstrating the strongest influence on the four other factors. Furthermore, creativity strongly influenced three factors, an environment that supports productivity influenced three factors, while quality education demonstrated a strong influence on two other factors. Here, the correlation analysis of the nine Smart People indicators demonstrated a strong correlation with one or more indicator/s, with the only exception being the percentage of educated citizens at different levels of education, which had a weak negative/positive relationship.
6. The literature review on the Smart City standards and frameworks established that the availability of an ICT infrastructure, and secured and innovative transport systems were predominant factors. These were emphasised by Smart City practitioners as critical success factors associated with a Smart Infrastructure. However, the qualitative analysis (see Chapter 6) following validation by the quantitative analysis (see Chapter 7) demonstrates that, in addition to the availability of an ICT infrastructure, and secured and innovative transport systems, environmental sustainability and a constant power supply also are the most important critical success factors for determining the level of Smartness of a city. These relate to how Smart and environmentally friendly the city has become as a result of deploying a Smarter development infrastructure.

7. The literature review also established that transparent governance and participation in decision-making are predominant factors for assessing the impacts of Smart City institutions. The generalised results from the qualitative and quantitative analysis establishes that transparent governance is the most prominent critical success factor, but there must also be productivity, and entrepreneurship and sustainable development to assess how Smart innovation in cities impacts on entrepreneurial growth and productivity.
8. The generalised results from the literature investigation, and the qualitative and quantitative analysis establishes that the quality of life, creativity, and quality education are the most critical success factors for assessing the impacts of Smartness on citizens. However, there must also be an enabling environment that supports productivity for creative and educated citizens to explore the opportunities arising from innovative development.
9. The System Dynamics model developed from the results of the sequential methodology (presented in Chapter 7) demonstrates that the Smart Infrastructure component has a greater influence on the performance of Smart Cities; this is followed by the Smart People component. The influence of the Smart Institution, based on the individual component analysis, is reliant on the capacity of the people and the existence of an efficient infrastructure. Thus, as a city attains maturity in its level of Smartness, the influence of institutions reduce significantly (see Figure 7.20).

9.4 Recommendations

After a comprehensive discussion of the key findings of this study, and on the basis of the literature review, the interviews with experts, the survey results, and the System Dynamics simulation, some key recommendations can be made to guide Smart City stakeholders, both in developing countries generally, and in FCT-Abuja in particular. The recommendations are drawn from the overall findings of this study and are summarised as follows:

1) To realise the expected socio-economic impacts and spatial consequences of Smart City initiatives, there is a need to adequately address the challenge of infrastructure deficits in core sectors of the city. This is peculiar to FCT-Abuja and similar cities in developing countries, given the apparent lack of development infrastructure necessary to effectively support Smart City deployment.

2) In general, there is a need for Smart City standards to define guidelines for Smart City practitioners in Nigeria. The development of standards can adapt the pro-active strategies adopted in the USA, UK, and Spain in formulating framework standards for Smart City development. For instance, BSI has rolled out a number of Smart City framework standards covering critical areas, such as Smart City Terminology (PAS 180), ISO/IEC 30182:2017, Smart City Framework Standard (PAS181), Data Concept model for Smart Cities (PAS 182), and the Guideline for Sharing Data (PAS 183).
3) Although some advanced cities have started to prototype and experiment with the real-world application of Smart City solutions in key sectors, such as transportation (mobility as a service for instance), security, and the environment, the generative potential of a Smart City in driving innovative changes in an urban environment still remain a rhetorical phenomenon, or at the very rudimentary stage in developing countries, including Abuja. Thus, there is a need for an official policy pronouncement with a policy document, or blue-print, for Smart City development to provide the starting point for its adoption in Abuja.
4) In view of the importance of Smart City innovation, it is imperative for city administrators and their partners to leverage the new changes introduced by Smart City development, as a golden opportunity to sustainably develop critical sectors of the city, including waste management, energy consumption, carbon foot-print, green areas, renewable energy sources, and water consumption.
5) Given the outcome of this study and the diverse opinions expressed by stakeholders regarding the major drivers of their Smart City innovations, priority domains, and challenges, it is important to develop a solid foundation for Smart City deployment that is built on a deep understanding of the local context as well as the integration of best practices within advanced cities.
6) Cities also need to first address how to take control of “city data” and transform it into business opportunities for Smart City to work effectively. The starting point for Smart Cities therefore is development of the technologies for analyzing data and controlling that data in order to make cities more sensitive to their environments.
7) Regarding the strategies and approach for Smart City adoption, a combination of both ‘top-down’ and ‘bottom-up’ approaches are recommended to provide an innovation ecosystem that will create a sense of citizen ownership of the Smart City initiatives, and in order to accelerate a deep commitment to deliver public value for sustainability.

8) Based on the outcomes of this study, particularly with regard to the critical success factors of future cities, there is need for local leaders or a visionary leadership that will serve as a 'Smart City Champion'. These individuals needs to be well-versed in the new era of social and technological innovation and well-grounded in international best practice with the ability to foresee the future trend of global events in Smart and Sustainable Cities development and the dynamism to attract the political-will to actualise the vision.
9) The model of New Urban Mechanics currently under experimentation in Boston, or the establishment of the City Laboratory that serves as a test-bed for innovators may be needed as an input in order to build knowledgeable human capital that will extend the development of knowledge workers from the factory-floor to the research laboratory of an intelligent city.
10) As emphasised by interviewees (see Chapter 6), a participatory stakeholder approach is recommended to define the priority areas on which Smart City initiatives must focus. Thus, in measuring the urban metabolism, or by analysing how the city becomes more productive, more entrepreneurial, and more efficient as a result of Smartness, there is need to define and adopt a KPI model that is relevant to the history and experiences of the city.
11) Smart City is also about economic development. Thus, aligning the Smart City strategies with the city-wide development strategy remain crucial in order to assess the socio-economic impacts of the Smart City initiatives.
12) Finally, inter-agency collaboration is necessary to encourage the active participation of both local and international development partners, whilst also reducing the bureaucratic bottle-neck that will hamper a citizen-sensitive culture in Smart City deployment.

9.5 Research Contributions

This study has made major contributions to the body of knowledge in Smart City development. The original contribution of this research is divided into three categories namely, the theoretical, methodological, and practical contributions.

A. Theoretical Contributions: The theoretical contributions of this study stem from its uniqueness. It combined various perspectives from previous studies on the evolution of the Smart City with new considerations through an in-depth examination of a large body of relevant literature; in doing so, it added unified/diverse schools of thought in an integrative manner. For instance, no previous study has addressed the need to develop a KPI model for Smart Cities through an empirical study. Moreover, the sequential methodology is unique in considering the experiences of cities in advanced and less-advanced regions to identify core factors/indicators of Smartness.

Another major theoretical contribution comes from the establishment of the Smart City core components and their associated factors/indicators that emerged from the pilot study, case studies, and quantitative analysis. The study, therefore, introduced a new perspective for understanding the relationships among the core components of Smart Cities based on empirical evidence. The primary intention was not to test existing theories but to create new theoretical insights that were well-grounded in the experiences of practitioners.

Most importantly, the study offers new theoretical insights worthy of sharing amongst those interested in laying the solid foundations for Smart City understanding and development. This was achieved by emphasising Smart Infrastructure as one of the core components of Smart Cities, and particularly relevant to establishing the concept of Smartness in developing countries.

B. Methodological Contributions: Firstly, the study reveals some interesting facts from the literature on research methods that are relevant to other researchers. Most importantly, the sequence of methodological approaches adopted for this study, from the pilot to the case study and by analysing both qualitative and quantitative data, has generally enriched the level of understanding of Smart City development. This approach allowed for the investigation of real issues relating to Smart City innovation in order to gain better insights and deeper knowledge on how the vision for Smarter cities is being pursued in different city regions.

Additionally, the different case studies selected from different regions helped to test the methodological approach. It achieved this by firstly, looking into different aspects of place-based innovation and the implications for the Smart aspiration of cities. Secondly, the approach also helped to test, from a generic perspective, the understanding of the Smart City concept amongst stakeholders in different city-regions in order to streamline the relevance and appropriateness of the core factors/indicators of Smartness. Although a number of Smart City studies canvassed the need for research on Smart Cities to adopt a case study methodology that includes cases from wealthier and poorer cities, its actual implementation with an inclusive selection of cases across diverse regions with different development indicators is rare. Thus, the outcomes of this study are valuable to research communities in both developed and developing countries.

C. Practical Contributions: In practice, the direct benefits of this study can be offered to Smart City practitioners in Abuja and to cities with a similar history/experiences within Nigeria and beyond, that are preparing to launch the Smart City concept as a development strategy. The study is therefore highly relevant to Smart City stakeholders as it provides a considerable insight into the conceptualisation of Smart City development through its rigorous reviews and case study development in the three world cities.

The core components and their associated factors/indicators that were established in this study through the different stages of testing have been integrated in the proposed framework model in the context of Abuja Smart City. Thus, with minor modification these findings from the study can serve as a blue-print for the easy adoption and adaptation to other similar cities in Nigeria. Because the study adopted a comprehensive data collection and analysis process on a multinational and multidisciplinary context, the findings and the framework may appeal to Smart City practitioners in both advanced and less-advanced cities across the globe, since it may identify core aspects of Smart innovation that are relevant to the sustainability of cities in any region.

Finally, the outcomes of the study are of the utmost relevance to core Smart City stakeholders in industry and academia as they raise the awareness amongst professionals of the System Dynamics approach for modelling the KPIs to assess the performance impacts of cities Smartness, which, in turn, supports effective and timely decision-making.

9.6 Research Limitations

Although this study has met its aim and objectives, and adequately addresses the research questions, it is important to acknowledge that it is exploratory in nature and as such, is expected to have some limitations, like any study. The limitations associated with this study are highlighted below:

1) The major limitation perhaps is the generalisability of the research outcomes across different regions. The study is restricted to the three cases of Boston City in North America, Manchester City in Europe, and FCT-Abuja in Africa and thus cannot be generalised universally until similar studies are conducted in other city regions, especially in Asian countries, which were not covered in this study.
2) The exclusion of end-user groups, who are non-experts, in this study. The outcomes of this study only looked at the experiences of key Smart City stakeholders, which include urban planners, ICT professionals, academia, transport professionals, and other professionals involved in Smart City initiatives. It did not seek contributions from citizens who are the beneficiaries -- and interest groups -- of Smart City development in the future. Such an inclusive research study would be time-consuming and costly, and thus beyond the scope of the current study. However, future research should include this category of stakeholders.
3) Inadequate documentation on ongoing Smart City projects, especially in CASE-2 (FCT Abuja), also limits the validation of the framework. The researcher hoped for robust documented evidence on ongoing Smart City initiatives, which was not readily available in Abuja due to the infancy of their Smart City development. This also accounted for the poor use case examples of Smart City presence in Abuja compared to Boston and Manchester, as highlighted in the case study analysis.
4) The data collection, as far as the interviews/case study development were concerned, involved travel to three different cities in different countries, thus creating logistical and time constraints. Similarly, the survey component in Abuja was based on the list of Smart City stakeholders in FCT with limited participation from civil society groups. This introduced the risk of poor representativeness, which was associated with the choice of data collection method, namely a survey.
5) Finally, the inability to test the framework model is also another limitation. The framework model needs to be tested and validated in a Smarter city environment to assess its feasibility and effectiveness. As acknowledged, FCTA's Smart City development is still at the foundational stage and data relating to the impacts of Smartness may not be reliable at this stage.

