Doctor of Business Administration

“Key enablers that influence Sustainable Development of Smart City: Penang, Malaysia”

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Submitted in partial fulfilment for the award of the degree of Doctor of Business Administration to the University of Wales Trinity Saint David, under the auspices of London School of Commerce

10 March 2024

DECLARATION SHEET

DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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STATEMENT 1

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ACKNOWLEDGEMENT

I am grateful to the lecturers, supervisor, former bosses, colleagues, and fellow DBA friends who helped transform my thoughts into reality. Completing this thesis would not have been feasible without firstly God's blessings in the shape of my family. I would like to take this opportunity to formally thank my parents (Mr. Dalbeer Singh and Mrs Harbans Kaur) for their prayers, my siblings for their encouraging words, my husband, Mr. Kelvinder Singh, and our two beautiful children (Kiara Kaur and Arian Singh) for their constant patience and understanding throughout this journey.

ABSTRACT

Sustainability represents a complex concept, and which is made up with diverse interacting aspects which do not work necessary in synergy with each other. There are various outcomes like digitalisation, which is for most cases difficult to assess, as to be able to achieve certain targets, it may inadvertently also hinder the progress towards others. The present investigation focusses on keys enablers influencing a sustainable development of smart city. Results showed that there are strong correlations existing between the various key enablers composite indices, sustainability. However, the key enablers analysis includes the citizen participation, leadership, infrastructure, fourth industrial revolution, political will, and a mediating variable of ICT applications. The research made use of quantitative research methods, with specific consideration of Penang Malaysia as location of the research.

Key words:

Smart City, Sustainability, Sustainable Organization, Information System, Urban Computing, Citizen Participation, Empowerment, Diversity, Leadership, Information and Communication Technology, Infrastructure, Fourth Industrial Revolution, Political Will,

Abbreviations:

ICT: Information and Communication Technology

4IR: Fourth Industrial Revolution

Sustainable Development Goals (SDGs)

United Nations Sustainable Development Goals (UN SDGs)

Strategic Sustainable Development (SSD)

Public Private Partnership (PPP)

Public interest groups (PIGs)

Geographic Information Technologies (GIT)

Internet of Things (IoT)

Artificial Intelligence (AI)

Sustainable development of smart city (SDSC)

LIST OF FIGURES

LIST OF TABLES

CHAPTER I: INTRODUCTION

Around the world, urbanization is being progressed more rapidly than ever before. The global urbanization rate exceeded 50% in 2007 and is expected to exceed 70% by 2050 (United Nation, 2018). The urban population, which was 1.4 billion in 1970, will increase to 6.3 billion by 2050, with 60% of the world's population expected to be concentrated in urban areas. This has led to various ongoing discussions about how to solve new urban problems. Smart cities are one of the most sought-after solutions. The smart city is a conceptual urban development model, which means city construction based on information and communication technology (ICT) (Kuttyetak.,2020; Agunbiade et al., 2021; Lee et al., 2023). The specific definition of a smart city differs according to the economic level and the city policy of the country, but it can be seen as a city that uses ICT applications to improve city competitiveness and quality of life and pursue urban sustainability. As interest in smart cities grows, many countries are spurring their construction. China plans to invest two trillion yuan (about US $333 billion) by 2025 to transform 80% of its cities into smart cities. Since 2010, Japan has invested approximately 68 billion yen in smart city-related policies to rebuild cities in the regions that were affected by the Great East Japan Earthquake. In 2015, the White House announced a smart city plan that included a $160 million research and development (R&D) investment plan to solve various urban problems. Navigant Research's study reflects this trend, and the global smart city market is expected to grow steadily, more than doubling from $424 billion in 2017 to $12 trillion in 2020.

Currently ICT applications have broadened the spectrum of action of public administration, so have these, in the same way, motivated the interest of society in general, and academics in particular, to establish and assess the real contributions to the effectiveness of the governments that integrate them into their administration. In this respect, several studies have taken place, such as that carried out by Fachinelli et al., 2023;Kitchin, Coletta, Evans & Heaphy (2019); Criado and Gil-García (2013), which aimed to describe the process of implementing ICT into government functions as a smart cities agenda in which networked ICTs are positioned; Vercelli (2013), in turn, became interested in describing the ways of citizen participation through ICT, and along the same lines, Pareja and Echeverría (2014) were interested in studying the role played by new technologies in the construction of public opinion. On the other hand, Mergel (2013) focused on evaluating the impact of the initiatives that integrate ICTs in the participation and collaboration of citizens, while pointing out that there is still little evidence to actively measure the impact of the digital interactions derived between government and citizens.

1.0 Background of the Study

The model and development of a Smart City differ from place to place, based on local demands and resources. There is no universally accepted single definition of Smart City, but in summary, the notion can be defined as an urban area that efficiently utilises information and communications technology (ICT) to enhance its city functions and improve the quality of life of its citizens.

As propound in 2007, a Smart City contains six key domains, namely Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment, and Smart Living, and that the performance of a city's as a Smart City can be assessed through a total of 33 factors (Giffinger et al., 2007).

The integration of ICT applications in modern cities use in different facets of city operations has led to the phenomena being given tags like "Cyberville", "digital city", "telicity", "information city" and "smart city". Popular among the tag lines is smart city use in the generalization of most cities.

The term smart city is relatively new with no distinct definition as professionals and academicians hold different views in relation to the actual meaning. It was first introduced in the 1990's tailored to enhance infrastructure and advance networks. The use of mass information technologies has propelled cities to improve on the quality of public services such as health and safety delivery (Hernandez-Munoz, et al., 2011), (Pereira, et al., 2017). One of the formal definitions jointly developed by UNECE and ITU of smart city is "an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operations and services, and competitiveness while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects".

Smart city can simply be described as a place that merge traditional network and services with modern systems resulting to efficient, timely and more sustainable delivery of services to people. It also boosts effective interaction via digital and telecommunication platforms amongst the public.

1.1 Rationale of the Study

The global population massively rose over the last twenty years, so do the level of demand for a better standard of living. Based on World urbanization Prospects: The 2018 Revision, the population is projected to spiral up further to 68% by 2050 and estimated 6 billion people will live in urban areas. These cities must be supported whilst reducing carbon emissions to as much as $1/10^{th}$ of current levels if we are to mitigate catastrophic climate change. The urbanisation trend also escalated the economic importance of cities in the global supply chain and will increase the political position of cities within their nation states. The increment in the world's urban population comes with its problems, causing states governments and administrative to device strategies of the ever-increasing responsibilities. Hence, poses as a challenge for highly unprepared cities as highlighted by the United Nations Human Settlement Programme (UN-Habitats). Thus, in the next few decades there can be severe negative impact, and this makes the concept of smart cities a necessity.

The concept of smart cities is a natural strategy to mitigate the problems emerging by rapid urbanization and urban population growth. Smart cities, in spite of the cost associated, once implemented can encounter urban problems ensuring quality, efficiency and safety. Malaysia like most Asian countries is witnessing similar proposition, as urbanization is resulting to population shift as aggregate migration percentage to urban far outweighs the aggregate rural population. Hence the development of a well plan sustainable smart city that eliminates all the problems that comes with urban migration is crucial.

1.2 Purpose of the Research

The purpose of the research is to identify the key enablers featuring information and communication technology (ICT) applications knowledge that influences the development of smart city and thus a strategy framework is developed and proposed to improve the city competitiveness and quality of life of the people of Penang State. The researcher will examine the key enablers of smart cities and their priorities through an analytic hierarchy process (AHP) technique and the Helices model is applied in this study.

1.3 Significance of the Research

This research study on the key enablers influencing the sustainable development of smart cities, particularly in a specific context like Penang, Malaysia, is significant because it can provide valuable insights and recommendations for policymakers, urban planners, and stakeholders working towards creating more liveable, efficient, and sustainable cities. Penang has continually positioned itself as a prominent tourist destination in Malaysia,

The study's focal point is Penang aiming to contribute to the realization of the vision to modernize the state and ultimately enhance the well-being of its residents. By harnessing key ICT applications facilitators, the state is poised to expedite its development in the areas of: a) prudent and inclusive governance; b) seamless and integrated accessibility; c) robust and sustainable environment; d) safer and more livable communities; and e) innovative economic growth.

Penang has successfully positioned itself as an evolving, eco-conscious smart city, drawing environmentally-conscious corporations and investors interested in collaborations that support the city's ambitious sustainability goals. Among them is also George Town, located in the region of Penang, official recognized as UNESCO World Heritage Site on July 7, 2008 was a notable achievement in historic preservation and urban growth.

Penang aspires to take a leading role in integrating intelligent technologies into critical sectors within the city. It is proactively responding to the emergence of the fourth industrial revolution as a catalyst for transformation. The ongoing technological endeavors in Penang, including the Digital Transformational Master Plan for Penang initiated by the state government, aligned with the Penang2030 vision, and numerous other projects, are dedicated to constructing an environmentally conscious and technologically advanced state that not only benefits its residents but also serves as a source of inspiration for the broader Malaysian community.

Sustainable Development Goals (SDGs): The research might be aligned with the United Nations Sustainable Development Goals (UN SDGs), which provide a global framework for addressing pressing challenges like poverty, inequality, climate change, and urbanization. Smart city initiatives can contribute significantly to achieving these goals.

Technological Innovation: Understanding the key enablers for smart city development implies identifying the technological advancements and innovations that are most impactful. This can lead to the creation of models and frameworks that can be applied not only in Penang but also in other similar regions globally.

Environmental Impact: Sustainable development, especially in the context of smart cities, often involves the integration of technologies that reduce environmental impact. This can include initiatives related to energy efficiency, waste management, transportation, and green infrastructure.

Economic Growth and Innovation: Smart city initiatives can stimulate economic growth by creating opportunities for innovation, entrepreneurship, and job creation. Understanding the key enablers in this context is crucial for policy-makers and urban planners.

Quality of Life: Smart city initiatives have the potential to significantly improve the quality of life for residents. This can involve better transportation systems, improved access to healthcare and education, enhanced public safety, and more.

Policy and Governance Implications: Research in this area often uncovers policy and governance considerations. This can involve questions about regulation, privacy, data security, and the role of government in steering smart city development.

Community Engagement: The research may consider how communities and citizens are involved in the planning and implementation of smart city initiatives. Engaging residents is crucial for the success and sustainability of such projects.

Replicability and Scalability: Successful models and enablers identified in this research could potentially be applied in other cities facing similar challenges. This scalability is vital for widespread adoption of smart city concepts.

Resilience and Future-Proofing: Smart cities should be designed with an eye toward long-term resilience. This involves planning for potential future challenges such as climate change, technological evolution, and demographic shifts.

1.3.1 Scope of Research

The present research study is limited only to Penang Malaysia. This study focuses on a specific region, Penang, Malaysia. This is important because solutions for sustainable development and smart cities need to be tailored to local contexts, considering factors like culture, economy, environment, and existing infrastructure. Furthermore, while looking at the generalization of the findings, this could have some limitation since results are specific to Penang.

Furthermore, while talking about smart cities, various variables can be considered, but the present research scope will be limited to factors influencing sustainable development specific with citizen participation, leadership, infrastructure, fourth industrial revolution and political will.

1.4 Problem Statement

As Penang, Malaysia, aspires to transform into a modern and sustainable smart city, it faces a complex array of challenges and opportunities. The integration of Information and Communication Technology (ICT) applications enablers holds the promise of expediting its development in critical areas such as governance, accessibility, environment, community safety, and economic growth. However, this transformation requires a systematic understanding of the key factors influencing the sustainable development of a smart city, the effective utilization of ICT applications, and the alignment of Penang's goals with the demands of the fourth industrial revolution.