9.7 Implications of this Study

It should be noted here that this research study has addressed the need for a framework to promote innovation in Smart Cities and serve as a guide to Smart City stakeholders in FCT-Abuja, Nigeria. The study is the first of its kind conducted in any city in Nigeria and by extension in any African city. The development of the framework benefits from high-quality data from knowledge-rich Smart City stakeholders involved in the ongoing smart innovations in Europe and North American cities. Thus, the outcome of this research study has implications for Smart City practitioners in the academia as well as the policy makers in city administration and the industry.

9.7.1 Implication for Policy and Industry Practice

The direct implications and benefits of this study can be offered to the industry and Smart City policy makers in the following area:

1) Addressing policy inconsistencies that militate against implementation of robust masterplan needed to promote smart growth in the city through adoption of home-grown Smart City framework model.
2) Introduction of new urban development planning strategies grounded in social and technological innovation ideals to help in addressing the challenges of development infrastructure deficits highlighted in this study and resolving cross-organisational challenges in the city.
3) Policy makers can contextualize how they can use the established critical success factors and indicators of Smart Cities KPIs for assessing impacts and the maturity level of their city sub-systems in order to understand what the city need in smart growth rather than copying from what others do in advanced regions or being pushed into “white-elephant” projects by vendors who are only interested in marketing solutions that may not address peculiar needs of their city.
4) The outcome of this study suggests the need for strong political leadership as champions of Smart City deployment. In this sense, smart growth requires interagency collaboration with strong commitment of the top decision makers. Relationship with top decision makers in this context can help to address any conflict of interest that may arise there in.

5) The findings from this empirical study also suggests the need for addressing funding challenges as emphasized in CASE-1. In this direction, the direct implications of this study can help city authorities to address issues relating to revenue leakages, budgetary constraints, and identifying alternative sources of funding for Smart City initiatives.

9.7.2 Implication for Academic Practice

The study has wide range of implications for academic practice in the following areas:

1) The study adopted sequential methodology to study the understanding of Smart City phenomenon in different city regions rather than examining or confirming existing theories in this research field. This is considered imperative to research and academic community as there is no existing theory that explore the direct experiences of cities from both advanced and developing regions for which to match the revelations of this research study.
2) As noted in the previous chapters (chapter 1, chapter 4, and chapter 8), this study is based a balanced view of Smart Infrastructure, Smart Institution, and Smart People components of Smart Cities. It further identified the need for Smart Infrastructure which prior to this study not well emphasized in Smart City literature as a priority. The results of the study suggests a number of CSFs and indicators of Smart Infrastructure that must be prioritized for integration of the complex systems of cities. In this direction, the study is offering Smart Infrastructure as a new core component of Smart Cities and as a new theme in this field of research.
3) The underlying relationships among the established Smart City KPIs in this study has direct implications for research and academic practices in the area of possible new hypotheses for further empirical studies. This way, the validity of System Dynamics approach for modelling Smart City KPIs can be examined.

9.8 Emerging Areas for Future Research

This study provides fertile ground for further researchers who may be interested in examining Smart City development in the context of cities in developing countries, and by extension, the Smart City world. The study in itself cannot be a destination but rather a process to improve the understanding of the Smart City concept for FCTA stakeholders. Thus, it could lead to useful prospective research in the following areas:

1) Further investigation of the everyday experiences of the governmental and non-governmental bodies that partner the FCT authorities to transform Abuja City into a Smarter environment could perhaps highlight interesting outcomes in terms of an appropriate Smart City model for cities in developing countries. The recent IBM Smart Cities Challenge award to FCT and the partnership formation between IBM management and FCT to implement Smart City initiatives in Abuja offers the potential for future studies
2) Efforts have been made in this study to analyse the critical success factors and indicators to assess the impacts of Smartness on cities. This involved a focus on three core components/dimensions; however, it also offers new research directions in revealing a number of potential relationships among the established factors that could be examined in the future.
3) It would be possible for future research to expand the scope of this study to cover more sectors of the economy. Moreover, comparing the relevance of the core factors and indicators identified in this study could perhaps highlight more interesting outcomes in enabling the development of a global view of Smart City KPIs.
4) The study has attempted to conceptualise a tool for modelling summarised Smart City KPIs to assess the performance and impacts of Smartness. Future research could explore ways to improve upon the proposed System Dynamic model to make it more robust and assess a Smart City performance in any region.
5) The proposed Smart City framework model could serve as a guide and the basis for a comprehensive blue-print with a range of measurable action plans and timelines for stakeholder organisations to implement in the core areas established in this study. This could involve a detailed implementation roadmap with identified Smart City champions at the municipal and higher authority levels, who will support the development of an effective Smart City in Abuja.

References

Abubakar, I. R. (2014). Abuja city profile. *Cities, 41*, 81-91.

Achaerandio, R., Bigliani, R., Curto, J., & Gallotti, G. (2012). Smart Cities Analysis in Spain 2012–The Smart Journey. *IDC. Available at: http://www. portalidc. com/resources/white_papers/IDC_Smart_City_Analysis_Spain_EN. pdf (visited 25 July 2013)*.

Agbali, M., Arayici, Y., & Trillo, C. (2017). Taking the advancement of sustainable smart cities seriously: the implication of emerging technologies. *Tamap J. Eng*.

Agbali, M., Trillo, C., Arayici, Y., & Fernando, T. (2017). Creating Smart and Healthy Cities by Exploring the Potentials of Emerging Technologies and Social Innovation for Urban Efficiency: Lessons from the Innovative City of Boston. *World Academy of Science, Engineering and Technology, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering, 11*(5), 617-627.

Agbali, M., Trillo, C., & Fernando, T. (2017). *Towards a Novel Framework of Key Performance Indicators for Measuring the Impacts of Smart Cities in Emerging Economies.* Paper presented at the 13th International Postgraduate Research Conference 2017, Manchester, UK.

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities, 60*, 234-245.

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology, 22*(1), 3-21.

American, P. A. (2015). Smart Cities and Sustainability Initiatives *www.planning.org* (Vol. Retrieved August 07, 2015).

Anderson, V. (2013). *Research methods in human resource management: investigating a business issue*: Kogan Page Publishers.

Andreini, F., Crisciani, F., Cicconetti, C., & Mambrini, R. (2011). *A scalable architecture for geo-localized service access in smart cities.* Paper presented at the Future Network & Mobile Summit (FutureNetw), 2011.

Angelidou, M. (2014). Smart city policies: A spatial approach. *Cities, 41*, S3-S11.

Anthopoulos, L., & Fitsilis, P. (2010). *From digital to ubiquitous cities: Defining a common architecture for urban development.* Paper presented at the Intelligent Environments (IE), 2010 Sixth International Conference on.

Anthopoulos, L., & Giannakidis, G. (2016). *Task-based process modeling for policy making in smart cities.* Paper presented at the ITU Kaleidoscope: ICTs for a Sustainable World (ITU WT), 2016.

Anthopoulos, L. G. (2015). Understanding the smart city domain: A literature review *Transforming city governments for successful smart cities* (pp. 9-21): Springer.

Anttiroiko, A.-V., Valkama, P., & Bailey, S. J. (2014). Smart cities in the new service economy: building platforms for smart services. *AI & society, 29*(3), 323-334.

Appleyard, B., Ferrell, C., Carroll, M., & Taecker, M. (2014). Toward Livability Ethics: A Framework to Guide Planning, Design, and Engineering Decisions. *Transportation Research Record: Journal of the Transportation Research Board*(2403), 62-71.

ATV. (2018). Smart City Systems Integrator and ICT Projects. Retrieved from http://abujatechnologyvillage.com/what-we-offer/invest/

Awuah, K. G. B. (2018). Urban development and governance in Nigeria: challenges, opportunities and policy direction. *International Development Planning Review, 40*(1), 27-49.

Bakıcı, T., Almirall, E., & Wareham, J. (2013). A smart city initiative: the case of Barcelona. *Journal of the Knowledge Economy, 4*(2), 135-148.

Bankvall, L., Dubois, A., & Lind, F. (2017). Conceptualizing business models in industrial networks. *Industrial Marketing Management, 60*, 196-203.

Barlas, Y. (1996). Formal aspects of model validity and validation in system dynamics. *System dynamics review, 12*(3), 183-210.

Bartlett, M. S. (1954). A note on the multiplying factors for various chi square approximations. *Journal of the Royal Statistical Society*, 296-298.

Bătăgan, L. (2011). Smart cities and sustainability models. *Informatica Economică, 15*(3), 80-87.

Batty, M. (2008). Cities as complex systems: scaling, interactions, networks, dynamics and urban morphologies.

Batty, M. (2013). Big data, smart cities and city planning. *Dialogues in Human Geography, 3*(3), 274-279.

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., . . . Portugali, Y. (2012). Smart cities of the future. *The European Physical Journal Special Topics, 214*(1), 481-518.

Benamrou, B., Mohamed, B., Bernoussi, A.-s., & Mustapha, O. (2016). *Ranking models of smart cities.* Paper presented at the Information Science and Technology (CiSt), 2016 4th IEEE International Colloquium on.

Berardi, U. (2013). Sustainability assessment of urban communities through rating systems. *Environment, development and sustainability, 15*(6), 1573-1591.

Bernstein, I. H., & Nunnally, J. (1994). Psychometric theory. *New York: Mc-Graw-Hill. Oliva, TA, Oliver, RL, & MacMillan, IC (1992). A Catastrophe Model for Developing Service Satisfaction Strategies. Journal of Marketing, 56*, 83-95.

Bis. (2013). *Global Innovators: International Case Studies on Smart Cities*. Retrieved from London SW1H 0ET: http://www.estudislocals.cat/wp-content/uploads/2016/11/global-innovators-international-smart-cities.pdf

Blaikie, N. (2010). *Designing Social Research* (Second ed.). UK: Polity Press.

Blanchard, R. D., Engle, D. L., Howley, L. D., Whicker, S. A., & Nagler, A. (2016). From the coliseum to the convention centre: a reflection on the current state of medical education conferences and conference-goers. *Medical education, 50*(12), 1258-1261.

Boes, K., Buhalis, D., & Inversini, A. (2015). Conceptualising smart tourism destination dimensions *Information and communication technologies in tourism 2015* (pp. 391-403): Springer.

Go Boston 2030, (2015).

Brace, I. (2008). *Questionnaire design: How to plan, structure and write survey material for effective market research*: Kogan Page Publishers.

Brenna, M., Falvo, M., Foiadelli, F., Martirano, L., Massaro, F., Poli, D., & Vaccaro, A. (2012). *Challenges in energy systems for the smart-cities of the future.* Paper presented at the Energy Conference and Exhibition (ENERGYCON), 2012 IEEE International.

Brewer, J., & Hunter, A. (2006). *Foundations of multimethod research: Synthesizing styles*: Sage.

BSI, T. B. S. I. (2014). Smart city framework Guide to establishing strategies for smart cities and communities. UK: BSI.

Budget Office. (2018). FCT Budget Proposal, 2018. Retrieved from http://www.budgetoffice.gov.ng/index.php/2018-budget-proposal/2018-budget-proposal

Burns, R. B. (1997). *Introduction to research methods*: Addison Wesley Longman.

Calzada, I. (2013a). Critical social innovation in the smart city era for a city-regional european horizon 2020. *Browser Download This Paper*.

Calzada, I. (2013b). Critical social innovation in the smart city era for a city-regional European Horizon 2020. *P3T Journal of Public Policies & Territories, Social Innovation and Territory*(6), 1-20.

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. *Journal of urban technology, 18*(2), 65-82.

Carli, R., Dotoli, M., Pellegrino, R., & Ranieri, L. (2013). *Measuring and managing the smartness of cities: A framework for classifying performance indicators.* Paper presented at the Systems, Man, and Cybernetics (SMC), 2013 IEEE International Conference on.

Carneiro, A. (2000). How does knowledge management influence innovation and competitiveness? *Journal of Knowledge Management, 4*(2), 87-98.

Carrillo, F. J., Yigitcanlar, T., Velibeyoglu, K., & Martinez-Fernandez, C. (2008). Rising knowledge cities: the role of urban knowledge precincts. *Journal of Knowledge Management, 12*(5), 8-20.

Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate behavioral research, 1*(2), 245-276.

Ceballos, G. R., & Larios, V. M. (2016). *A model to promote citizen driven government in a smart city: Use case at GDL smart city.* Paper presented at the Smart Cities Conference (ISC2), 2016 IEEE International.

CentreforCities. (2014). *Smart Cities*. Retrieved from http://www.centreforcities.org/wp-content/uploads/2014/08/14-05-29-Smart-Cities-briefing.pdf

Chao, Y., & Zishan, M. (2013). system dynamics model of Shanghai passenger transportation structure evolution. *Procedia-Social and Behavioral Sciences, 96*, 1110-1118.

Chen, M.-C., Ho, T.-P., & Jan, C.-G. (2006). A system dynamics model of sustainable urban development: assessing air purification policies at Taipei city. *Asian Pacific Planning Review, 4*(1), 29-52.

Chinatown, P. (2017). Participatory Chinatown, Boston. Retrieved from http://www.participatorychinatown.org/

Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., . . . Scholl, H. J. (2012). *Understanding smart cities: An integrative framework.* Paper presented at the System Science (HICSS), 2012 45th Hawaii International Conference on.

Chowdhury, S. N., & Dhawan, S. (2016). *Evaluation of key performance indicators of smartcities by Delphi analysis.* Paper presented at the Recent Trends in Electronics, Information & Communication Technology (RTEICT), IEEE International Conference on.

City of Boston. (2015a). Go Boston 2030.

City of Boston. (2015b). *Go Boston 2030*. Retrieved from https://www.boston.gov/transportation/go-boston-2030

City of Boston. (2017). *Imagine Boston, 2030*. Retrieved from https://www.boston.gov/news/last-draft-imagine-boston-2030-plan-released

City of Boston. (2018). Fiscal Year 2018 Budget. Retrieved from https://budget.boston.gov

CityVerve. (2018). Smart City Case Studies. Retrieved from http://www.manchester.gov.uk/directory_record/178563/cityverve/category/1160/case_studies

Clarke, R. Y. (2013). Smart cities and the internet of everything: The foundation for delivering next-generation citizen services. *Alexandria, VA, Tech. Rep*.

Cocchia, A. (2014). Smart and digital city: A systematic literature review *Smart city* (pp. 13-43): Springer.

Cohen, B. (2012). What Exactly is Smart City? (Vol. 2017).

Cohen, B. (2013a). Boyd Cohen: The Smart City Wheel. Retrieved from https://www.smart-circle.org/smartcity/blog/boyd-cohen-the-smart-city-wheel/

Cohen, B. (2013b). The Smart City Wheel. Retrieved from https://www.smart-circle.org/smartcity/blog/boyd-cohen-the-smart-city-wheel

Cohen, B. (2015). Keynote Address -What Exactly is Smart City? (Vol. 2017).

Collis, J., & Hussey, R. (2013). *Business research: A practical guide for undergraduate and postgraduate students*: Palgrave macmillan.

Collis, J. a. H., Roger. (2014). *Business research : A practical guide for undergraduate & postgraduate students* (Fourth Edition ed.). UK: PALGRAVE.

Convene. (2010). Is Boston the Smartest City? Retrieved from https://convene.com/catalyst/is-boston-the-smartest-city

Corden, A., & Sainsbury, R. (2006). *Using verbatim quotations in reporting qualitative social research: researchers' views*: University of York York, UK.

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical assessment, research & evaluation, 10*(7), 1-9.

Coutard, O. (2004). Urban space and the development of networks: a discussion of the “splintering urbanism” thesis *Sustaining Urban Networks* (pp. 64-80): Routledge.

Coyle, G. (2009). Qualitative and quantitative modelling in system dynamics. *SYSTEM DYNAMICS-Volume II*, 33.

Creswell, J. (2015). *A Concise Introduction to Mixed Method Research*. Los Angeles: SAGE.

Crotty, M. (2003). *The foundations of social research : Meaning and perspective in the research process.* London: SAGE.

Datta, A. (2015). New urban utopias of postcolonial India: ‘Entrepreneurial urbanization’in Dholera smart city, Gujarat. *Dialogues in Human Geography, 5*(1), 3-22.

Dawes, J. G. (2012). Do data characteristics change according to the number of scale points used? An experiment using 5 point, 7 point and 10 point scales.

Dawson, C. (2009). *Introduction to research methods: A practical guide for anyone undertaking a research project*: Hachette UK.

Denscombe, M. (2014). *The good research guide: for small-scale social research projects*: McGraw-Hill Education (UK).

Denzin, N. K. (1970). *The research act in sociology*.

DePoy, E., & Gitlin, L. N. (2015). *Introduction to Research-E-Book: Understanding and Applying Multiple Strategies*: Elsevier Health Sciences.

Dirks, S., & Keeling, M. (2009). A vision of smarter cities: How cities can lead the way into a prosperous and sustainable future. *IBM Institute for business Value, 8*.

Distefano, S., Merlino, G., & Puliafito, A. (2013). Exploiting SAaaS in smart city scenarios *Intelligent Computing Theories* (pp. 638-647): Springer.

Dodgson, M., & Gann, D. (2011). Technological innovation and complex systems in cities. *Journal of Urban Technology, 18*(3), 101-113.

Du Plessis, M. (2007). The role of knowledge management in innovation. *Journal of Knowledge Management, 11*(4), 20-29.

Easterby-Smith, M., Thorpe, R., & Jackson, P. R. (2012). *Management research*: Sage.

Eberlein, R. L., & Peterson, D. W. (1992). Understanding models with Vensim™. *European journal of operational research, 59*(1), 216-219.

Estevez, E., Lopes, N., & Janowski, T. (2016). Smart sustainable cities: Reconnaissance Study.

Evans, J., & Karvonen, A. (2014). ‘Give Me a Laboratory and I Will Lower Your Carbon Footprint!’— Urban Laboratories and the Governance of Low-Carbon Futures. *International Journal of Urban and Regional Research, 38*(2), 413-430.

Falconer, G., & Mitchell, S. (2012). Smart city framework: a systematic process for enabling smart+ connected communities. *Cisco IBSG*, 1-11.

Fidel, R. (2008). Are we there yet?: Mixed methods research in library and information science. *Library & Information Science Research, 30*(4), 265-272.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*: sage.

Fiksel, J. (2006). Sustainability and resilience: toward a systems approach. *Sustainability: Science, Practice and Policy, 2*(2), 14-21.

Filipponi, L., Vitaletti, A., Landi, G., Memeo, V., Laura, G., & Pucci, P. (2010). *Smart city: An event driven architecture for monitoring public spaces with heterogeneous sensors.* Paper presented at the Sensor Technologies and Applications (SENSORCOMM), 2010 Fourth International Conference on.

Forrester, J. W. (1995). The beginning of system dynamics. *McKinsey Quarterly*, 4-17.

Gabrys, J. (2014). Programming environments: environmentality and citizen sensing in the smart city. *Environment and Planning D: Society and Space, 32*(1), 30-48.

Gebhardt, C. (2015). The spatial dimension of the triple helix: the city revisited–towards a mode 3 model of innovation systems. *Triple Helix, 1*(2), 1-4.

Ghanbari, A., Laya, A., Alonso-Zarate, J., & Markendahl, J. (2017). Business development in the internet of things: a matter of vertical cooperation. *IEEE Communications Magazine, 55*(2), 135-141.

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., & Meijers, E. (2007). *Smart cities-Ranking of European medium-sized cities*. Retrieved from

Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: an effective instrument for the positioning of the cities? *ACE: Architecture, City and Environment, 4*(12), 7-26.

Goldsmith, S., & Crawford, S. (2014). *The responsive city: Engaging communities through data-smart governance*: John Wiley & Sons.

Goodspeed, R. (2014). Smart cities: moving beyond urban cybernetics to tackle wicked problems. *Cambridge Journal of Regions, Economy and Society, 8*(1), 79-92.

Gordon Falconer and Shane Mitchell. (2012). Smart City Framework: A Systematic Process for Enabling Smart+Connected Communities. Retrieved from https://www.cisco.com/c/dam/en_us/about/ac79/docs/ps/motm/Smart-City-Framework.pdf

Gray, D. (2009). *Doing research in the real world.* Los Angeles, [Calif.] ; London.: SAGE.

Gray, D. E. (2013). *Doing research in the real world*: Sage.

Grossi, G., & Pianezzi, D. (2017). Smart cities: Utopia or neoliberal ideology? *Cities, 69*, 79-85.

Guallart, V., & Giralt, F. (2014). City Anatomy: A Framework to support City Governance, Evaluation and Transformation.

Habitat, U. (2013). *State of the world's cities 2012/2013: Prosperity of cities*: Routledge.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (1998). *Multivariate data analysis* (Vol. 5): Prentice hall Upper Saddle River, NJ.

Hall, P. G., & Raumplaner, S. (1998). Cities in civilization.

Harrison, C., & Donnelly, I. A. (2011). *A theory of smart cities.* Paper presented at the Proceedings of the 55th Annual Meeting of the ISSS-2011, Hull, UK.