While Penang has successfully attracted environmentally conscious companies and investors interested in sustainable partnerships, the path to becoming a truly smart and sustainable city is fraught with intricacies. Future cities must embody sustainability, prioritize knowledge and innovation, and leverage technology to facilitate progress and generate value for residents, enterprises, communities, and society at large. The forward trajectory of urban development necessitates the adoption of a smart city approach, guided by a visionary and strategic outlook (Albino, 2015); (Caragliu, 2011); (Dameri, 2013); (Evans, 2005); (Giffinger, 2007); (Nam, 2011a), (Nam., 2011b); (Newman, 2008); (Williams, 2010).This includes the need to balance economic growth with environmental stewardship, ensure inclusivity in the development process, address the challenges posed by rapid technological change, and achieve coherence in the implementation of smart technologies across various sectors.

Furthermore, the success of Penang's smart city initiatives is contingent on navigating political, financial, and organizational complexities, along with ensuring that these efforts align with local and national political priorities and strategies.

In light of these challenges and opportunities, this research aims to investigate the key enablers influencing the sustainable development of a smart city in Penang, Malaysia. It seeks to provide insights into how ICT applications can be effectively harnessed to address these challenges and foster sustainable growth, benefiting the residents of Penang while setting an example for the broader Malaysian context.

Enhancing the ability to envision and influence the future doesn't entail merely enlarging council teams. Rather, it entails becoming a well-interconnected and deeply engaged participant within a broad ecosystem, all while adhering to ethical conduct. Mauro Romanelli (2017) introduces the 'Helices' model, which surfaces as a conceptual framework and organizational structure for cities that are focused on smart solutions and strategically propelling innovation in the provisioning of services, construction materials, and intangible infrastructures, all aimed at fostering urban growth. The Helices model is adopted because it emphasizes the relationships between universities, industries, and governments to stimulate innovation. It is relevant for this research as connecting methodologies and recognising the cooperation as local development dynamics to build a smart city and likewise on a wealth creation measure with smart governance standards. Researcher suggests a city is smart when investments in human and social capital and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance (Caragliu et al., 2009). Furthermore, cities can become smart if universities and industry support governments investment in the development of such infrastructures.

The sustainable progress of cities appears to hinge on the concurrent adoption of both the 'smart cities approach' and the 'Helices' model as catalysts for sustaining innovation. (Afonso, 2010); (Carayannis, 2012); (Deakin, 2014); (Etzkowitz, 2000); (Etzkovitz, 293-337); (Etzkowitz, 2006); (Leydesdorff, 2011); (Todeva, 2013)).

1.5 Research Aim

The aim of this research is to identify the key enablers in developing smart city with ICT applications as a mediator, it will contribute to the knowledge of literature in information communication technology and smart city which will deliver a better city administration whereby authorities such as municipal and state policymakers will understand the effect and impact of urban management using technical tools while saving resources and achieving sustainable smart city.

1.6 Research Questions

What are the key enablers that can significantly influence the development of sustainable Smart City in Penang?

Specific questions derived would be as follows:

i. What the relationship between key enablers of smart city and ICT applications in the context of developing sustainability of smart city?
ii. What is the relationship between key enablers of smart city and development of sustainability of smart city?
iii. What is the relationship between ICT applications and development of sustainability of smart city?
iv. What is the model of strategy, of key enablers of smart city and development of sustainability of smart city mediated by ICT applications?

1.7 Research Objectives

To identify the key enablers that has positive significant influence towards developing sustainable smart city in Penang

Specific objectives would be as follows:

i. To determine the relationship between key enablers of smart city and ICT applications in the context of developing sustainability of smart city.
ii. To examine the relationship between key enablers of smart city and development of sustainability of smart city.
iii. To analyse the relationship between ICT applications and development of sustainability of smart city.
iv. To evaluate the model fit of the strategy framework, of key enablers of smart city and development of sustainability of smart city mediated by ICT applications.

1.8 Knowledge Gaps

We know that digital technologies are offering new opportunities for cities to meet the challenges of the 21st century. There is an opportunity to use ubiquitous urban sensing, big data, and analytics to better understand the real-time functioning of our cities, as well as inform longer-term planning and policy decisions. Smart grids could enable efficiency within our energy infrastructure and intelligent transport systems may encourage multi-modal low carbon urban mobility. Anywhere access to information through smartphones and mobile infrastructure could transform the way people use the city and support the development of new products and services.

But of course, technological capability is only one part of the answer and is interwoven within layers of complexity. City governments are faced with the challenge of exploring the economic return in smart city investment, the business models, the value that it brings to citizens and the role that they should play within an ecosystem of delivery partners and stakeholders. They must decipher funding options, measurement and reporting regimes and the implications for their organisational structure, operational requirements, and responsibilities. On top of this, they must understand how these investments align to existing local and national political priorities and strategies. This is not trivial.

Cities must be responsive to the changing context within which they operate, especially when that context is offering significantly improved capability or efficiency, or where the general population is adopting new patterns of behaviour that are no longer served by traditional modes of governance.

This is relevant to all city authorities. It's time to understand what can be achieved and it's time to take some action. Smart cities research has transformed into variety of domains and disciplines and yet very little empirical research based on how key enablers such as technological advances may be applied in developing smart city. Only few impetuses were given in relation to the development of sustainability in cities thoroughly delving into the impacts of using technology. Key enablers such as people and governance with ICT applications in developing sustainable smart city remain underexplored. Recently, attention has focused on both sustainability as the goal for somatization and on ICT as a relevant tool or as the key to addressing smart processes (Meijer, 2015), especially given the findings contained in official reports released by organizations and local agencies.

1.9 Structure of the Thesis

This thesis is presented into following chapters:

Table 1: Structure of the Thesis

Chapter Number	Title	Overview
1	Introduction and Research Background	Presented an overview of the study including key areas such as the background of the industry, purpose of research, significance and scope of research, problem statement, Research aim, Questions and Research Objectives, and Knowledge gap.
2	Literature Review	Literature review provided critical evaluation of the theories and models relevant to the independent variables including citizen participation, leadership, infrastructure, and political will; the mediating variable which is the ICT applications and the dependent variable which is Sustainable Development of Smart City in Penang, Malaysia.
3	Research Methodology	This chapter outlines with justifications the key research choices and research design including the quantitative design, research instrument development, sampling techniques, data collection method. Data collection method, Reliability and validity and ethical considerations will also be discussed in this chapter.
4	Research Findings	The chapter presents the findings from the primary data analysis. Results of various statistical tests and statistical analysis of each of the research objectives are provided in this chapter; an exploratory factor analysis done; reliability of scale and interferential analysis is performed including the Pearson correlation and hypothesis testing.
5	Discussion of Findings	Discussion of the findings from primary research, backed up by secondary research is provided in this chapter. These include findings on demographic, socio economic status, observation on Bivariate data, findings from the variables and research objectives.
6	Conclusion and Recommendations	This chapter provides a conclusion on how research objectives were met, managerial implications, and contribution to literature, recommendations, limitations, and recommendations for further research.

1.9.1 Operational Definition

i. Citizen Participation

Citizen participation in the context of a smart city refers to the active involvement, engagement, and contribution of residents and stakeholders within the urban community in various digital and physical platforms, processes, and initiatives. This includes activities such as providing feedback on urban policies through digital interfaces, participating in virtual town hall meetings, and collaborating with local authorities on smart city projects. It also involves the use of technology-enabled channels and platforms to facilitate meaningful interactions, discussions, and co-creation of solutions that enhance the quality of urban life and contribute to the sustainable development of the city

ii. Leadership:

Operational Definition: Leadership in a smart city context refers to the effectiveness and strategic direction provided by city officials, administrators, and stakeholders in guiding the development and implementation of smart city projects. It encompasses the ability to set clear goals, mobilize resources, foster collaboration, and adapt to the dynamic nature of technological advancements and urban challenges.

iii. Infrastructure:

Operational Definition: Infrastructure in the context of a smart city comprises the interconnected physical and digital systems, facilities, and networks that enable the efficient functioning of the urban environment. This encompasses traditional physical infrastructure like transportation, utilities, and buildings, as well as digital infrastructure such as broadband networks, IoT sensors, and data centres that support smart technologies and services.

iv. Fourth Industrial Revolution:

Operational Definition: The Fourth Industrial Revolution in the context of a smart city refers to the technological developments and the process in cyber-physical systems such as high capacity connectivity; new human-machine interaction modes such as touch interfaces and virtual reality systems; and improvements in transferring digital instructions. (Giuseppe Grossi, et al., 2020) . It represents a shift towards data-driven decision-making, autonomous systems, and the convergence of physical and digital realms in city planning and management.

v. Political Will:

Operational Definition: Political will in the context of a smart city pertains to the demonstrated commitment and determination of political leaders, policymakers, and governmental bodies to prioritize and invest in the adoption of smart technologies and sustainable urban development practices. It involves the allocation of resources, the creation of supportive policies, and the active promotion of smart city initiatives to enhance urban living conditions.

vi. Sustainable Development

"Sustainable development involves a balanced and integrated approach to economic, social, and environmental progress, aiming to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. It combines sustainable technologies and strategies to optimise city life and the environment and provide residents with sustainable social, economic and environmental benefits (Bibri & Krogstie 2017b).

vii. Information and Communication Technology (ICT) Applications

This is the practical implementation and utilization of the Information and Communication Technology (ICT) solutions and tools within various aspects of the urban governance, infrastructure, services, and citizen engagement. This encompasses the deployment of technologies such as urban sensing, data analytics, Internet of Things (IoT) devices, and digital communication networks to enhance the efficiency, effectiveness, and sustainability of city operations. It involves the integration of ICT to facilitate real-time data collection, analysis, and decision-making processes, with the goal of optimizing urban services, infrastructure, and resource utilization. Additionally, ICT applications aims to improve citizen experiences, promote transparency, and foster innovation in the delivery of urban services."

CHAPTER II: LITTERATURE REVIEW

2.0 Introduction

According to (Giffinger, 2007) smart city refers to the search for intelligent solutions which drive cities to enhance the quality of services provided to citizens by paying attention to economy, people, governance, mobility, environment, and living identifying the combination of activities relying on aware citizens too. Characteristics are identified in order to qualify what a smart city should be and concern: smart infrastructure use of technology and ICTs – local and international accessibility, ICT infrastructure sustainable and innovative; smart people as social and human capital level of qualification, affinity to lifelong learning, social and ethnic diversity, creativity, cosmopolitanism, participation in public life; smart governance in terms of democratic participation in decision making, transparent governance, political strategies.

According to the dictionary, sustainability refers to the capacity or ability of a system, process, or practice to be maintained or continued over the long term without depleting essential resources or causing significant harm to the environment, economy, or society. It emphasizes the responsible and balanced use of resources to meet present needs without compromising the ability of future generations to meet their own needs. Sustainability encompasses various dimensions, including environmental, economic, and social considerations, and is often associated with practices that promote ecological integrity, economic viability, and social equity. It is a fundamental concept in addressing global challenges related to climate change, resource conservation, and overall well-being.

The Operational definition of sustainable development involves a balanced and integrated approach to economic, social, and environmental progress, aiming to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. It entails the judicious use and management of resources, equitable access to opportunities, and the promotion of resilient and inclusive communities. Sustainable development seeks to create a harmonious and equitable society by fostering economic prosperity, social equity, environmental stewardship, and cultural vitality, while simultaneously building the capacity to adapt to changing circumstances and global challenges."