Henderson, K. A. (2011). Post-positivism and the pragmatics of leisure research. *Leisure Sciences, 33*(4), 341-346.

Hernandez, J. L. (2014). Connecting Cities with Globally Standardized City Data ICLEI Resilient Cities Webinar: ISO 37120 and the World Council on City Data. Retrieved from http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Webinar_Series/HERNANDEZ_-_ICLEI_Resilient_Cities_Webinar__FINAL_.pdf

Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial? *City, 12*(3), 303-320.

Hu, H., Wen, Y., Chua, T.-S., & Li, X. (2014). Toward scalable systems for big data analytics: A technology tutorial. *Access, IEEE, 2*, 652-687.

IBM. (2012a). *IBM's Smarter Cities Challenge Boston Report*. Retrieved from https://www.smartercitieschallenge.org/assets/cities/boston-united-states/documents/boston-united-states-full-report-2012.pdf

IBM. (2012b). Smarter Planet. Retrieved from http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/smarterplanet

IBM. (2014). 16 cities chosen for IBM's Smarter Cities Challenge 2014.

IBM. (2017a). Analysing the Future of Cities.

IBM. (2017b). IBM Smarter Cities Challenge, Abuja, Nigeria Report.

ISO IEC. (2014). *Smart Cities Preliminary Report*. Retrieved from https://www.iso.org/files/live/sites/isoorg/files/developing_standards/docs/en/smart_cities_report-jtc1.pdf

Jara, A. J., Ladid, L., & Gómez-Skarmeta, A. F. (2013). The Internet of Everything through IPv6: An Analysis of Challenges, Solutions and Opportunities. *JoWUA, 4*(3), 97-118.

Jin, J., Gubbi, J., Marusic, S., & Palaniswami, M. (2014). An information framework for creating a smart city through internet of things. *IEEE Internet of Things Journal, 1*(2), 112-121.

Jiriko, G., JY, D. G., & Wapwera, S. (2015). THE EVOLUTION OF ABUJA AS A 'SMART CITY'A PROGNOSIS.

Jiriko, G. K., Jy, D. G., & Wapwera, S. D. (2015). THE EVOLUTION OF ABUJA AS A 'SMART CITY'A PROGNOSIS.

Kagioglou, M., Cooper, R., Aouad, G., & Sexton, M. (2000). Rethinking construction: the generic design and construction process protocol. *Engineering construction and architectural management, 7*(2), 141-153.

Kaiser, H. F. (1970). A second generation little jiffy. *Psychometrika, 35*(4), 401-415.

Karnouskos, S. (2011). *Demand side management via prosumer interactions in a smart city energy marketplace.* Paper presented at the Innovative Smart Grid Technologies (ISGT Europe), 2011 2nd IEEE PES International Conference and Exhibition on.

Keppel, G., Saufley, W. H., & Tokunaga, H. (1992). *Introduction to design and analysis: A student's handbook*: Macmillan.

Kim, J. S. (2015). Making smart cities work in the face of conflicts: lessons from practitioners of South Korea's U-City projects. *Town Planning Review, 86*(5), 561-585.

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal, 79*(1), 1-14.

Koed Madsen, T. (1989). Successful export marketing management: some empirical evidence. *International Marketing Review, 6*(4).

Koivistoinen, A. (2016). *StartUp Health Insights, Digital Health Funding Rankings Q3, 2016*. Retrieved from https://www.ey.co.il/userfiles/1-aki%20koivistoinen.pdf

Komninos, N., Pallot, M., & Schaffers, H. (2013). Special issue on smart cities and the future internet in Europe. *Journal of the Knowledge Economy, 4*(2), 119-134.

Kourtit, K., Macharis, C., & Nijkamp, P. (2014). A multi-actor multi-criteria analysis of the performance of global cities. *Applied Geography, 49*, 24-36.

Kourtit, K., & Nijkamp, P. (2012). Smart cities in the innovation age. *Innovation: The European Journal of Social Science Research, 25*(2), 93-95.

Kral, M. J., Links, P. S., & Bergmans, Y. (2012). Suicide studies and the need for mixed methods research. *Journal of Mixed Methods Research, 6*(3), 236-249.

Kyriazis, D., Varvarigou, T., White, D., Rossi, A., & Cooper, J. (2013). *Sustainable smart city IoT applications: Heat and electricity management & Eco-conscious cruise control for public transportation.* Paper presented at the World of Wireless, Mobile and Multimedia Networks (WoWMoM), 2013 IEEE 14th International Symposium and Workshops on a.

Kyriazopoulou, C. (2015). *Smart city technologies and architectures: A literature review.* Paper presented at the Smart Cities and Green ICT Systems (SMARTGREENS), 2015 International Conference on.

Lacinák, M., & Ristvej, J. (2017). Smart City, Safety and Security. *Procedia engineering, 192*, 522-527.

Lampard, E. E. (1955). The history of cities in the economically advanced areas. *Economic Development and Cultural Change, 3*(2), 81-136.

Lazaroiu, G. C., & Roscia, M. (2012). Definition methodology for the smart cities model. *Energy, 47*(1), 326-332.

Lee, D., Felix, J. R. A., He, S., Offenhuber, D., & Ratti, C. (2015). *CityEye: Real-time visual dashboard for managing urban services and citizen feedback loops.* Paper presented at the Proc. 14th Int. Conf. on Comp. in Urban Plann. & Urban Manag. CUPUM 2015.

Lee, J.-H., & Hancock, M. (2012). Toward a framework for smart cities: A comparison of Seoul, San Francisco and Amsterdam. *Research Paper, Yonsei University and Stanford University*.

Lee, J. H., Hancock, M. G., & Hu, M.-C. (2014). Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. *Technological Forecasting and Social Change, 89*, 80-99.

Lincoln, Y. S., and Guba, Egon G. (1994). *'Competing paradigms in qualitative research', in Denzin, N.K. and Lincoln, Y.S. Handbook of Qualitative Research.* (N. K. a. L. Denzin, Yvonna S. Ed.). Califonia: SAGE Publications Inc.

Lombardi, P., Giordano, S., Farouh, H., & Yousef, W. (2012). Modelling the smart city performance. *Innovation: The European Journal of Social Science Research, 25*(2), 137-149.

Luna-Reyes, L. F., & Andersen, D. L. (2003). Collecting and analyzing qualitative data for system dynamics: methods and models. *System Dynamics Review, 19*(4), 271-296.

Malhotra, A., Melville, N. P., & Watson, R. T. (2013). Spurring impactful research on information systems for environmental sustainability. *MIS Quarterly, 37*(4), 1265-1274.

Manchester City Council. (2018a). Capital Strategy and Budget 2018/2019. Retrieved from www.manchester.gov.uk/.../16_-_capital_strategy_and_budget_201819_to_202223

Manchester City Council. (2018b). *Digital Strategy – Project Proposal*. Retrieved from www.manchester.gov.uk/download/meetings/.../5c_digital_strategy_–_project_proposal/

Manchester City Council. (2018c). *The Manchester Digital Strategy*. Retrieved from www.manchester.gov.uk/download/meetings/id/3541/digital_challenge_strategy

Manzini, E. (2014). Making things happen: Social innovation and design. *Design Issues, 30*(1), 57-66.

Marceau, J. (2008). Innovation in the city and innovative cities. Special Edition of. *Innovation: Management, policy and practice, 10*(2-3), 136-145.

Marsal-Llacuna, M.-L., Colomer-Llinàs, J., & Meléndez-Frigola, J. (2015). Lessons in urban monitoring taken from sustainable and livable cities to better address the Smart Cities initiative. *Technological Forecasting and Social Change, 90*, 611-622.

Martinez-Balleste, A., Pérez-Martínez, P. A., & Solanas, A. (2013). The pursuit of citizens' privacy: a privacy-aware smart city is possible. *IEEE Communications Magazine, 51*(6), 136-141.

Masadeh, M. A. (2012). Linking philosophy, methodology, and methods: toward mixed model design in the hospitality industry. *European Journal of Social Sciences, 28*(1), 128-137.

MassTech. (2015). Index of Massachusetts Innovation Economy 2015/2016 Edition.

MassTech. (2016). *The Index of the Massachusetts Innovation Economy*

2015/2016 Edition. Retrieved from https://masstech.org/sites/mtc/files/documents/InnovationInstitute/Index/MAInnovationEconomy_2015.pdf

Matsunaga, M. (2010). How to Factor-Analyze Your Data Right: Do's, Don'ts, and How-To's. *International journal of psychological research, 3*(1).

McCarney, P. (2015). The evolution of global city indicators and ISO37120: The first international standard on city indicators. *Statistical Journal of the IAOS, 31*(1), 103-110.

Mitton, N., Papavassiliou, S., Puliafito, A., & Trivedi, K. S. (2012). Combining Cloud and sensors in a smart city environment. *EURASIP journal on Wireless Communications and Networking, 2012*(1), 1-10.

Mohanty, S. P., Choppali, U., & Kougianos, E. (2016). Everything you wanted to know about smart cities: The internet of things is the backbone. *IEEE Consumer Electronics Magazine, 5*(3), 60-70.

Moretti, L. G. (2015). Social Innovation in (smart) cities.

Moustakas, C. (1994). *Phenomenological research methods*: Sage.

Mulgan, G. (2006). The process of social innovation. *innovations, 1*(2), 145-162.

Mulgan, G., Tucker, S., Ali, R., & Sanders, B. (2007). Social innovation: what it is, why it matters and how it can be accelerated.

Mulligan, C. E., & Olsson, M. (2013). Architectural implications of smart city business models: an evolutionary perspective. *Communications Magazine, IEEE, 51*(6), 80-85.

Mumford, L. (1966). *The City in History: Its Origin, Its Transformations, and Its Prospects; With 64 Pl*: Penguin Books.

Nam, T., & Pardo, T. A. (2011a). *Conceptualizing smart city with dimensions of technology, people, and institutions.* Paper presented at the Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times.

Nam, T., & Pardo, T. A. (2011b). *Smart city as urban innovation: Focusing on management, policy, and context.* Paper presented at the Proceedings of the 5th international conference on theory and practice of electronic governance.

Nam, T., & Pardo, T. A. (2014). The changing face of a city government: A case study of Philly311. *Government Information Quarterly, 31*, S1-S9.

Naoum, S. G. (2013). *Dissertation Research and Writing for Construction Students* (3rd ed. ed. Vol. Routledge 3rd ed. 2013).

Naphade, M., Banavar, G., Harrison, C., Paraszczak, J., & Morris, R. (2011). Smarter cities and their innovation challenges. *Computer, 44*(6), 32-39.

Nation, U. (2015). Sustainable Development Goal.

National Population, C. (2013). *Nigeria Demographic and Health Survey*. Retrieved from Nigeria:

National Population Commission. (2013). *Nigeria Demographic and Health Survey*. Retrieved from Nigeria:

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. *Cities, 38*, 25-36.

NIST. (2016). Internet of Things (IoT) Enabled Smart City Framework (Vol. 2017).

Nunnally, J. C., & Bernstein, I. H. (1978). Psychometric theory.

Nunnally, J. C., & Bernstein, I. H. (2007). Psychometric theory.

Odendaal, N. (2003). Information and communication technology and local governance: understanding the difference between cities in developed and emerging economies. *Computers, Environment and Urban Systems, 27*(6), 585-607.

Opeifa, K. (2017). *FCT Integrated Transport System; Efforts, Challenges and Vision*. Paper presented at the 2nd Transportation Growth Initiatives

International Conference, Abuja-Nigeria, FCT Abuja.

Open Data Network. (2016a). Boston Metro Area GDP, 2016. Retrieved from https://www.opendatanetwork.com/entity/310M200US14460/Boston_Metro_Area_MA_NH/economy.gdp.per_capita_gdp?year=2016

Open Data Network. (2016b). Manchester Metro Area GDP, 2016. Retrieved from https://www.opendatanetwork.com/entity/310M200US31700/Manchester_Metro_Area_NH/economy.gdp.per_capita_gdp?year=2016

Pallant, J. (2005). SPSS survival manual: A step guide to data analysis using SPSS for Windows version 12: Chicago, Illinois: Open University Press.

Pallant, J. (2013). *SPSS survival manual*: McGraw-Hill Education (UK).

Palmisano, S. J. (2008). A smarter planet: the next leadership agenda. *IBM. November, 6*, 1-8.

Park, S., & Kim, G. (2016). Applications of system dynamics modelling for management policy implementation of a water supply system. *WIT Transactions on The Built Environment, 165*, 83-92.

Paroutis, S., Bennett, M., & Heracleous, L. (2014). A strategic view on smart city technology: The case of IBM Smarter Cities during a recession. *Technological Forecasting and Social Change, 89*, 262-272. doi:http://dx.doi.org/10.1016/j.techfore.2013.08.041

Paskaleva, K. A. (2009). Enabling the smart city: The progress of city e-governance in Europe. *International Journal of Innovation and Regional Development, 1*(4), 405-422.

Pathirage, C., Amaratunga, RDG, & Haigh, RP. (2008). The role of philosophical context in the development of research methodology and theory.

Penza, M., Suriano, D., Villani, M. G., Spinelle, L., & Gerboles, M. (2014). *Towards air quality indices in smart cities by calibrated low-cost sensors applied to networks.* Paper presented at the SENSORS, 2014 IEEE.

Peter, S. (1990). The fifth discipline. *The Art & Practice of Learning Organization. Doupleday Currence, New York*.

Peterson, D. W., & Eberlein, R. L. (1994). Reality check: A bridge between systems thinking and system dynamics. *System Dynamics Review, 10*(2-3), 159-174.

Phithakkitnukoon, S., Wolf, M. I., Offenhuber, D., Lee, D., Biderman, A., & Ratti, C. (2013). Tracking trash. *IEEE Pervasive Computing, 12*(2), 38-48.

Pile, S., Massey, D., Allen, J., & Pile, S. (1999). What is a city? *City worlds*, 3-52.

City Anatomy: A Framework to support City Governance, Evaluation and Transformation, CPA-I_001-v2 C.F.R. (2015).

Qu, S. Q., & Dumay, J. (2011). The qualitative research interview. *Qualitative research in accounting & management, 8*(3), 238-264.

Ratti, C., & Townsend, A. (2011). The social nexus. *Scientific American, 305*(3), 42-48.

Remenyi, D., Williams B., Money A. and Swartz E. (2003). *Doing research in business and management an introduction to process and method.* London: SAGE.

Robinson, J. (2011). Cities in a world of cities: the comparative gesture. *International journal of urban and regional research, 35*(1), 1-23.

Robson, C., & McCartan, K. (2016). *Real world research*: John Wiley & Sons.

Roman, R., Najera, P., & Lopez, J. (2011). Securing the internet of things. *Computer, 44*(9), 51-58.

Rose, R. (1991). What is lesson-drawing? *Journal of public policy, 11*(01), 3-30.

Rotmans, J., van Asselt, M., & Vellinga, P. (2000). An integrated planning tool for sustainable cities. *Environmental impact assessment review, 20*(3), 265-276.

Ruddock, L. (2008). *Approaches to Economic Modelling and Analysis. In: Knight, A, & Ruddock, L. Advanced research methods in the built environment*. Oxford, UK: Blackwell Publishing Ltd.

Sarantakos, S. (2012). *Social research*: Palgrave Macmillan.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*: Pearson education.

Saunders, M. N. (2011). *Research methods for business students, 5/e*: Pearson Education India.

Saunders, M. P. L. a. A. T. (2009). *Research Methods for Business Students* (Fifth Edition ed.). England: Pearson Education Limited.

Saunders, T., & Baeck, P. (2015). Rethinking Smart Cities from the Ground Up. *London: Nesta*.

Saysel, A. K., Barlas, Y., & Yenigün, O. (2002). Environmental sustainability in an agricultural development project: a system dynamics approach. *Journal of environmental management, 64*(3), 247-260.

Schaffers, H., Komninos, N., Pallot, M., Aguas, M., Almirall, E., Bakici, T., . . . Fernadez, J. (2012). Smart cities as innovation ecosystems sustained by the future internet.

Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M., & Oliveira, A. (2011a). *Smart cities and the future internet: Towards cooperation frameworks for open innovation.* Paper presented at the The future internet assembly.

Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M., & Oliveira, A. (2011b). Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation. *Future Internet Assembly, 6656*, 431-446.

Schootman, M., Nelson, E., Werner, K., Shacham, E., Elliott, M., Ratnapradipa, K., . . . McVay, A. (2016). Emerging technologies to measure neighborhood conditions in public health: implications for interventions and next steps. *International journal of health geographics, 15*(1), 20.

Senge, P. M., & Forrester, J. W. (1980). Tests for building confidence in system dynamics models. *System dynamics, TIMS studies in management sciences, 14*, 209-228.

Shapiro, J. M. (2006). Smart cities: quality of life, productivity, and the growth effects of human capital. *The review of economics and statistics, 88*(2), 324-335.

Shi, Z. (2013). Dilemmas in using phenomenology to investigate elementary school children learning English as a second language. *in education, 17*(1).

Singh, D., Tripathi, G., & Jara, A. J. (2014). *A survey of internet-of-things: future vision, architecture, challenges and services.* Paper presented at the Internet of Things (WF-IoT), 2014 IEEE World Forum on.

Smart, E.-C., & Cooperation, G. C. (2014). Comparative Study of Smart Cities in Europe and China. *Current Chinese Economic Report Series, Springer*.

Solanas, A., Patsakis, C., Conti, M., Vlachos, I. S., Ramos, V., Falcone, F., . . . Perrea, D. N. (2014). Smart health: a context-aware health paradigm within smart cities. *IEEE Communications Magazine, 52*(8), 74-81.

Soriano, J., Lizcano, D., Cañas, M. A., Reyes, M., & Hierro, J. J. (2007). Fostering innovation in a mashup-oriented enterprise 2.0 collaboration environment. *UK, sai: sisn, 24*(2007), 62-68.

Speedtest Global Index. (2018). Ranking mobile and fixed broadband speeds from around the world on a monthly basis. Retrieved from http://www.speedtest.net/global-index

Stephenson, W. (1953). The study of behavior; Q-technique and its methodology.

Sterman, J. D. (2000). *Business dynamics: systems thinking and modeling for a complex world*.

Sterman, J. D. (2002). All models are wrong: reflections on becoming a systems scientist. *System Dynamics Review, 18*(4), 501-531.

Suciu, G., Vulpe, A., Halunga, S., Fratu, O., Todoran, G., & Suciu, V. (2013). *Smart cities built on resilient cloud computing and secure internet of things.* Paper presented at the Control Systems and Computer Science (CSCS), 2013 19th International Conference on.

Sultan, N. (2013). Knowledge management in the age of cloud computing and Web 2.0: Experiencing the power of disruptive innovations. *International Journal of Information Management, 33*(1), 160-165.

Sultan, W. H., Woods, P. C., & Koo, A.-C. (2011). A constructivist approach for digital learning: Malaysian schools case study. *Journal of Educational Technology & Society, 14*(4), 149.

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics*: Allyn & Bacon/Pearson Education.

Tabachnik, B., & Fidell, L. (2007). Using multivariate statistics. Boston. *MA: Pearson*.

Tashakkori, A., & Teddlie, C. (2010). *Sage handbook of mixed methods in social & behavioral research*: Sage.

Techpoint. (2017). Civic Innovation Lab launches in Abuja to harness the possibilities in social innovation. Retrieved from https://techpoint.ng/2017/08/09/civic-innovation-lab-abuja-launch/

TestMy.net. (2018). Internet Speed Test. Retrieved from https://testmy.net/city

Thisday. (2016). Nigeria: NITDA, FCTA, State Govts to Collaborate On Smart Cities Initiatives. Retrieved from http://allafrica.com/stories/201602120629.html

Thoma, I., Fedon, L., Jara, A., & Bocchi, Y. (2015). *Towards a Human Centric Intelligent Society: Using Cloud and the Web of Everything to Facilitate New Social Infrastructures.* Paper presented at the Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2015 9th International Conference on.

Townsend, A. M. (2013). *Smart cities: Big data, civic hackers, and the quest for a new utopia*: WW Norton & Company.

Trading Economics. (2016). FCT GDP per Capita. Retrieved from https://tradingeconomics.com/nigeria/gdp-per-capita

Trochim, W., Donnelly, J. P., & Arora, K. (2015). *Research methods: The essential knowledge base*: Nelson Education.

Tsolakis, N., & Anthopoulos, L. (2015). Eco-cities: An integrated system dynamics framework and a concise research taxonomy. *Sustainable Cities and Society, 17*, 1-14.

Turok, I. (2004). Cities, regions and competitiveness. *Regional studies, 38*(9), 1069-1083.

URBACT. (2017). Building an effective entrepreneurship eco-system. Retrieved from http://urbact.eu/building-effective-entrepreneurship-eco-system

Vafa-Arani, H., Jahani, S., Dashti, H., Heydari, J., & Moazen, S. (2014). A system dynamics modeling for urban air pollution: A case study of Tehran, Iran. *Transportation Research Part D: Transport and Environment, 31*, 21-36.

Vicki L., P. C., John W. Creswell. (2008). *The Mixed Methods Reader*: Sage.

Viitanen, J., & Kingston, R. (2014). Smart cities and green growth: outsourcing democratic and environmental resilience to the global technology sector. *Environment and Planning A, 46*(4), 803-819.

Walliman, N. (2010). *Research methods: The basics*: Routledge.

Walton, D. N. (2004). *Abductive Reasoning*. United States of America: University of Alabama Press.

Wan, J., Li, D., Zou, C., & Zhou, K. (2012). *M2M communications for smart city: an event-based architecture.* Paper presented at the Computer and Information Technology (CIT), 2012 IEEE 12th International Conference on.