2.1 Smart City

As far as the definition for "smart city" is concerned, there is no universally accepted definition and some authors have registered a "lack of definitional precision" (Hollands, 2008). Cities use this discrepancy and try to self-define as smart cities (Hollands, 2008; Caragliu et al., 2011; Tranos and Gertner, 2012). Early research suggests that a smart city is "the urban centre of the future, made safe, secure environmentally green, and efficient because all structures – whether for power, water, transportation, etc. are designed, built and maintained making use of advanced and integrated materials, sensors, electronics, and networks which are interfaced with computerized systems" (Hall, 2000, p. 1).

Komninos (2006) related the definition of the smart city to knowledge and learning, stressing the potential for knowledge creation using digital infrastructures. Smart cities are "Territories with high capacity for learning and innovation, which are built on the creativity of their population, their institutions of knowledge creation, and their digital infrastructures for communication and knowledge management" (Komninos, 2006, p. 6). Giffinger et al. (2007, p. 11) related smart cities to six characteristics, supported on the smart combinations of endowments (a smart economy, smart mobility, smart environment, smart people, smart living, and smart governance).

Hollands (2008) argued that smart cities are based on the utilization of networks to promote economic and political efficiency and to allow social, cultural, and urban development. Caragliu et al. (2011) proposed that for a city to become smart, it must invest in human and social capital, traditional and modern information, and communication technologies (ICT) and communication infrastructure and must fuel sustainable economic growth and a high quality of life, with careful management of natural resources through participatory governance. Georgiadis, A. (2021), defines a smart city as any city that leverages advanced technologies to achieve the goals in the areas of financial development, education, eradication of poverty, social equality, enhanced citizens security, tourism, cultural education, intercultural physique, environment, and fast citizen service in public services.

Malaysian Industry-Government Group of High Technology, MIGHT (2021) refers to Smart City as one that empower economy through digital technology and creates a harmonious living environment for its citizens. In Malaysia Smart City Outlook 2021-2022 (MSCF), the term smart city was defined as cities that use ICT and technological advancement to address urban issues, including improving quality of life, promoting economic growth, developing sustainable and safe environment.

According to Carvalho (2017), a smart city is a smart regional ecosystem that includes various interconnected stakeholders that develop collaborative networks (firms, citizens, public organizations, cultural, economic, and social infrastructures) to create an open and creative environment which is useful for improving the population's quality of life and for developing smart and innovative businesses and social projects. These regions present high standards regarding indicators associated with innovation, creativity, environment, quality of life, entrepreneurial activities, and support facilities.

In general, the eclectic smart city concept includes not only infrastructures but also human and social factors (Aguilera et al., 2013). Nevertheless, as stated above, there is no consensual definition for this concept (Al Nuaimi et al., 2015) and the literature in general explores dimensions that influence cities' characteristics, as can be seen in Table 2.

Table 2: Dimensions of Smart Cities

Dimension	Authors
ICT (use and availability)	Bakici et al.,2013; Caragliu et al., 2011; Hollands, 2008; Komninos, 2022; Thite, 2011; Tranos and Gertner, 2012.
Entrepreneurial ecosystems (entrepreneurial activities and business creation)	Carvalho, 2016; Gottdiener, 2001; Klein, 2000; Monbiot, 2000; Hollands, 2008; Lombardi et al., 2012; Thite, 201; Lucas et al, 2017.
E-government and resident inclusion	Bakici et.al., 2013; Caragliu et al., 2011; Hollands, 2008; Schaffers et al., 2011; Bernardo, 2017.
Creative industries and high tech	Hollands, 2008; Florida, 2002; Winters, 2011.
Human capital and community	Bolisani and Scarso, 2000; Kourtit et al., 2012; Albuquerque, 2017.
Social capital and relationships	Coe et al., 2001; Kourtit et al., 2012.
Social and environmental sustainability	Cargliu et al., 2011; Nathan, 2013; Sen et al., 2012; Shafiullah et al., 2012; Sivaram et al., 2013; Strielkowski, 2017.

Previous literature has explored dimensions that affect the characteristics of smart cities: the economy, human capital, technology, the environment, international outreach, social cohesion, mobility and transportation, governance, urban planning, and public management (Berrone &

Ricart, 2017). However, it must be said that the determinants of the status quo of smart cities have been analysed to a lesser extent. In this sense, one of the approaches which is most often employed is to determine the factors that could also affect the development of smart cities.

2.1.1 Smart Cities Concept

Developing the smart city concept should help to refine the image of cities as common goods and drive citizens to actively contribute and share ideas and value of cities as a common heritage to govern Cerchiara & Zupi 2015. 'Smart city' is a concept future-oriented integrating new technologies, social systems and ecological concerns relying on city governments, businesses and citizens embracing and using ICTs in order to reinforce and sustain the role of local community in the new service economies and to improve the quality of life within community (Anttiroiko, 2014).

Smart cities involve various concepts in academia, governments, global corporations, and international organizations. In other words, there is no consensus on the concept of a smart city.

Hollands discussed the difficulties of establishing a smart city concept by explaining the hidden factors involved in the labelling of smart cities. First, the definition of smart cities has not been refined since 2000, and no new elements have been added. Second, there have been various studies on ICT applications, but the concept of quality of life is still uncertain, and the link between smart technology and quality of life has not been clearly established. Finally, he explained that the meaning of "smart" and its connection to cities remain ambiguous.

Hall mentioned that the vision of "smart cities" is one of urban centres of the future made safe, secure, environmentally friendly, and efficient because all of the structures—whether for power, water, transportation, etc.—are designed, constructed, and maintained while making use of advanced integrated materials, sensors, electronics, and networks that are interfaced with computerized systems comprising databases, tracking technology, and decision-making algorithms.

Bakıcı et al. argued that a smart city is a tech-intensive and advanced city that connects people, information, and city elements using new technologies in order to create a sustainable, greener city that features competitive and innovative commerce and an increased quality of life.

Giffinger insisted that a smart city is a smart society in which various elements such as people; the environment, mobility, governance, and the economy are built within a smart infrastructure.

On the other hand, citizens must be included in a smart city. Citizens are a key element of smart cities as they form such a city through continuous interactions. For this reason, a smart populace is recognized as a key driver of smart cities; so, education, learning, and knowledge are important strategies in smart cities. In addition, social infrastructures such as intellectual capital and social capital can be seen as essential elements of smart cities because they connect people and form relationships. Yigitcanlar et al. found six subthemes as determinants of a smart city by reviewing 78 journal articles including ‘productivity’, ‘sustainability’, ‘accessibility’, ‘well-being’, ‘liveability’, and ‘governance’, which are considered desired outcomes of smart cities. Accordingly, the concept of a smart city implies a complex mixture of education, culture, art, business, economy, and commerce.

While there are a variety of views on the definition of a smart city, it is clear that a smart city adopts new technologies in order to improve the level of efficiency associated with utilizing urban infrastructure functions. A smart city also seeks to improve the quality of life of its citizens. Thus, the concept of a “smart city” can be defined as “a city that is sustained based on highly intelligent ICT applications and social networking; communication between people and things and things and things, which goes beyond time and space; convergence between ICT applications and real time; and convergence with other industries by which new value-added contents and services are constantly re-created accompanied by innovation of society as a whole, including work styles, lifestyles, culture, politics, and the economy”.

2.1.2 The Development & Primary Features of Smart City Models

The approach towards smart cities has evolved through a focus on one or more elements favouring the smartization process. However, only the integration of all of the domains of intervention based on the contribution of ICT applications can help cities to achieve long-lasting and sustainable economic growth and a better quality of life for urban stakeholders (Anthopoulos and Tougountzoglou, 2012), (Lihi Lahat & Regev Nathansohn, 2023).

This process of integrating different smart initiatives in urban and metropolitan contexts has been achieved through the efforts of different stakeholders (Tregua et al., 2015) playing a role in the analysis of the prerequisites for creating cities with an improved quality of life (Giffinger et al., 2007). These stakeholders include industry players, central or national agencies (i.e., the European Union), and scholars. Their efforts to study smart cities have led to the creation of models which collect the dimensions of urban life to be enhanced and developed through the implementation of smart city projects.

These features have been grouped into clusters and are called drivers because of their propelling role in the development of smart cities. These sets of smart elements have undergone various changes over recent years, and this path can be seen in a selection of studies ordered from the oldest to the most recent (Table 3), showing a greater number of studies performed in the last five years.

This table shows an early attempt by the Centre of Regional Science at the Vienna University of Technology, to create a smart city model, which, as of today, remains the most cited and most frequently used (Schaffers et al., 2011). The approach at the foundation of the model considers a smart city to be "a city well performing in a forward looking way in these six characteristics" (Giffinger et al., 2007), namely: Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment, and Smart Living. Similarly the smart city components were reflected in the Malaysia Smart City Framework (2018), and whereby how ICT shaping the future of Malaysian cities.

The Smart Economy groups all features related to economic competitiveness, such as entrepreneurship, innovation, productivity, and flexibility of the labour market, as well as the international expansion of the local economy. The development of a smart city is closely linked to the creation of an urban context that stimulates new industrial activities (Bronstein, 2009).

Another driver is Smart People, which has been defined through the quality of social interactions in cities, openness towards different cultures, the development of human capital, the education of people, and the role of ICT in the improvement of participation and the reduction of the digital divide (Giffinger et al., 2007). Smart Governance concerns citizens' participation in urban decision-making processes (Kolsaker and LeeKelley, 2008); (Ebuties, 2022), the co-creation of new services for an improved quality of life (Bélissent, 2010), and the implementation of different instruments for collaboration, service integration, and data exchange (Maltby, 2013).

Smart Mobility focuses both on sustainable and intermodal transport systems offering safe and secure conditions through the use of ICT (Bifulco et al., 2014), and on local, national, and international accessibility.

The Smart Environment has been studied in connection with pollution reduction, natural resource management, and the protection and conservation of natural habitats through the efficient use of resources as well as the re-use or substitution of natural resources to reach sustainability goals (Tanguay et al., 2010).

Table 3: Smart Cities Drivers

Drivers	Authors – Study Developer (year)
Economy, people, governance, mobility, environment, living	Centre of Regional Science, Vienna UT (Giffinger et al, 2007)
Transportation, healthcare, education, public safety, and security, building management, city administration, waste management	Belissent (2010)
Buildings, energy, telecommunication, payments, transport, human services, water, public safety	Smart Cities Council (2013)
Governance, economy, mobility, environment, people, living	EU-European Parliament (2014)
Economy, living, environment, mobility, infrastructure, government, people	Malaysia Smart City Framework (2018)
Citizen participation, infrastructure, technologies	Veselitskaya N., Karasev O., Beloshitskiy A. (2019)
Energy and the environment, economy, mobility, society, governance	Oke et al (2022)

Finally, Smart Living has been identified with quality of life, namely, housing, culture, health, tourism, and a specific interest in the search for high levels of social cohesion.

This smart city model was updated by the European Parliament in "Mapping Smart Cities in the EU" and the comparison between the two studies shows that the EU highlights ICT as a feature within all the six previous identified characteristics rather than as a particular element acting as a Smart Mobility driver. ICT applications is considered to be a fundamental feature with specific qualities: it is an across-the-board driver, specifically, "a key enabler for cities to address these challenges in a 'smart' manner".