Washburn, D., Sindhu, U., Balaouras, S., Dines, R., Hayes, N., & Nelson, L. (2009). Helping CIOs understand "smart city" initiatives. *Growth, 17*.

Watson, V. (2015). The allure of 'smart city'rhetoric: India and Africa. *Dialogues in Human Geography, 5*(1), 36-39.

Wenge, R., Zhang, X., Dave, C., Chao, L., & Hao, S. (2014). Smart city architecture: a technology guide for implementation and design challenges. *Communications, China, 11*(3), 56-69.

Who. (1998). *PROGRAMME ON MENTAL HEALTH: WHOQOL User Manual*. Retrieved from Geneva: http://www.who.int/mental_health/evidence/who_qol_user_manual_98.pdf

Williams, L., Roberts, R. A., & McIntosh, A. (2012). *Radical human ecology: Intercultural and indigenous approaches*: Ashgate Publishing, Ltd.

Willis, K. S., & Aurigi, A. (2017). *Digital and Smart Cities*: Routledge.

Wong, C. (2002). Developing indicators to inform local economic development in England. *Urban Studies, 39*(10), 1833-1863.

World Population Review. (2018). Boston Population 2018.

Xiong, Z., Zheng, Y., & Li, C. (2014). *Data Vitalization's Perspective Towards Smart City: A Reference Model for Data Service Oriented Architecture.* Paper presented at the Cluster, Cloud and Grid Computing (CCGrid), 2014 14th IEEE/ACM International Symposium on.

Xu, Z., & Coors, V. (2012). Combining system dynamics model, GIS and 3D visualization in sustainability assessment of urban residential development. *Building and Environment, 47*, 272-287.

Yamagata, Y., & Seya, H. (2013). Simulating a future smart city: An integrated land use-energy model. *Applied Energy, 112*, 1466-1474.

Yigitcanlar, T., & Velibeyoglu, K. (2008). Knowledge-based urban development: The local economic development path of Brisbane, Australia. *Local Economy, 23*(3), 195-207.

Yin, R. (1994). *Case study research : Design and methods*. London: SAGE.

Yin, R. (2009). *Case study research : Design and methods (4th ed., Applied social research methods series ;* (Vol. 4th Edition). CA London: SAGE.

Yin, R. (2014). *Case study research : Design and methods* (Vol. Fifth Edition). Los Angeles, USA: SAGE.

Yong, A. G., & Pearce, S. (2013). A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in quantitative methods for psychology, 9*(2), 79-94.

Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of things for smart cities. *Internet of Things Journal, IEEE, 1*(1), 22-32.

Zdraveski, V., Mishev, K., Trajanov, D., & Kocarev, L. (2017). ISO-Standardized Smart City Platform Architecture and Dashboard. *IEEE Pervasive Computing, 16*(2), 35-43.

APPENDICES

APPENDIX A: ISO 37120 SUSTAINABLE DEVELOPMENT OF COMMUNITIES INDICATORS FOR CITY SERVICES AND QUALITY OF LIFE

Component	**Indicator**
Economy	City's unemployment rate (Core indicator)
	Assessed value of commercial and industrial properties as % of total assessed value of all properties (core indicator)
	% of city population living in poverty (core)
	% of persons in full-time employment (supporting indicator)
	Youth unemployment rate (supporting indicator)
	Number of businesses per 100000 population (supporting indicator)
	number of new patents per 100000 population per year (supporting indicator)
Education	% of female school-aged population enrolled in schools (core indicator
	% of students completing primary education survival rate (core indicator)
	%of students completing secondary education survival rate (core indicator)
	Primary education student/teacher ratio (core indicator)
	% of male school-aged population enrolled in schools (supporting indicator)
	% of school-aged population enrolled in schools (supporting indicator)
	Number of higher education degrees per 100000 population (supporting indicator)
Energy	Total rersidential electrical energy use per capita (KWH/year) (Core indicator)
	% of city population with authorized electrical service (core indicator)
	Energy consumption of public buildings per year (KWH/m2) (core indicator)
	% of total energy derived from renewable sources as a share of the city's total energy consumption (core indicator)
	Total electricity energy use per capita (KWH/year) (supporting indicator)
	Average number of electrical interuptions per customer per year (supporting indicator)
	Average length of electrical interuptions (in hours) (supporting indicator)
Environment	Fine particulate matter (PM2.5) concentration (core indicator)
	Particulate matter (PM10) concentration (core indicator)
	Greenhouse gas emissions measured in tones per capita (core indicator)
	NO2 (nitrogen dioxide) concentration (supporting indicator)
	SO2 (sulphur dioxide) concentration (supporting indicator)
	O3 (ozone) concentration (supporting indicator)
	Noise pollution (supporting indicator)

	% change change in number of native species (supporting indicator)
Finance	Debt service ratio (debt service expenditure as a % of a municipality's own-source revenue) (core indicator)
	Capital spending as a % of total expenditures (supporting indicator)
	Own-source revenue as a % of total revenues (supporting indicator)
	Tax collected as a % of tax billed (supporting indicator)
Fire and Emergency Response	Number of firefighter per 100000 population (core indicator)
	Number of fire related deaths per 100000 population (core indicator)
	Number of natural disaster related deaths per 100000 population (core indicator)
	Number of volunteer and part-time firefighters per 100000 population (supporting indicator)
	Response time for emergency response services from initial call (supporting indicator)
	Response time for fire department from initiatial call (supporting indicator)
Governance	Voter participation in last municipal election (as % of eligible voters) (core indicator)
	Women as a % of total elected to city-level office (core indicator)
	% of women employed in the city government workforce (supporting indicator)
	Number of convictions for corruption and/or bribery by city officials per 100000 population (supporting indicator)
	Citizens' representation number of local officials elected to office per 100000 population (supporting indicator)
	Number of registered voters as a % of the voting age population (supporting indicator)
Health	Average life expectancy (core indicator)
	Number of in-patient hospital beds per 100000 population (core indicator)
	Number of Physicians per 100000 population (core indicator)
	Number of mental health practitioners per 10000 population (supporting indicator)
	Under age five mortality per 1000 live births (core indicator)
	Number of nursing and midwifery personnel per 100000 population (supporting indicator)
	Suicide rate per 100000 population (supporting indicator)
Recreation	Square meters of public indoor recreation space per capita (supporting indicator)
	Square meters of public outdoor recreation space per capita (supporting indicator)
Safety	Number of police officers per 100000 population (core indicator)
	Number of homicides per 100000 population (core indicator)
	Crime against property per 100000 population (supporting indicator)
	Response time for police department from initial call (supporting indicator)
	Violent crime rate per 100000 population (supporting indicator)

Shelter	% of city population living in slums (core indicator)
	Number of homeless per 100000 population (supporting indicator)
	% of households that exist without registered legal titles (supporting indicator)
Solid Waste	% of city population with regular solid waste collection (residential) (core indicator)
	Total collected municipal solid waste per capita (core indicator)
	% of the city's solid waste that is recycled (core indicator)
	% of the city's solid waste that is disposed of in a sanitary landfill (supporting indicator)
	% of the city's solid waste that is disposed in an incinerator (supporting indicator)
	% of the city's solid waste that is burned openly (supporting indicator)
	% of the city's solid waste that is disposed of in an open dump (supporting indicator)
	% of the city's solid waste that is disposed by other means (supporting indicator)
	Hazardous waste generation per capita (tonnes) (supporting indicator)
	% of the city's hazardous waste that is recycled (supporting indicator)
Telecommunication and Innovation	Number of Internet connections per 100000 population (core indicator)
	Number of cell phone connections per 10000 population (core indicator)
	Number of landline phone connections per 10000 population
Transportation	kilometres of high capacity public transport system per 10000 population (core indicator)
	kilometres of light passenger public transport system per 100000 population (core indicator
	Annual number of public transport trips per capita (core indicator)
	Number of personal automobiles per capita (core indicator)
	% of commuters using a travel mode to work other than a personal vehicle (supporting indicator)
	Number of two-wheel motorized vehicles per capita (supporting indicator)
	Kilometres of bicycle paths and lanes per 100000 population (supporting indicator)
	Transportation fatalities per 100000 population (supporting indicator)
	Commercial air connectivity (number of non-stop commercial air destinations) (supporting indicator)
Urban Planning	Green area (hectares) per 100000 population (core indicator)
	Annual number of trees planted per 100000 population (supporting indicator)
	Areal size of informal settlements as a % of city area (supporting indicator)
	Jobs/housing ratio (supporting indicator)
WasteWater	% of city population served by wastewater collection (core indicator)
	% of the city's wastewater that has received no treatment (core indicator)

	% of the city's wastewater receiving primary treatment (core indicator)
	% of the city's wastewater receiving secondary treatment (core indicator)
	% of the city's wastewater receiving tertiary treatment (core indicator)
Water & Sanitation	% of city population with potable water supply service (core indicator)
	% of city population with sustainable access to an improved water source (core indicator)
	% of population with access to improved sanitation (core indicator)
	Total domestic water consumption per capita (litre/day) (core indicator)
	Total water consumption per capita (litre/day) (supporting indicator)
	Average annual hours of water service interruption per household (supporting indicator)
	% of water loss (unaccounted for water) (supporting indicator)

APPENDIX B: SEMI STRUCTURED INTERVIEW GUIDE

DEVELOPING A FRAMEWORK TO PROMOTE INNOVATION IN SOCIO-ECONOMIC DEVELOPMENT IN SMART CITIES

Semi-structured Interview Guide

PART A: Introduction

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i. What is your official designation/job title in this organisation/agency?
ii. In brief, what are your official responsibilities?
iii. How long have you been functioning in this capacity?
iv. In the course of this interview, I will be taking notes in addition to digital recording. Is that Okay by you?

PART B: Stakeholders Perception of Smart City in Nigeria

The aim of this section is to understand the perception of interviewees about Smart City generally and its deployment in FCTA and Nigerian cities.

i. What is your understanding of Smart City concept?
    - ✓ Kindly give an example of what it means for a city to be smart
    - ✓ Could you mention any characteristics of Smart Cities?
    - ✓ Are you aware of any other city label?

ii. Do you think that the concept of Smart City can assist in addressing development challenges of Nigerian cities (in particular FCT Abuja city)?
    - ✓ Further, – kindly state how the concept may help
    - ✓ Are you aware of any Smart City projects/programmes in Nigeria? ***Yes***

iii. How do you measure the impacts of cities smartness?
iv. What are the metrics (KPIs) for measuring impacts of Smart Cities?
    - ✓ Could you mention the critical success factors of smart city?

  - ✓ Any specific indicators?

v. What aspects of Smart City concept do you feel are relevant to Nigerian cities given our peculiar needs? (e.g. core components)

vi. Kindly mention the priority areas of Smart City components that are key to its deployment in Abuja, Nigeria.

vii. What sector of the city in your opinion should be prioritised in the deployment of Smart City projects/programmes?

viii. What profession do you think should be identified as key stakeholders in the Smart City project?

ix. Do you think a framework or guideline for Smart City deployment should be developed with a model to guide in terms of Smart City best practice?