2.1.3 Characteristics of Smart Cities

The definition of smart cities by Caragliu, Del Bo, and Nijkamp (2011) is based on the Smart City Model, developed by Giffinger et al. (2007). This model is a classification system under which smart cities can be assessed and developed through six distinct characteristics (see Table 4). The Smart City Model was developed as a ranking tool for evaluating mid-sized European smart cities in the areas of economy, people, governance, mobility, environment and living. Through this model, a city can examine its current state, and in turn identify the areas that require further development in order to meet the necessary conditions of a smart city (Giffinger et al. 2007). Cities can use this model to individually create goals based on their unique circumstances by following the vision outlined by the six characteristics (Giffinger et al. 2007; Steinert et al. 2011).

Table 4: Six Characteristics of Smart City

Smart Economy (Competitiveness) • Innovative Spirit • Productivity • Flexibility of labour market	**Smart People** (Social/Human Capital) • Affinity for life-long learning • Participation in public life • Creativity and flexibility	**Smart Governance** (Participation) • Participation in Decision-making • Transparent Governance
Smart Mobility (Transportation and ICT) • Local Accessibility • ICT infrastructure • Sustainable, innovative and safe transport systems	**Smart Environment** (Natural Resources) • Attractiveness of natural conditions • Environmental protection • Sustainable resource mgmt	**Smart Living** (Quality of Life) • Cultural Facilities • Health Conditions • Housing Quality • Social Cohesion

Source: (Giffinger et al. 2007)

Smart Economy refers to a city's overall competitiveness, based on its innovative approach to business, research and development (R&D) expenditures, entrepreneurship opportunities, productivity and flexibility of the labour markets, and the economical role of the city in the national and international market.

Smart People means delivering a high and consistent level of education to the citizens, and also describes the quality of social interactions, cultural awareness, open-mindedness, and the level of participation that citizens hold in their interactions with the public life.

Smart Governance more specifically addresses participation at a municipal level. The governance system is transparent and allows for citizens to partake in decision-making. ICT infrastructure makes it easy for citizens to access information and data concerning the management of their city. By creating a more efficient and interconnected governance system, barriers related to communication and collaboration can be eliminated.

Smart Mobility advocates more efficient transportation systems (e.g., non-motorised options) and promotes new social attitudes towards vehicle usage, ensuring that citizens have access to local and public transportation, and that ICT again is integrated to increase efficiency. Smart cities seek to increase how efficiently people, goods, and vehicles are transported in an urban environment.

Smart Environment emphasises the need for responsible resource management and sustainable urban planning. Through pollution and emission reductions, and efforts towards environmental protection, the natural beauty of the city can be enhanced. Smart cities promote the reduction of energy consumption, and the integration of new technological innovations that result in efficiency gains.

Smart Living seeks to enhance the quality of life of citizens and does so by providing healthy and safe living conditions. Citizens in smart cities have easy access to health care services, electronic health management, and to diverse social services.

2.1.4 General Criticisms of Smart Cities

Murray, Minevich, and Abdoullaev (2011) state that in order to achieve the full potential of the smart city, a deep-rooted culture of innovation, learning, and partnership within and between the components of a city is required. A widely diverse population is needed to fuel collaboration and increase knowledge sharing between citizens. Difficulties when aiming to attract and retain this type of population are often faced due to outdated governmental policies and organisational structures in need of reform. Clancy (2013) notes that many smart cities pilot programs have overlooked the need for citizen engagement and the public's role in the design process, which could have several negative consequences if the programs were to be implemented on a larger scale. Murray, Minevich, and Abdoullaev (2011) also identify that the lack of financing is a major obstacle facing smart cities, even though there is research suggesting that the investment in the development of human capital contributes to economic growth.

Hollands (2008) criticises the actual term smart city and refers to it as an urban labelling phenomenon. He claims that the definition is imprecise, self-congratulatory, leads to self-designation, and holds unspoken assumptions. Murray, Minevich, and Abdoullaev (2011) argue that due to the necessary increases in automation and interconnectedness, a smart city becomes vulnerable to large-scale failures as one single error can ripple through and break down the entire system. Future cyber-attacks are deemed as a major threat to smart cities, due to the challenges associated with providing security to a large magnitude of electronic devices and systems. Further, the authors identify socio-political risks associated with smart cities. The increased artificial constructs within a city can have dehumanising effects on its inhabitants, and the high level of monitored control can lead to the breakdown of social order. Further, the business-led approach to smart city development can marginalise people if they are unable to compete (Hollands 2008). This issue is also touched upon by Roumet (2010) who states that, since ICT is so closely related to smart cities, more attention needs to be devoted to issues such as mistrust in ICT, and how the private lives of inhabitants' will be protected.

Smart cities are further criticised based on the premises that the benefits of this urban digital revolution will not be able to reach everyone within the city. Instead of decreasing inequality between citizens, this digital divide may deepen social and cultural divisions by increasing the gap between skilled workers attracted to move to the city, and the IT illiterate, poorer, and less educated inhabitants (Peck, 2005; Graham, 2002). Additionally, it has been noted that certain smart city initiatives can have a negative effect on the environment, such as the fossil fuels and chemicals needed for development within transportation and ICT, and the amount of waste created due to the need for continuous technological upgrades (Newman and Kenworthy 1999; Sample 2004). The literature also raises the question of whether economic growth and environmental sustainability in terms of smart cities are compatible, and to what extent they may conflict with each other (Gleeson and Low 2000; Hollands 2008).

Given the current understanding of the global sustainability challenge, the emergence of smart cities can be viewed as a step in the direction of sustainability. Smart cities highlight important aspects of sustainability, such as the need for responsible resource management, energy efficiency, and citizen engagement. Referring to the funnel metaphor, smart cities hold the potential to manoeuvre within a system that is faced with ever-decreasing resources and increasing demands. However, to reach socio-ecological sustainability, wherein a city functions within the natural boundaries of Earth and supports the requirements for a sustained social system, the smart city concept must address its challenges and opportunities in a strategic manner.

Based on the current understanding of the smart city concept, it is not evident whether it holds the necessary characteristics to ensure that sustainable development occurs. Without strategic guidance, achieving the successes of the six Smart City Model characteristics does not necessarily ensure that sustainability is reached. For example, developments within smart living may well result in resource depletion if materials are not sourced in a responsible manner.

Further, increased dependency on technology may marginalise portions of the population who are unable to adapt, which would impede their abilities to meet their needs within a city. Smart cities are also developing into increasingly complex systems since they are built from large, interconnected structures. Studying this would therefore require an approach that allows analysis to occur within complex systems. A possible approach for developing and planning when aiming to become a smart city is the Strategic Sustainable Development (SSD) approach, which allows a concept to be studied from a systems perspective to ensure that sustainability can be reached.

2.1.5 Systems Thinking Approach

The term has been defined and redefined in many different ways since its coining by Barry Richmond in 1987. As with most systems, systems thinking consists of three kind of things: elements, interconnections and a function or purpose (Arnold and Wade, 2015).

In understanding the condition and factors that influence sustainability, specifically in urban settings, requires a systems-thinking perspective (Davidson and Venning 2011). This perspective calls for an awareness of the systems and sub-systems of any subject, along with the feedbacks and behaviours exhibited through the interactions of the system (Robèrt et al. 2002). In order to examine cities through a lens of sustainability, one must understand the systems under which the city functions.

The Copenhagen Cleantech Cluster (2012, 6) states that “the basic premise for the development of smart cities requires understanding the city as ‘a system of systems’: data, energy supply, waste management, infrastructure, transport, etc. The individual systems can be more or less smart or intelligent – and more or less intelligently integrated.”

Technological advancement spawns system after system, each increasing in interdependence on other systems that have come before (Internet, GPS, power grid, software APIs, et. Al). In Japan, Society 5.0 defines a system of systems. In it, several systems (such as energy management and highway transportation systems, among others) are connected on the Internet for the mitigation of both local and global social problems (such as the reduction of carbon emissions). Thus, studying a smart city from a systems thinking perspective allows for a better understanding of the interconnections and relationships, and creates the conditions necessary to develop inclusive and effective sustainability initiatives. Further, a systems thinking approach allows for a smart city to be examined within the context of the systems surrounding it, namely the greater social and ecological systems that function beyond the boundaries of the city.

Table 5 shows the roles of different actors and the system needed for effective implementation of Smart City Technologies.

Table 5: Selected Smart City Technologies

Domain	**Example of technologies**
Government	E-government systems; online transactions; city operating systems; performance management systems; urban dashboards
Security and emergency services	Centralised control rooms; digital surveillance; predictive policing; coordinated emergency response
Transport	Intelligent transport systems; integrated ticketing; smart travel cards; bike share; real-time passenger information; smart parking; logistics management; transport apps; dynamic road signs
Energy	Smart grids; smart meters; energy usage apps; smart lighting
Waste	Compactor bins and dynamic routing / collection
Environment	IoT sensor networks (e.g. pollution, noise, weather; land movement; flood management); dynamically responsive interventions (e.g. automated flood defences)
Buildings	Building management systems; sensor networks
Homes	Smart meters; app-controlled smart appliances

Source: Kitchin, Coletta, Evans & Heaphy (2019)

2.2 Cities as Sustainable Organizations

Cities as settled aggregation of people creating urban organisms and relevant entities for driving the human development of societies and communities tend to play a proactive role in stimulating and fostering social, economic, and cultural growth in urban and regional areas. Defining what a city is and which peculiarities cities should have been both a very difficult and intriguing task and field at the same time. In literature, there are many and different definitions about the need of identifying a satisfying concept of what are a city (Bourne, 1971). Organization tends to exist when coordination among organized activities or systems of activities exists being governed by forms of organization (Grandori, 1999).

Cities as geographical and organizational entities have the capability to better exercise some functions having a beneficial impact on the urban area, on the regional growth and development with regard to a surrounding environment that is served and for which cities are producing some beneficial effects, social, cultural, and economic gains (Mossello, 1990). Cities as informational and relational networks and spaces tend to continuously change as living and evolving organisms and places as learning systems, knowledge creation and innovation oriented that sustain and support creative and morphogenetic processes over time (Camagni, 1992). Cities are social organisms and expression of the human capacity for driving meaningful communication, social entities displaying both internal and external forms of symbiosis and symbolic communication between individuals (Schnore, 1971).

Cities as sustainable organisations should move forward by adopting a smart cities approach as a vision and strategic perspective driving the future urban development (Mauro Romanelli, 2017). As a way forward, undeterred attention of policymakers is suggested for the successful development of cities that are smart and sustainable(R.K.Mishra et al. 2022). Cities tend to act and behave as sustainable and knowledge-based forms of organization that develop structures and practices for encouraging the creation and the use of knowledge in order to manage, use, disseminate and share knowledge establishing objectives related to social, economic and environmental issues developing programs as beneficial for all the stakeholders by searching for cooperation and collaboration with institutions, businesses, and other member of the community (Leon, 2013). Cities are considered as sustainable places where customers, enterprises, and governments actively contribute to support a sustainable development (Satterthwaite, 1997), and citizens are better informed in order to take by embracing practical ethical considerations in everyday decisions (Haughton, 1997). The label of the sustainability tends to follow a multiplicity of views that make available a set of different options for proceeding towards sustainable urban development. Cities should develop a sustainable path by promoting both a social and technological change (Williams, 2009).