PART C: Overview of Smart City Initiative, Projects & Programmes

---

i. Kindly give me an overview of your Smart City initiatives, projects & programmes
  - ✓ What are the core objectives of the initiative?
  - ✓ What is the status of this initiative (completed or ongoing)?
  - ✓ Who are the stakeholders involved in this project (individuals/organizations)

ii. How are the people benefiting from the services provided through this project or how are they using it?

iii. How are the emerging technologies being deployed for this project?
  - ✓ What sort of network infrastructure deployed for the project?
  - ✓ What specific services available through this initiative?
  - ✓ What are the implementation strategies?

iv. How is this project managed?
  - ✓ State the funding mechanism
  - ✓ Is there any PPP arrangement?
  - ✓ Do the implementation agency have rules and guidelines for the project?

v. What are the governance structure for this initiative?
  - ✓ Who does what and how?

- ✓ State the roles played by internal stakeholders (staff) and the key stakeholders/partners
- ✓ What is the governance model (top-down or bottom-up)?
- ✓ State the mechanism for information sharing

vi. In terms of participatory processes, how are NGOs or individuals involved in this initiative?
   - ✓ What is the influence of political environment (policy) on this initiative?

vii. How is this initiative impacting on the city, communities, and the people generally?
   - ✓ Is it improving the quality of lives for the citizens?
   - ✓ Is it addressing their mobility needs?
   - ✓ Is it improving the competitiveness of the communities?
   - ✓ Is it creating more skilled workers?

viii. How are the communities entrepreneuring as a result of this initiative?
   - ✓ How is it creating new jobs?
   - ✓ How about improved productivity? And
   - ✓ Innovation?

ix. What is the impact of the initiative on the natural environment?

x. Any known challenges in deploying emerging technologies on this initiative?
   - ✓ How about bureaucracy?
   - ✓ How about security, skills, and resources?

xi. Please how any challenges encountered on this initiative mitigated.

PART D: Stakeholders Understanding of the Smart City implications in critical Sector

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The aim of this section is to understand the perception of participants on the implications of Smart City deployment in critical sectors.

i. What impact do you think the Smart City concept will have on the quality of life of the citizens?
    - ✓ Do you think that the expected impacts will increase life expectancy of the people?
    - ✓ Does your organisation or FCT Administration have policy document or blue-print for Smart City deployment?
    - ✓ Could you mention or list these policies?

ii. Do your institute have policy for emerging sectors such as Big Data, Open Data, and OpenHealth?
    - ✓ Kindly mention the specific initiatives for leveraging these emerging sectors for entrepreneurial development.

iii. In your opinion, what spatial factors boost innovation in your city
    - ✓ Kindly highlight the funding mechanism/arrangements for technology adoption in your organisation.

iv. What is your opinion on necessary steps to ensure sustainability of Smart City initiative generally?

Additional comments and contributions considered necessary in your candid opinion will be highly appreciated please.

PARTICIPANT CONSENT SECTION

Name of Research: Mohammed Agbali

Tick as appropriate (√)

S/N		**Yes**	**No**
1	I confirm that I have read and understood the information sheet for the above study and what my contribution will be		
2	I have been given the opportunity to ask questions about the study		
3	I agree to take part in the interview		
4	I understand that the information provided will only be kept for the duration of this research		
5	I understand that the information provided will be confidential and any information about me will not be disclosed to a third party		
6	I agree to the interview being tape recorded		
7	I understand that my participation is voluntary and that I can withdraw from the research at any time without giving any reason and any information provided destroyed immediately		
8	I agree to digital images being taken during the research exercises		
9	I agree to take part in the above study		

Name of participant: ………………………………………………………………..

Signature:………………………………………………………………………………..

Date:………………………………………………………………………………………...

If you wish to be contacted for other part of the study, please enter your contact information	Email Address :

APPENDIX C: SURVEY INSTRUMENT

DEVELOPING A FRAMEWORK TO PROMOTE INNOVATION IN SOCIO-ECONOMIC DEVELOPMENT IN SMART CITIES

Instructions:

The questions provided in this instrument are close ended but respondents are free to make suggestions or supply additional information where necessary. If there is need to attach document, it is appreciated. Please tick the boxes as appropriate. All Stakeholders should complete sections A, B, C, D and E respectively.

The instrument is targeted at key stakeholders in the Manchester Smart Cities initiative. Thus, your views and comments on a number of issues articulated in this instrument are important to the success of the research. It is estimated that the instrument will take 20-25 minutes to complete.

SECTION A: General Information and Respondent Profile

In each of options, please tick the corresponding box (***one box only for each line***)

1. How best can you describe yourself in the industry on the following?

Educational qualification HND [ ] BSc [ ] MSc [ ] PhD [ ]

Status of employment Temporary [ ] Permanent [ ]

Level of IT Experience/Expertise Low [ ] Medium [ ] High [ ]

Prior Smart City Awareness Low [ ] Medium [ ] High [ ]

	Year				
2. Number of years in practice	0 – 5 [ ]	6 – 10 [ ]	11 – 15 [ ]	16 – 20 [ ]	21 – 25 [ ]

3. Kindly indicate the sector of your organisation by ticking a box from the following list:

Answers: ICT Industry [ ] City Administration [ ] Academia [ ]

4. Please indicate your area of specialisation as it relates to Smart City skills/expertise

Answers: IT Expert [ ] Urban Planner [ ] Transport Expert [ ] Security Expert [ ] Healthcare [ ]

SECTION B: In this section, the focus is to identify core components of Smart city to streamline the indicators.

(1) Do you consider the following components as core components for building sustainable Smart City?

i. Smart Infrastructure
ii. Smart Institutions
iii. Smart people

Answers	YES	NO	Don’t Know
	☐	☐	☐

(2) If NO to question 1 above, please give reasons or suggestions for improvement
…………………………………………………………………………………………
…………………………………………………………

Tick as appropriate (√)

3. Kindly rate the following core components on the scale of 1 to 5 (1 being the least priority and 5 being the highest priority)	1	2	3	4	5
Smart Infrastructure					
Smart Institution					
Smart People					

SECTION C: In this section, the focus is to identify key factors for classification of core indicators for measuring impacts of Smart City.

1. On a scale of 1 to 5 (1 being the least priority and 5 being the highest priority) rate the following factors of Smart infrastructure:	1	2	3	4	5
Availability of smart grid.					
Availability of Constant Power supply					
Availability of ICT Infrastructure					
Secured and innovative technologies.					
Attractive natural environment					
Educational facilities					
Pollution control					
Individual safety					
Environmental Sustainability					
Availability of sustainable transport system					
Availability of sustainable public water supply					
Existence of sustainable healthcare facilities.					
Others please specify ………………………………………………					

2. On a scale of 1 to 5 (1 being the least priority and 5 being the highest priority) rate the following factors of Smart Institutions:	1	2	3	4	5
Innovative and proactive system.					
Flexibility of Labour Market					
Secured service delivery system.					
Productivity.					
Tourist Attraction					
Open Data and Big Data					
Transparent governance					
International accessibility					
Entrepreneurship & Sustainable development.					
Social Cohesion					
Participation in decision making					
Others please specify …………………………………………					

3. On a scale of 1 to 5 (1 being the least priority and 5 being the highest priority) rate the following factors of Smart people:	1	2	3	4	5
Quality of life.					
Social awareness.					
Unity					
Flexibility					
Participation in public life					
Quality education.					
Creativity					
Environment that supports productivity.					
Others please specify …………………………………………					

SECTION D: In this section, the focus is to identify core indicators for measuring impacts of Smart cities.

1. On a scale of 1 to 5 (1 being the least priority and 5 being the highest priority) rate the following indicators of Smart infrastructure	1	2	3	4	5
No. of green energy sources & megawatts generated per inhabitant.					
No. of hospitals per inhabitant					
Robotic mobile ambulance available per inhabitant					
Ratio of Smart wheelchair (computerised) per inhabitant.					
Number of mobile phone as % of city population					
Level of uninterruptible power available per inhabitant.					
Number of Internet access as % of city population					
Use of environmental friendly vehicles					
Number of autonomous vehicles					
Efficient transport network & transport system per inhabitant.					
Reduction in Greenhouse gas emission per capita					
Improved Air quality (CO, SO2, NO2 reduction)					
Existence of Smart Equipment for real-time monitoring and control.					
Reduction in noise pollution					
Availability of Smart technologies & Broadband access.					
Others please specify …………………..					

2. On a scale of 1 to 5 (1 being the least priority and 5 being the highest priority) rate the following indicators of Smart institution.	1	2	3	4	5
% increase in self-employment rate.					
Satisfaction with quality of healthcare delivery					
Satisfaction with quality of Schools & key public institutions					
Number of qualified doctors, nurses, and health attendants per inhabitant					
Reduction in crime rate					
Number of crime profiled in **real-time**					
Satisfaction with safety of life and properties.					
Increased number of innovation hubs.					
Number of visitors to tourist centres					
Revenue generated in tourism as % of total revenue					
Increased number of new registered businesses					
Others please specify …………………….					

3. On a scale of 1 to 5 (1 being the least priority and 5 being the highest priority) rate the following indicators of Smart people	1	2	3	4	5
% of educated citizens at different levels of education.					
Number of skilled citizen as % of city population					
Increased life expectancy					
Number of voters turnout as % of city population					
Number of healthy citizens as % of city population.					
Material Living Condition					
GDP as % of employed citizens in the city.					

3. On a scale of 1 to 5 (1 being the least priority and 5 being the highest priority) rate the following indicators of Smart people	1	2	3	4	5
Ratio of employed to unemployed citizens					
No. of entrepreneurs as % of city population					
Others please specify …………………….					

General Comment about Smart City Deployment

1 . What is your comment on Smart City concept generally?

____

____

2. What in your opinion are constraints and impediments to the success of Smart City projects?

____

____

3. What are your suggested solutions to the constraints listed in (2) above?

____

____

APPENDIX D: ETHICAL APPROVAL

University of Salford MANCHESTER

Research, Innovation and Academic Engagement Ethical Approval Panel

Research Centres Support Team
G0.3 Joule House
University of Salford
M5 4WT

T +44(0)161 295 5278

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2 September 2016

Dear Mohammed,

RE: ETHICS APPLICATION ST16/122 – DEVELOPING A KNOWLEDGE MANAGEMENT FRAMEWORK TO ENABLE SOCIAL INNOVATION FOR LOCAL ECONOMIC DEVELOPMENT IN SMART CITIES

Based on the information you provided, I am pleased to inform you that your application ST 16/122 has been approved.

If there are any changes to the project and/ or its methodology, please inform the Panel as soon as possible by contacting S&T-ResearchEthics@salford.ac.uk

Yours sincerely,

Prof Mohammed Arif
Chair of the Science & Technology Research Ethics Panel
Professor of Sustainability and Process Management,
School of Built Environment
University of Salford
Maxwell Building, The Crescent
Greater Manchester, UK M5 4WT
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APPENDIX E: INDIVIDUAL CASE ANALYSIS OF THE CSFS AND KPIS OF SMART CITY COMPONENTS

Table 1a: *Smart City Core Components and the Degree of Emphasis in CASE-1*

SC. Components	**Sources**	**References**	**Percentages (%)**
Education Component	2	3	3.03
Energy Component	1	2	2.03
Environment Component	6	7	7.07
Governance Component	3	4	4.04
Health Component	6	10	10.1
Infrastructure Component	8	21	21.21
Institution Component	6	14	14.14
Living Component	1	1	1.01
People Component	9	36	36.36
Water & Sanitation Component	1	1	1.01
Total	**43**	**99**	**100**

Table 1b: *Smart City Core Components and the Degree of Emphasis in CASE-2*

SC. Components	**Sources**	**References**	**Percentages (%)**
Education Component	2	3	3.26
Energy Component	2	2	2.17
Environmental Component	5	15	16.3
Governance Component	3	4	4.35
Health Component	3	5	5.43
Infrastructure Component	7	23	25
Institution Component	7	17	18.48
Living Component	3	4	4.35
People Component	7	19	20.65
Water & Sanitation Component	0	0	0
Total	**39**	**92**	**100**

Table 1c: *Smart City Core Components and the Degree of Emphasis in CASE-3*

Components	**Sources**	**References**	**Percentages (%)**
Education Component	1	1	1.09
Energy Component	2	3	3.26
Environmental Component	4	10	10.87
Governance Component	3	5	5.43
Health Component	2	4	4.35
Infrastructure Component	5	18	19.57
Institution Component	5	19	20.65
Living Component	0	0	0
People Component	5	31	33.7
Water & Sanitation Component	1	1	1.09
Total	**28**	**92**	**100**

Table 2a: Priority Critical Success Factors CSFs of Smart Infrastructure –CASE-1

Factor	**Source**	**Reference**	**Percentages (%)**
Availability of ICT Infrastructure	6	10	22.22
Constant Power Supply	2	2	4.44
Educational Facilities	3	4	8.89
Environmental Sustainability	5	11	24.44
Pollution Control	2	3	6.67
Secured and Innovative Technologies	3	3	6.67
Sustainable Transport Systems	7	12	26.67
Total	**28**	**45**	**100**

Table 2b: Priority Critical Success Factors CSFs of Smart Infrastructure –CASE-2

Factor	**Source**	**Reference**	**Percentages (%)**
Availability of ICT Infrastructure	3	3	9.38
Constant Power Supply	3	3	9.38
Educational Facilities	2	3	9.38
Environmental Sustainability	4	7	21.88
Pollution Control	1	1	3.13
Secured and Innovative Technologies	3	4	12.5
Sustainable Transport Systems	4	11	34.38
Total	**20**	**32**	**100**

Table 2c: Priority Critical Success Factors CSFs of Smart Infrastructure –CASE-3

Factor	**Source**	**Reference**	**Percentages (%)**
Availability of ICT Infrastructure	4	5	15.15
Constant Power Supply	1	1	3.03
Educational Facilities	1	1	3.03
Environmental Sustainability	4	9	27.27
Pollution Control	2	2	6.06
Secured and Innovative Technologies	2	2	6.06
Sustainable Transport Systems	5	13	39.39
Total	**19**	**33**	**99.99**

Table 3a: Priority Critical Success Factors CSFs of Smart Institution –CASE-1

Factor	**Source**	**Reference**	**Percentages (%)**
Entrepreneurship and Sustainable Dev	4	6	17.65
Innovative and Proactive Systems	2	3	8.82
OpenData BigData	2	3	8.82
Productivity	3	5	14.71
Public and Social Services	2	2	5.88
Social Cohesion	3	7	20.59
Transparent Governance	5	8	23.53
Total	**21**	**34**	**100**

Table 3b: Priority Critical Success Factors CSFs of Smart Institution –CASE-2

Factor	**Source**	**Reference**	**Percentages (%)**
Entrepreneurship and Sustainable Dev	4	4	17.39
Innovative and Proactive Systems	3	3	13.04
OpenData BigData	1	1	4.35
Productivity	5	6	26.09
Public and Social Services	1	1	4.35
Social Cohesion	0	0	0
Transparent Governance	5	8	34.78
Total	**19**	**23**	**100**

Table 3c: Priority Critical Success Factors CSFs of Smart Institution –CASE-3

Factor	**Source**	**Reference**	**Percentages (%)**
Entrepreneurship and Sustainable Dev	1	4	19.05
Innovative and Proactive Systems	1	1	4.76
OpenData BigData	3	4	19.05
Productivity	1	5	23.81
Public and Social Services	0	0	0
Social Cohesion	1	2	9.52
Transparent Governance	3	5	23.81
Total	**10**	**21**	**100**

Table 4a: Priority Critical Success Factors CSFs of Smart People –CASE-1

Factor	**Source**	**Reference**	**Percentages (%)**
Creativity	1	2	13.33
Environment that Support Productivity	2	3	20
Flexibility	1	1	6.67
Quality Education	2	4	26.67
Quality of Life	3	5	33.33
Total	**9**	**15**	**100**

Table 4b: Priority Critical Success Factors CSFs of Smart People –CASE-2

Factor	**Source**	**Reference**	**Percentages (%)**
Creativity	2	2	9.52
Environment that Support Productivity	2	3	14.29
Flexibility	1	1	4.76
Quality Education	3	5	23.81
Quality of Life	5	10	47.62
Total	**13**	**21**	**100**

Table 4c: Priority Critical Success Factors CSFs of Smart People –CASE-3

Factor	**Source**	**Reference**	**Percentages (%)**
Creativity	2	2	15.38
Environment that Support Productivity	2	2	15.38
Flexibility	1	1	7.69
Quality Education	3	3	23.08
Quality of Life	5	5	38.46

Total	**13**	**13**	**100**

Table 5a: Priority Key Performance Indicators KPIs of Smart Infrastructure –CASE-1

Indicator	**Source**	**Reference**	**Percentages (%)**
Green energy sources	1	2	12.5
Hospitals per inhabitant	1	1	6.25
Internet Access as % of city population	1	2	12.5
Mobile phone penetration as % of city population	2	3	18.75
Reduction in greenhouse gas emission	1	1	6.25
Reduction in Noise pollution	2	2	12.5
Smart Wheelchair	1	1	6.25
Use of environmental friendly vehicles	4	4	25
Total	**13**	**16**	**100**

Table 5b: Priority Key Performance Indicators KPIs of Smart Infrastructure –CASE-2

Indicator	**Source**	**Reference**	**Percentages (%)**
Green energy sources	3	3	8.11
Hospitals per inhabitant	2	5	13.51
Internet Access as % of city population	3	7	18.92
Mobile phone penetration as % of city population	3	6	16.22
Reduction in greenhouse gas emission	2	2	5.41
Reduction in Noise pollution	1	1	2.7
Smart Wheelchair	1	1	2.7
Use of environmental friendly vehicles	5	12	32.43
Total	**20**	**37**	**100**

Table 5c: Priority Key Performance Indicators KPIs of Smart Infrastructure –CASE-3

Indicator	**Source**	**Reference**	**Percentages (%)**
Green energy sources	2	2	7.69
Hospitals per inhabitant	2	3	11.54
Internet Access as % of city population	4	6	23.08
Mobile phone penetration as % of city population	3	3	11.54
Reduction in greenhouse gas emission	1	1	3.85
Reduction in Noise pollution	1	1	3.85
Smart Wheelchair	1	1	3.85
Use of environmental friendly vehicles	4	9	34.62
Total	**18**	**26**	**100**

Table 6a: Priority Key Performance Indicators KPIs of Smart Institution –CASE-1

Indicator	**Source**	**Reference**	**Percentages (%)**
Increase in self-employment rate	2	2	15.38
Increased number of innovation hubs	2	3	23.08
Number of crimes profiled in rea-time	1	1	7.69
Revenue generated in tourism as % of total revenue	1	1	7.69
Satisfaction with quality of healthcare delivery	2	2	15.38
Satisfaction with quality of schools and key public institutions	3	3	23.08
Satisfaction with safety of life and properties	1	1	7.69
Total	**12**	**13**	**100**

Table 6b: Priority Key Performance Indicators KPIs of Smart Institution –CASE-2

Indicator	**Source**	**Reference**	**Percentages (%)**
Increase in self-employment rate	4	5	16.67
Increased number of innovation hubs	1	1	3.33
Number of crimes profiled in rea-time	3	3	10
Revenue generated in tourism as % of total revenue	3	5	16.67
Satisfaction with quality of healthcare delivery	5	7	23.33
Satisfaction with quality of schools and key public institutions	3	6	20
Satisfaction with safety of life and properties	3	3	10
Total	**22**	**30**	**100**

Table 6c: Priority Key Performance Indicators KPIs of Smart Institution –CASE-3

Indicator	**Source**	**Reference**	**Percentages (%)**
Increase in self-employment rate	4	5	23.81
Increased number of innovation hubs	2	3	14.29
Number of crimes profiled in rea-time	1	1	4.76
Revenue generated in tourism as % of total revenue	1	1	4.76
Satisfaction with quality of healthcare delivery	2	5	23.81
Satisfaction with quality of schools and key public institutions	3	3	14.29

Satisfaction with safety of life and properties	2	3	14.29
Total	**15**	**21**	**100**

Table 7a: Priority Key Performance Indicators KPIs of Smart People –CASE-1

Indicator	**Source**	**Reference**	**Percentages (%)**
GDP as % of employed citizens in the city	1	1	8.33
No of entrepreneurs as % of city population	3	4	33.33
No of healthy citizens as % of city population	2	2	16.67
No of skilled citizen as % of city population	3	4	33.33
Ratio of employed to unemployed citizens	1	1	8.33
Total	**10**	**12**	**100**

Table 7b: Priority Key Performance Indicators KPIs of Smart People –CASE-2

Indicator	**Source**	**Reference**	**Percentages (%)**
GDP as % of employed citizens in the city	2	3	18.75
No of entreprenurs as % of city population	4	5	31.25
No of healthy citizens as % of city population	1	1	6.25
No of skilled citizen as % of city population	4	5	31.25
Ratio of employed to unemployed citizens	2	2	12.5
Total	**13**	**16**	**100**

Table 7c: Priority Key Performance Indicators KPIs of Smart People –CASE-3

Indicator	**Source**	**Reference**	**Percentages (%)**
GDP as % of employed citizens in the city	4	4	23.53
No of entreprenurs as % of city population	3	4	23.53
No of healthy citizens as % of city population	1	3	17.65
No of skilled citizen as % of city population	4	5	29.41
Ratio of employed to unemployed citizens	1	1	5.88
Total	**13**	**17**	**100**