Cities as services providers are areas for life and goods production at the heart of the civilization, and the primary source for producing wealth and creating enterprises. They are emerging as meeting places for inspiring architecture and the great centres for sustaining learning and education, culture, and politics, tend to emerge as the main social incubator for driving change and creating social and economic innovation (Evans, Joas, Thundback, & Theobald, 2005).

2.2.1 Sustainability of Smart City

Cities as sustainable ecosystems made up of living and non-living components are becoming the principal engines of economic growth and places where most of the humanity is living and producing goods and services in the twenty-first century (Newman, 2008). Cities as service and technology-oriented communities provide service ICTs-enabled infrastructures and digital platforms for advances services to support business and facilitate public life (Anttiroiko, 2014). Sustainable cities are places of social interaction, a locus for engendering creativity as entities that help to sustain, improve, and extend the wealth of people within the community (Camagni R., 1996).

The sustainability of cities seems to rely on developing and implementing a 'smart cities approach' driven and supported by the 'Helices' model as engine and driver for innovation and development, for knowledge and creative ideas. Sustainability relying on combining technology, knowledge, governance, and participation seems to be the result of innovation processes.

Driving cities to be sustainable smart city relies on using technologies as means for proceeding towards a smart, social, cultural, and economic development by employing the 'Helices' models ('Triple' or 'Quadruple' and 'Quintuple' 'Helix') as organizational and strategic framework in order to support and govern processes of innovation and new knowledge creation. The perspective offered by 'Triple Helix' model seems to explain how the cultural development relies on developing policies in which governing and local authorities play a relevant and central role in contribution to constructing them.

Cities following the "Triple Helix" model tend to become smart when the ICT applications of future Internet developments successfully embed the networks society needs for them sustaining intellectual capital and wealth, developing both the environmental capacity, the ecology and vitality of those spaces enriched by direct democracy and participatory governance adding value (Deakin, 2014).

2.2.2 The Role of ICT Applications and Sustainability in Smart Cities

The increasing number of smart city initiatives can be linked to the diffusion and integration of new technologies, in particular, ICT applications and data management functionalities, expanded from elementary data acquisition to data processing and interpretation. These advances have been widely exploited due to the diffusion of mobile devices, which allow people to participate in (Kirwan, 2015) and contribute to their urban and metropolitan environments.

The important role played by people, the so-called human component (Nam and Pardo, 2011), within the smartization process has led to a different conceptualization of technologies as intelligent instruments aimed at the creation of cities with an improved quality of life (Bulu, 2014) and at the improvement of human participation through services co-creation (Kirwan, 2015). The participation should be further enabled to avoid social marginality (Vanolo, 2014; Huston et al., 2015).

The technological elements required to deploy smart initiatives include the implementation of the necessary hardware (sensors, wireless equipment, etc.) and software (artificial intelligence, expert systems, etc.) to create a "physical-digital environment of smart cities" (Schaffers et al., 2011, p. 435; Li et al., 2015). Scholars have focused their attention on the relationship between technology and urban life, and some recent studies (Lombardi et al., 2012) analyse the requirements of a new holistic system for integrated data acquisition, querying, and mining that can be realized through the development of common open platforms and ubiquitous ICT infrastructures. Specifically, a smart city must deploy smart computing technologies, combining the use of software systems, server infrastructures, network infrastructures, and client devices to connect different urban services and stakeholders (Åkesson et al., 2008).

Some of the most developed ICT applications in smart cities is GPS technologies to enhance transportation and traffic flow; database technologies for health, energy efficiency, and education; pattern recognition software to improve security systems; and mobile technologies to engage people in services co-creation or social activities (Bulu, 2014). The role of ICT is related to the development of smart initiatives within all smart city drivers, but it has also a clear relationship with the challenge of sustainable development in urban environments (Lombardi et al., 2012; Meijer and Rodríguez-Bolívar, 2015) for all citizens, looking for a participation as wide as possible (Vanolo, 2014; Luque-Ayala and Marvin, 2015).

In Japan, based on a society-centered approach, Society 5.0 seeks to take advantage of technological advances to finally solve the problems that currently threaten Japan. It aims at solving social issues from a new perspective. Once services are powered by smart systems, the urban community as a whole becomes a smart city. For instance, Fujisawa sustainable smart town by Panasonic, integrated advanced technology-based infrastructure enabling residents to have eco-friendly and comfortable lifestyles incorporating smart processes that facilitates to realise smart lifestyles while ensuring safety and security.

Strictly related to ICT, sustainability has been widely analysed among international agencies, scholars, and associations, and its application in the smart context (Lombardi and Vanolo, 2015) has led to different definitions in relation to the focus on a specific dimension (economic, social, and environmental) in the deployment of smart projects.

In fact, the concept of sustainability is widely recognized as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987). This first attempt to define the context of sustainable development has been expanded to consider the economic and social dynamics of modern economies, leading to a broader meaning with the so-called "triple bottom line" (Rogers and Ryan, 2001). The prevalent definition of sustainability has been used to underline the relevance of the preservation of natural resources, social equity, and economic development in search of a systemic vision with elements that contribute to achieving common goals.

The application of sustainability within territories has been proposed by different scholars such as Beatley (2000), who considered the concept of smart growth in urban neighbourhood, Schilling, and Logan (2008) who emphasized sustainable strategies in cities to create new urban scenarios, especially regarding local communities, and Talen (2011), who argued the replace of unsustainable contexts with sustainable ones.

Other operative implications of sustainability in urban contexts have been proposed by Yigitcanlar and Lönnqvist (2013), who focused on the role played by knowledge in city design and on strategies concerning all three different dimensions of sustainability for a sustainable urban development; Hollands (2015) highlighted the role of sustainability in smart cities and the opportunity offered by new technologies to achieve sustainable goals.

Furthermore, another field of study has focused on more complex issues, namely, sustainability models, first conceived by scholars such as Hartwick (1977) and Solow (1986), who considered sustainability to be an investment with clearly observable direct impacts in relation to the achievement of a goal. Consequently, scholars have focused on sustainability within the domain of economics and finance to analyse the existing evaluation tools and to create new ones. Increasing attention has been paid to identifying financing opportunities for smart initiatives and to selecting the most suitable initiatives to create smart city projects that are sustainable in the long term. One of the main contributions to the analysis of financial solutions was provided by Komninos (2013), who delineated the instruments used to support the implementation of an enabling platform for the development of innovative city services for urban stakeholders. Specifically, the identified solutions are public development funding, reselling, data monetization, free core services and payments for additional features, advertising, sponsorship, leasing, and crowdfunding (Komninos, 2013).

Finally, there has been increasing interest in sustainability in smart cities from a quantitative perspective; namely, attention has focused on the development of measures and indicators. One important attempt was made by Tanguay et al. (2010), who first provided an overview of sustainability and the definition of the “triple bottom line”, after which they explored a wide range of indicators aimed at examining the risks related to data accessibility, and the absence of standards before analyzing and presenting suitable indicators to apply in smart cities. The approach to sustainability was even considered as a limit when referred just “to classic dimensions” (Tanguay et al., 2010, p. 410), since a city requires a perspective as wider as possible to the multiple challenges arising (Hollands, 2015).

2.3 Drivers and Barriers in Initiating Smart Cities

Technology, actors, policies, goals, vision, and governance are identified as drivers of smart city development (Dameri 2013). Moreover, to Dameri (2013), the main driver for smart city birth and development is technology. Anttiroiko, et al. (2014) also identified the importance of smart use of ICTs as a driver in initiating smart cities. Physical capital, natural capital, social capital, and digital capital are the drivers of smart cities identified by Abdoullaev (2011). VanWinden and Van Den Buuse (2017) stated that, smart city projects require support from municipalities and run-in partnerships with funding from subsidies. Table 6, Drivers in initiating smart cities, summarises the key drivers encountered in key literature.

Table 6: Drivers in initiating smart cities

Drivers	1	2	3	4	5
Technology	✓	✓	✓	✓	
Stakeholders	✓		✓		✓
Governance	✓		✓	✓	✓
Policies	✓				✓
Required funding		✓		✓	✓
Goals and Vision	✓				✓

Source : 1. Dameri (2013) ; 2. Anttiroiko, et al. (2014); 3. Abdoullaev (2011); 4. VanWinden and Van Den Buuse (2017); 5. Chourabi, et al. (2012);Oke et.al (2022);KIM, J. H (2022)

According to Hernández-Muñoz, et al. (2011), lack of ICT infrastructure and knowledge related for technological advancement is a challenge in adopting smart cities. Moreover, Elmangoush, et al. (2013) also highlighted the requirement of knowledge and competence in initiating smart cities. The need for policy changes, limited capital availability, political uncertainties and disorganized funding structures prevent in-vestment in initiating smart cities (Vilajosana, et al. 2013). Scuotto, et al. (2016) mentioned that, building knowledge, and creating relationships with external stakeholders is a barrier in initiating smart cities. Initiating smart cities require consideration of the stakeholders who need to be involved in the planning and governance of the city. Hence, it is also considered as a barrier for adopting smart cities (Höjer and Wangel 2015). Furthermore, modelling, understanding, and influencing human behaviour, and creating trust in technologies act as key challenges (Naphade, et al. 2011). Bakıcı, et al. (2013) identified lack of skilled human capital, funding, and global connectivity as barriers in a smart city development project. Table 7 summarises the barriers in initiating smart cities.

Table 7: Barriers in initiating smart cities

Drivers	1	2	3	4	5	6
Lack of Technology	✓				✓	
Lack of knowledge & competence	✓	✓		✓		✓
Limited available capital			✓			✓
Political uncertainties			✓	✓	✓	
Disorganized funding structures	✓		✓			
Creating relationship with stakeholders		✓	✓	✓	✓	✓

Sources : 1. Hernández-Muñoz, et al. (2011) ; 2. Elmangoush, et al. (2013) ; 3. Vilajosana, et al. (2013); 4. Scuotto, et al. (2016); 5. Höjer and Wangel (2015); 6. Bakıcı, et al. (2013); 7. A Razmjoo (2021); 8. Makki, A.A.; Alqahtani, A.Y. (2024)

2.3.1 Strategies to Overcome the Barriers in Initiating Smart Cities

In the consideration of the identified barriers, it can be identified that most of the barriers are due to improper stakeholder management. Therefore, managing these stakeholders of a smart city project is required for the success of the project. According to (Rose 2013) (as cited in Aragonés-Beltrán, et al. 2017), stakeholders can be "an individual, group, or organization who may affect, be affected by, or perceived itself to be affected by a decision, activity or outcome of a project" (p.451). Moreover, to the author, stakeholder can have a positive or negative impact on the project. As stated by Karlsen (2002), stakeholders play a major role in the accomplishment of the tasks in a project. Handling different set of stakeholders across different levels is identified as a challenge which can be overcome through stakeholder management (Sunder M 2016). Stakeholder management focuses on understanding the nature of the relationships between the stakeholders (von Meding, et al. 2013). According to Wagner Mainardes, et al. (2012), stakeholder management concept is to recognise, analyse and examine the individual and group characteristics that influence or are influenced by the project or organisational behaviours and actions. Verdicts of the above literature findings states the importance of effective stakeholder management, which is required for the success of building the base of smart city development.

Governance is a key for the success and growth of smart cities because urban development and urban planning is based on governance with multiple stakeholders (Nam and Pardo, 2011). Utilisation of political strategies with transparent governance will provide the required capital and funding for the development of smart city projects (Giffinger and Gudrun 2010). With reference to (Chourabi, et al. 2012), effective communication, leadership and accountability are also beneficial for the initiation of smart cities, which is a global concern. A major challenge faced in the beginning of the drive to smart cities, is to adapt human re-sources for the change, can be mitigated by capacity building (Schaffers et al. 2011). As defined by (Chaskin 2001), capacity building at the individual level concentrates on "instrumental skills to support employment and on opportunity for civic engagement" (p.306). Moreover, capacity building includes individual development, institutional development, knowledge development and the development of associated decision support systems (Agrawal 2015). According to Hollands (2008), people undergoing capacity building will be able to seek a balance economic growth with sustainability more efficiently in smart cities. Public Private Partnership (PPP) is also identified as an advantageous solution for enabling smart cities (Chan, et al. 2010). Milenković, Rašić, and Vojković (2017) identified that, PPP models provide a better outcome in developing smart cities, crowdsourcing and democratic ecologies provide better and more efficient public services by taking advantage of private sector's competence. PPP benefits all the stakeholders in a smart city deployment and is one of the popular implementation models used for the development of smart buildings and infrastructure (Vilajosana, et al. 2013).

2.4 Theoretical Evaluation

2.4.1 The Triple Helix Model

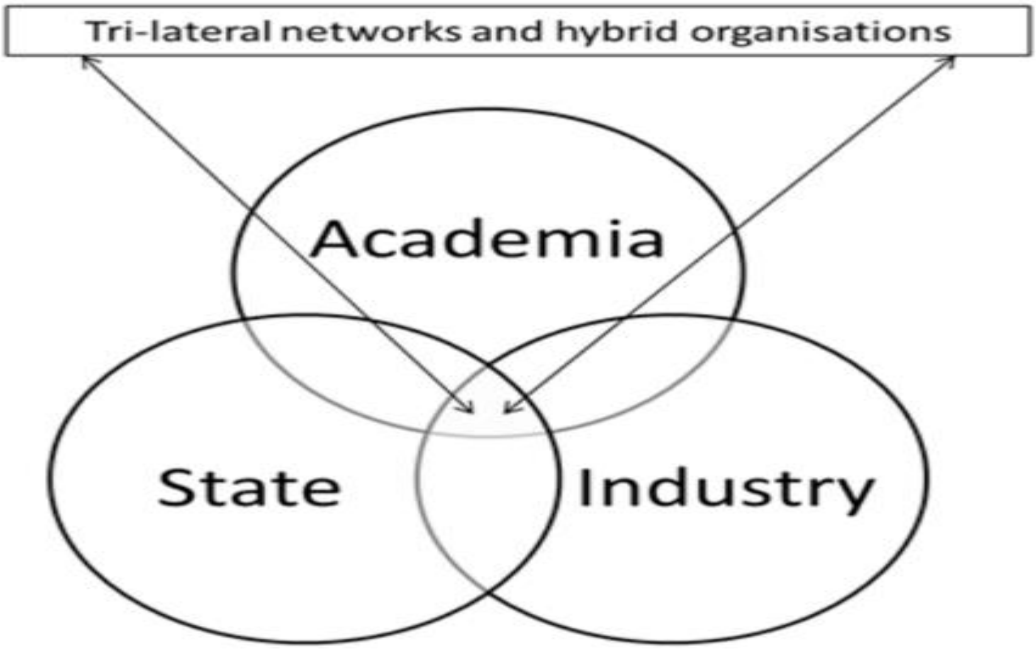


Figure 1: Triple Helix Model

Source: Balanced model (Etzkowitz & Leydesdorff 2000: 111)

Etzkowitz and Leydesdorff (2000) distinguish three types of Triple Helix models, namely the "statist model", the "laissez-faire model", and the "balanced model" (Figure 1). The balanced model of Triple Helix "begins from two opposing standpoints: a statist model of government controlling academia and industry, and a laissez-faire model with industry, academic and government separate and apart from each other, interacting only modestly across strong boundaries" (Etzkowitz 2008: 12). In the statist model, the government controls both academia and industry and is expected to take the lead in developing projects and providing the re-sources for new initiatives. Basically, there are five major aspects of the rationale of an ideal-type or a normative balanced model of Triple Helix that foster optimal conditions for innovation.

First, the theoretical core of the Triple Helix model is its consideration of triadic interactions as an Occam's razor principle (Walsh 1979). The core of the Occam's razor principle is about necessity; "if it is not absolutely necessary to introduce certain complexities or hypothetical constructs into a given explanation, then don't do it" (Braithwaite, 2017: 2). Triple Helix explores the implications of classical sociologist Georg Simmel's micro levels analysis of dy-ads and triads (Wolff 1950) at the meso level of organizational interaction, in addition to the classic intermediating properties of the Tertius Gaudens. Tertius Gaudens, the third party, takes advantage of the interactions between two parties for competition against each other or gaining favour from each other, leads to benefits (Wolff 1950). In the Triple Helix model, the third element also introduces a propensity for innovation, especially in organizational innovations and the invention of new organizational formats such as the venture capital firm (Etzkowitz 2002a). The Triple Helix model, in its original elaboration, focuses on the reciprocal relations/interactions between the three sectors of university, industry, and government (Etzkowitz & Leydesdorff 1995, 1997)

Second, the core mechanism underlying the Triple Helix interactions as optimal condition for innovation is “taking the role of the other” (Etzkowitz 2008), performing new roles as well as their traditional functions. Organizations taking non-traditional roles are viewed as a major potential source of innovation in innovation. For instance, firms continue to produce goods and services, but also do research and provide training at high levels (e.g., through the corporate university). The government is responsible for resolving market failures, adjusting public policies, and establishing market rules, but also makes available venture capital to start new enterprises, particularly for high-risk businesses. Universities keep their traditional roles of teaching and research, but also devote effort to the capitalization of knowledge, patents, and start-up companies. Indeed, an increasing number of universities have evolved an increasingly complex innovation system, starting with technology transfer offices, incubators, and science parks, extending into translational research and extension of entrepreneurship education across the campus. These activities are often in the guise of design thinking or into an ecosystem that comprises a penumbra that encompasses and illuminates traditional academia (Rice 2019) through a bi-directional flow, instantiated in faculty members who carry out varying proportions of them in academia and other institutional spheres (Dzisah & Etzkowitz 2008).

Third, evolutionary mechanisms are underlying the development of the Triple Helix model. However, the model is not the result of a self-organized evolution; rather the process of development needs to be pre-structured/ coordinated (Leydesdorff & Meyer 2006), e.g., through innovation policies (Cai et al. 2017) or agency (Cai & Liu 2020). Etzkowitz (2008: 21) noted that the spirally developing triple helix is “a synthesis of evolution in the vertical axis and circulation in the horizontal”. While “taking the role of the other” mainly reflects the horizontal circulation in terms of observable actions, it results in the evolution of each of the three spheres, in the vertical axis, and the model of their interactions. Etzkowitz and Leydesdorff respectively takes neo-institutional theory and neo-evolutional theory perspectives when understanding evolutionary mechanisms (Leydesdorff, 2012: 29–30). From an institutional theory perspective, as the environment, i.e., the patterns of triple helix interactions between university, industry, and government, in a regional or nation may change over time, the “genes” of organizations in the three sectors may mutate with the changes in the environment. From an evolutional perspective, the three functions, namely wealth generation, knowledge production, and normative control, are respectively the three evolutional mechanisms. While traditional evolutionary economics mainly deal with two sub-dynamics in the form of co-revolution, the triple helix configuration includes three sub-dynamics, including market, innovation, and control (Ley-desdorff 2000, 2012; Leydesdorff & Meyer 2006).

Fourth, when it comes to the coordination for developing the Triple Helix interactions, the core is to enable functional mechanisms mediating between top-down and bottom-up initiatives. Part of the role of government in Triple Helix interactions is developing innovation policies and initiating priority in-novation program in a top-down manner. However, the dynamic of Triple Helix also relies on bottom-up initiatives, which is in conjunction with “an active civil society in which initiatives are encouraged from various parts of society role” (Etzkowitz, 2008, p. 11). Both top-down and lateral coordination and bottom-up initiatives are dimensions of the Triple Helix model.

Fifth, to build optimal conditions for innovation in innovation, leadership and capabilities are required. Triple Helix interactions are enabled in two types of conditions, sufficient condition of convening authority and necessary condition of innovation capacity. Convening authority can be seen in the early 20th century New England, when representatives of the three helixes were convened by political authorities to address an innovation gap (Etzkowitz 1993, 2002a). In 1990’s Silicon Valley, industry took the lead. The essential principle was that: activation of a triple helix requires leadership by persons and organizations who have the respect of all the key players. This principle was confirmed by a later failure case (1990’s New York City) in which once the initial convener passed on the convening role to an organization, lacking gravitas across the helices, the initial effort dissipated (Etzkowitz & Zhou 2017).

2.4.2 EU's Smart City Wheel

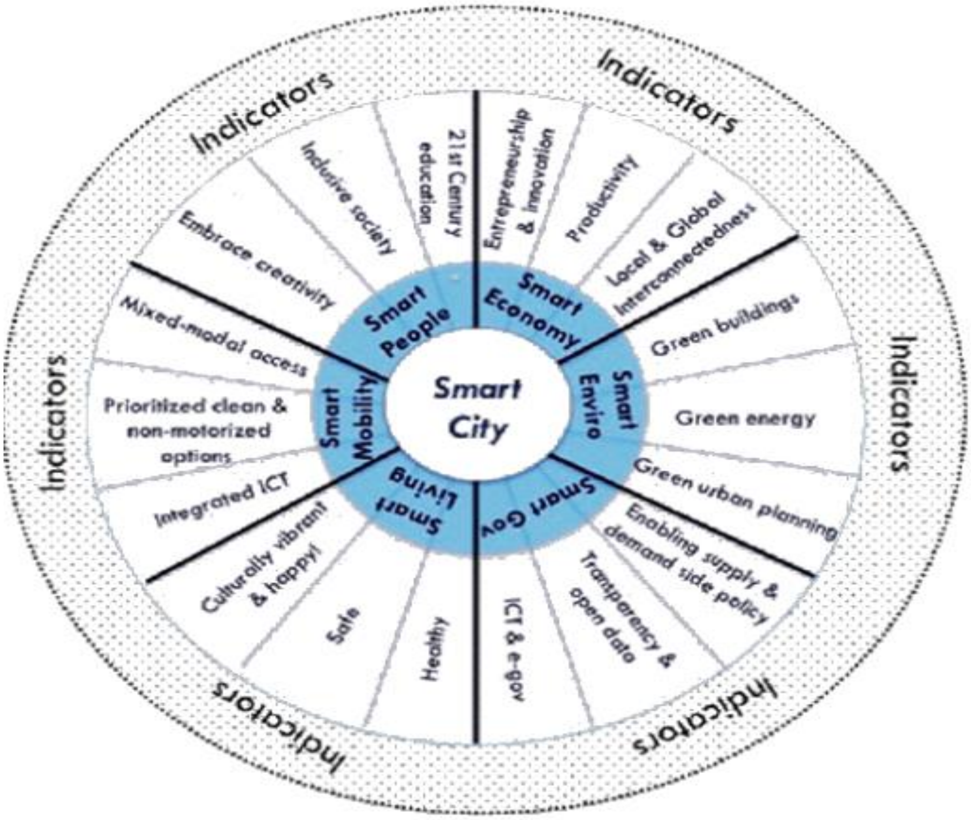


Figure 2: EU's Smart City Wheel

Source: Smart City Wheel (Cohen, 2012)

Perhaps the most known one is the EU's smart city wheel. According to this wheel, smart cities can be characterised by having smart economy (e.g., productivity), smart people (e.g., community with high social and human capitals), smart governance (e.g., good governance and policy), smart mobility (e.g., transport and technology accessibility), smart environment (e.g., sustainability), and smart living (e.g., liveability and wellbeing) (EU, 2014). Despite covering all primary smart city domains and serving as a model to integrate smart city practice areas, this popular wheel is far from being a comprehensive framework—as it lacks underlining relationships among the smart city domains. However, it serves a noble purpose particularly in emphasising a holistic view for moving smart city projects' focus beyond the technology realm. Additionally, Angelidou (2015) conceptualise a smart city based on four major forces, namely: (a) Urban futures; (b) Knowledge and innovation economy; (c) Technology push; (d) Application pull. While these driving forces are highly relevant, this framework is highly abstract to be easily adopted in a local smart city planning context.

2.5 Overview of Mediating Variable: ICT Applications

This study employs a series of causal mediation models based on counterfactual framework for mediation analysis. Further, assess the influence of mediating variable between endogenous and exogenous variable. Barron and Kenny (1986) define a mediating variable as a third variable that represents the generative method, allowing the main exogenous variable to impact the endogenous variable. The mediator variable correlates with both the dependent and independent variables and can shift from effect to cause. When the relationship between endogenous and exogenous variables is strong, mediation is most effective and influences the outcome of the relationship.

This chapter has shown that numerous existing literatures have provided evidence that each of the key enablers of smart cities has some relationships and influences on the development of sustainability smart city. According to Hsiaoping Yeh (2017), the adoption of ICT applications for the development of innovative, sustainable, and smart cities has become a new model for municipal cooperations between government and corporations. The findings show that citizens are willing to embrace and employ ICT-based smart city services if they are built with new concepts that protect their privacy while providing high-quality services.

In the context of this study, the ICT applications becomes the mediating variable between the key enablers of smart city and development of sustainability smart city. The key enablers of smart city are the antecedent to the ICT applications use. The ICT applications usage influences the significance of relationship between each key enablers of smart city and development of sustainability smart city which overall outcome of improved quality of life.

2.5.1 Key concept: Empowering ICT

Although citizens' participation is emphasised and the benchmarks even hint at possible change in roles of government and citizens, the Smart City concept remains, both as benchmark and as marketing tool, highly top-down oriented aimed at better managing and controlling city systems by collating ever-detailed information about real time functioning and being able to optimise decision making in the immediate, short, and long term. Cosgrave et al. (2013) state that 'the Smart City should not necessarily be interpreted as top-down vision delivered solely through government investment. Quite the opposite, the Smart City is largely an organic system of systems (Harrison and Abbott Donnelly, 2011), which comprises an ecosystem of products, services, companies, people, and society that are working together creatively to foster innovation within the city'. From a transition perspective the key concept of the Smart City should be application of ICT that is aimed at empowering citizens, rather than focussed on improving control of city systems. 'Citizens are not only engaged and informed in the relationship between their activities, their neighbourhoods, and the wider urban ecosystems, but are actively encouraged to see the city itself as something they can collectively tune, such that it is efficient, interactive, engaging, adaptive and flexible' as Arup (2011) describes in their Smart City vision.

2.5.2 Smart City Information System Based on the IoT and Cloud Computing

Smart homes are IoT-enabled appliances, air conditioning and heating systems, televisions, audio and video streaming devices and security systems that communicate to each other to provide the best comfort and security while reducing energy consumption. The IoT is a network of connected devices such as cars, sensors and household devices that communicate and exchange data. This communication takes place via IoT-based central control units that use the Internet. The data collected and delivered by IoT sensors and devices is stored on cloud servers. Resource use and other devices play an important role in analysing, managing, and managing the resources of an IoT smart city. Connecting IoT sensors and devices with the use of data analytics (DA) facilitates the convergence of physical and digital urban elements to improve efficiency of public and private sectors, provide economic benefits and improve citizens' lives. The Smart City ecosystem collects data by intelligent sensors at the edge can be transformed into a cloud fog for processing, managing, storing, interpreting, and operating various IoT applications. The diverse sectors of smart cities have recently expanded the possibilities of smart technologies in action. Smart urban technologies have led to efficiency gains in urban manufacturing and agriculture, including jobs creation, energy efficiency, space management and fresher products for consumers.

IoT research is revolutionising smart city services. Proper use of resources and other devices plays an important role in the study, management, and management of IoT resources in a smart city. Cities around the world are turning to this technology and advanced networks to help them overcome resource scarcity. With 65% of US Internet users comfortable with the idea of living in a smart city, the adoption of this technology in the coming years will continue to grow. As populations and urbanization increase, many cities will turn to the Internet of Things (IoT) and advanced networks in the coming years to help themselves cope with resource scarcity. Smart cities offer solutions for rapid urbanization, exploding populations, scarce resources, congestion of traffic and energy management through the effective and integrated use of information and communication technologies. The design, integration and implementation of smart cities is recognised as a means to optimise limited resources and improve people's quality of life. It outlines how smart cities offer their inhabitants an efficient and high-quality lifestyle and what methods were used to achieve these goals.

Thence, it is interesting to examine the role of emerging technologies in smart city solutions. It examines various topics including traffic management, air quality management, public safety solutions, smart parking, smart lighting, and smart waste collection. In line with Smart Cities use cases, the proposed study introduces an Analytics Network Process (ANP) to evaluate Smart Cities. The Smart City energy system's aspect is crucial for the overall security and privacy of the infrastructure as third parties can connect to the grid to monitor usage patterns and predict consumer behaviour. Wireless network technology focuses on the nature of many systems that supply and control the city with heat and light, exposing vulnerabilities in network security. Security, privacy, and health services. The concept of smart cities is a key factor in the overall minimum disclosure of data and information security infrastructure. Data protection is a key issue for smart cities and one that is linked to a minimal understanding of privacy by local governments and businesses when collecting and processing personal data. Other legal issues such as jurisdiction and governance as well as the handling and consent of data in smart cities will also be examined. In order to support the Internet of Things and cloud computing.

City systems are based on these technologies. Traditional urban systems, such as those handed down from antiquity, are inefficient and cumbersome, because information systems are not shared and interconnected. It is obvious that some sectors (smart cities, smart energy, smart vehicles) based on IoT projects have a larger market share compared to others. It can be seen that the American continent contributes more to health care and smart supply chain projects, while the European continent contributes more to smart urban project. The Internet of Things (IoT) is a platform for global networking and the integration of sensors, actuators, RFID, Bluetooth, and other digital devices. It consists of integrated components, services, data networks and sensors. The Internet of Things (IoT) is an important driver of smart cities by facilitating communication between a large number of devices. IoT connectivity and interoperability will help build a smart city around the world.

2.5.3 Urban Computing for Intelligently Improving the Lives of Citizen

One can see that urban computing for intelligently improving human lives is important in order to create a coherent framework that includes all the approaches that are capable of dealing with such issues. The results generated by our framework will be useful to a variety of applications including urban planning, site selection, business, and social recommendations. Specific experiments will be carried out to validate solutions and proof of concept, which will be repeated as often as possible with real case studies and pilot projects. Urban computing is an interdisciplinary area that combines information and communication technologies, advanced management of large amounts of data, and diverse methods of data analysis to propose solutions to urban problems. Urban computing helps us understand the nature of urban phenomena and predict the future of cities. It combines discreet and ubiquitous sensor technology with advanced data management and analysis models and novel visualization techniques to create win-win solutions to improve the urban environment, human life and the quality of urban operations and systems. Urban Computing combines urban sensors, data management and data analytics services to provide recurring processes for the unobtrusive and continuous improvement of people's lives, urban operations, systems, and environments. Smart cities use information and communication technologies (ICT) applications to increase operational efficiency, share information with the public and ensure a better quality of public services for citizens' well-being. Smart cities' main objective is to optimise urban functions, promote economic growth and improve the quality of life of citizens through the use of smart technologies and data analysis. Connected devices that communicate, and exchange data include vehicles, household appliances and street sensors. The collected data by these devices is stored on cloud servers that can improve both the efficiency of the public and private sectors with economic benefits and improvements in citizens' lives. The data must be available in real time and with reliable access to ensure that it fulfils its functions and monitors different parts of the smart city infrastructure. Regarding this, one can define an intelligent city as an urban area that functions as a robust system — a system of economic, social, environmental, and governmental activities based on sustainable practices driven by AI technologies that can help us achieve social well-being and other desired outcomes for the future of humans and non-humans. The modern city is a complex and pluriform ecosystem that requires thorough scientific treatment and sustained policy management. The city is more than a collection of places and people - places need to be reinvented and reinvented by the people who occupy them. Some scientists see AI as an opportunity to drive smart cities and intelligence of cities while others see AI generating a whole new brand in our cities as AI applications become mainstream. In the age of smart cities, urban areas are adapted to smart technologies, including sensors and networks. With the increasingly sophisticated capabilities of artificial intelligence, we see the potential for dramatic changes in our cities and societies. The explosion in data growth is due to a number of key technologies in ICT applications and various forms of ubiquitous computing, and these technologies are increasingly embedded in the fabric of modern and futuristic cities. At this point, much of the ICT applications investment is directed toward technology giants such as Google, IBM, Oracle, Microsoft, SAP, and Cisco to develop novel computing models that improve existing practices for different purposes in terms of storage, processing, analysis, management, modelling, simulation, evaluation, big data visualization, deployment, and analytical results. Big data analytics is a prerequisite for the realization of new applications and services that promise ICT applications vision and ubiquitous computing as determinants, enablers, and powerful drivers of such cities.

Many smart applications affect our lifestyles, but many applications remain outside the digital world. In recent years, the importance of scale analysis and hierarchical modelling on the hierarchical organization of complex urban systems has led to a broad interest in systemic urban studies. New approaches to understanding and managing urban dynamics, complex policy issues, functional flow networks, bilateral and multi-level interconnections, coordination of efforts at the sub-functional level of the urban spatial economy in combination with intelligent transformations from big data to intelligent data management represent newer concepts of collective intelligence. An intelligent city is defined as an intelligent environment that is embedded in ICT applications and aims to create interactive spaces that bring computation into the physical world. From the perspective of smart cities, smart space refers to the physical environment in which ICT applications sensor systems disappear when embedded in physical objects and environments in which we live, work and travel. Smart cities are communities, clusters or regions defined as multi-layered territorial innovation systems that bring together knowledge-intensive activities, institutions, cooperation, learning and innovation in digital spaces of communication and interaction to increase the city's problem-solving capacity. Cisco today unveiled its holistic design for smart urbanization, a global initiative designed to help cities around the world utilize networks as the next tool to integrate urban management for better quality of life for citizens and economic development.

2.6 Citizen Participation

2.6.0 Definition

Citizen participation in the context of a smart city refers to the active involvement, engagement, and contribution of residents and stakeholders within the urban community in various digital and physical platforms, processes, and initiatives. This includes activities such as providing feedback on urban policies through digital interfaces, participating in virtual town hall meetings, and collaborating with local authorities on smart city projects. It also involves the use of technology-enabled channels and platforms to facilitate meaningful interactions, discussions, and co-creation of solutions that enhance the quality of urban life and contribute to the sustainable development of the city

Citizen participation can be defined in many ways. Traditionally, it concerns voluntary or coerced participation in local, state, and national issues that involve governmental decision-making. The term “coercion” does not imply the use of force or violence. Rather, it is used in the same sense that Theodore J. Lowi describes “forced compliance” with government rules and regulations (Lowi, 1964). (One example of this option is the imposition of small civil fines for failure to vote used in many democratic countries (not the United States) to “coerce” electoral participation.) Citizen participation implies a readiness on the part of both citizens and government institutions to accept certain pre-defined civic responsibilities and roles. It also means that each contribution is accepted, valued, and possibly used in decision making. The inclusion of citizen representatives as co-equal partners in decision-making processes contributes to successful citizen participation. In some form, citizen participation has played a significant role in democratic forms of government since the founding of organized societies.

The ideology of citizen participation has firm roots in democratic political values, especially relating to the concept of participatory democracy. In the United States, the push for greater citizen participation in government decision making was reborn in the 1960s out of related movements for civil rights, “black liberation,” and decentralization of urban government structures. It originated in demands by minorities for a larger voice in determining policies and programs directly affecting them. The urban poor, at least during the 1960s, concentrated on organizing themselves and confronting those in power with demands for change. Their participation was formally incorporated in both the planning and implementation of federal Model Cities and community-action programs and in other programs since then.

Citizen Participation factor refers to citizen or resident participation in urban policy decisions, not just as beneficiaries of simple urban policy decisions that can directly support their interests. The citizens or residents express their wishes and seek solutions to them; this also relates to the concept of the inhabitants.

Margerum argued that for sustainable urban development, the planning and enforcement of planned urban policies are necessary, but that various groups such as citizens and civil society should participate in the formulation and enforcement of such urban policies. Therefore, the activation of citizen participation is essential in enhancing democracy and the efficiency of city policy.

Kim Han-Jun argued that urban planning in the smart era should be expanded and transformed to be different from existing urban planning. The development of ICT applications has brought about changes in society and human behaviour in various fields. In the process of smart city development, it has been argued that the expansion of citizen participation in the form of bottom–up, experimental innovation; open-source platforms; and living labs appeared as a new urban plan.

Deakin said that the greatest virtue of a smart city is turning government-led policy decision making into citizen-led policy decision making. He called for citizens to actively intervene in the practice of social justice and environmental justice in the city by means of advisory groups, debates, civic participation budgets, and civic petitions.

2.6.1 Citizen Participation Categories

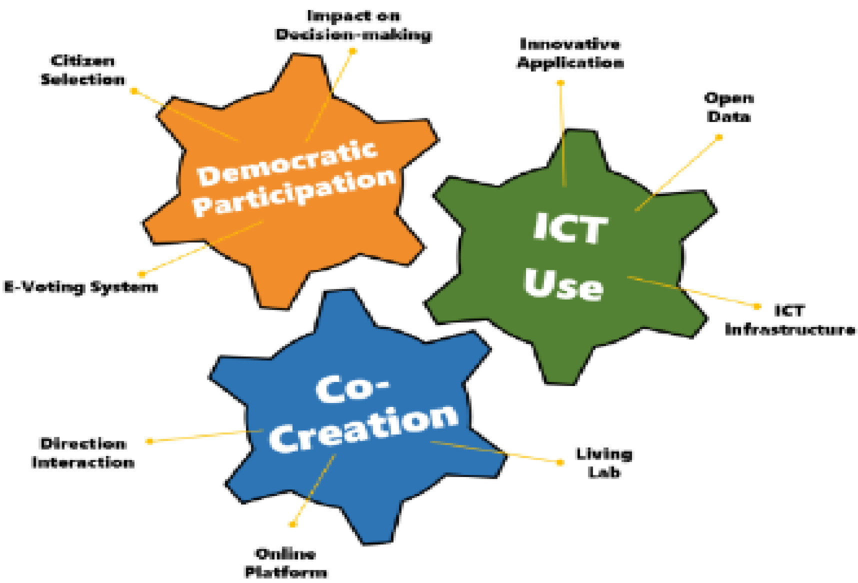


Figure 3: Citizen Participation Categories

Source: (Anthony Simonofski, et al., 2019)

2.6.1.1 Citizen as a Demographic Participation

Viewing citizens as active participants in the democratic processes of a smart city brings forth numerous benefits (Albino, et al., 2015). Through their involvement in decision-making, citizens gain insights into complex technical issues and become well-versed in matters of public significance. Additionally, public servants also glean valuable insights from citizens on why certain policies may face resistance and how to mitigate this. This form of democratic participation is cost-effective, as it reduces the likelihood of legal disputes or, in the context of a smart city, investments that may not be utilized or beneficial to the public.

However, the practical implementation of democratic citizen participation encounters several challenges. Firstly, the group of citizens engaged in the process must be adequately representative of the population. For instance, the selected group may inadvertently skew towards individuals whose lives are more heavily impacted by decisions regarding the smart city strategy. This representation can be ensured by using basic demographic statistics about the population to guarantee the inclusivity of each subgroup. Secondly, the participation process can be resource-intensive in terms of time, money, and effort (Cocchia, 2014). These challenges may lead to an overrepresentation of a particular social group that possesses the resources and availability to participate (Weber, 2000). To mitigate the resource-intensive nature of the decision-making process, support measures can be implemented to incentivize citizens through financial rewards as well as other social benefits, such as awards for outstanding civic engagement or access to free training programs.

Furthermore, the time-consuming nature of the decision-making process and the associated challenge of underrepresentation for those with limited availability can be addressed through the introduction of e-voting systems. Given that citizens may not be accustomed to participating in these types of meetings, facilitators should employ techniques to ensure that every voice is heard (Dameri & Rosenthal-Sabroux, 2014).

For instance, in the realm of e-voting systems, there are two main categories, namely physically supervised systems by electoral authorities, such as electronic voting machines stationed at polling places, and remote voting systems that enable citizens to vote from home or without visiting a polling station. In its most advanced form, E-voting enables the Electronic Direct Democracy paradigm, empowering citizens to directly influence all aspects of public life from a distance, including ongoing legislation, new regulations, and the selection of representatives (Zissis & Lekkas, 2011).

2.6.1.2 Citizen as Co-Creators

The traditional approach to urban innovation involved centralized decision-making by urban planners based on their own ideas. However, in recent years, especially within the context of smart cities, a new model has emerged that leverages the input and ideas of citizens (Simonofski, et al., 2017). Instead of viewing citizens as passive consumers, they are recognized as essential stakeholders who can generate valuable ideas to address societal needs.

This section delves into how this collaborative approach, known as co-creation, can be applied in the context of a smart city.

Various techniques exist to directly interact with citizens and gather their ideas. These methods encompass activities such as conducting focus groups or interviews with experts and users, hosting town hall meetings, conducting usability, functionality, and accessibility tests, encouraging real-time comments and suggestions, and establishing measures and standards of service quality (Johannessen, 2010). For example, a citizen-oriented approach (van Velsen, van der Geest, ter Hedde, & Derks, 2009) recommends conducting semi-directive interviews to uncover the critical needs of citizens for potential systems. Additionally, applying agile and crowdsourcing paradigms to traditional requirements engineering methods offers new avenues for collecting citizens' needs in a more effective manner (Schön, Thomaschewski, & Escalona, 2016; Adepetu, Ahmed, & Abd, 2012).

Living labs, defined as "user-driven open innovation ecosystems based on business-citizens-government partnership which enables users to take active part in the research, development and innovation process" (European Commission, 2009, p. 7), represent another popular technique. These labs involve users early in the development process, from needs analysis to brainstorming solutions, and even in the concrete development of ideas and prototype testing. The goal is to closely engage citizens to understand their expectations and assess how the innovation aligns with their daily environment. Living labs find relevance in various domains of smart cities, including eHealth, ambient assisted living, e-governance, and ICT for energy or environment (Pallot, Trousse, Senach, & Scapin, 2010).

Furthermore, to overcome time or space constraints, citizen participation can be bolstered through centralized platforms and social media analysis (Berntzen & Johannessen, 2016). While centralized platforms may be costly and challenging to maintain, social media platforms can effectively reach a larger audience of citizens in diverse contexts, encompassing crowdsourcing platforms, collaboration tools, social networking, and polling tools (Criado, et al., 2013).

2.6.1.3 Citizen as ICT applications Users

While ICT applications is a crucial component of smart cities, it alone is not sufficient. In fact, an overemphasis on ICT has been identified as a major drawback in certain smart city initiatives (Merli & Bonollo, 2014). Integrating ICT applications into a city, however, can bring forth a range of new opportunities and transform the urban landscape. Technological progress facilitates the establishment of a "ubiquitous computing" infrastructure (Merli & Bonollo, 2014).

(Friedewald & Raabe, 2011), a concept closely linked with sensors and the Internet of Things. This pertains to the incorporation of wireless, interconnected microprocessors, etc., into everyday objects, allowing them to record and alter the environment. The key is to harness these technological advancements for the benefit of citizens. Yet, for most citizens, these developments remain too theoretical; they are more interested in practical solutions (Schaffers et al., 2011). This is where citizen-oriented applications play a crucial role. These innovative applications span from Augmented Reality systems (Gutierrez et al., 2013, p. 174), to Citizen Science platforms (Khan & Kiani, 2012), and Public Displays (Du, Degbelo, & Kray, 2017), among others, creating an environment where citizens feel surrounded by and supported by technology, motivating them to engage in various applications.

2.6.2 Empowerment and Diversity

ICT applications possess a transformative potential in that they enable previously marginalized individuals and groups, who might otherwise remain unheard and invisible, to voice their perspectives and gain visibility. In doing so, ICT applications unveil the inherent diversity within society, representing a spectrum of opinions that existed but were previously excluded from public decision-making processes. This shift is, in part, attributed to the capacity of ICT applications to redistribute power away from centralized governments, thereby challenging the dominance of rational, administrative institutions in political and social control. This phenomenon appears to be global, with bureaucratic institutions witnessing an erosion of their monopoly over critical information sources and surveillance capabilities, allowing for the emergence of alternative voices in civil society.

ICT applications, notably the internet, have proven highly beneficial to citizen activists, non-governmental organizations, and emerging social movements striving to challenge and establish new public arenas where previously disenfranchised citizens can participate. These fresh public spaces also present challenges to established theories of the public sphere, or the polisphere. The internet facilitates the proliferation of a multitude of alternative public spaces, often referred to as counter-public spheres, alongside the growth of a shared public sphere for discussion and deliberation. The continually expanding internet fosters oppositional "blogispheres" equipped with intricate networking and communication systems. These polispheres represent a much broader array of viewpoints and possibilities compared to earlier counter public organizational media in the nineteenth and twentieth centuries, which primarily offered information in the form of documents, critiques, press releases, alternative publications, audio, video, list serves, chat groups, and references to other pertinent sites. For those who feel marginalized by mainstream public media, the internet, with its estimated 30 billion websites and 112 million weblogs or "blogs," provides swift access to an alternative realm of expression, networking, and mobilization. One consequence of this new mode of communication is the potential to intensify the postmodern challenge to conventional authority structures, as observed in developing nations like China, Cuba, Iran, and Mexico.

2.6.3 Reflecting Ideological Differences

The ongoing ideological debates surrounding citizen participation in governance mirror the broader discourse in American and European politics regarding the distribution of administrative authority between central and decentralized entities. Within the federal system, citizen participation serves as an embodiment of the decentralist principle, which advocates for the delegation of decision-making power to a wider range of affected individuals and groups. This decentralization approach inherently encourages broader participation, ensures a more inclusive representation of diverse opinions, and enhances the legitimacy of decision-making processes and outcomes. Given that federalism was established to safeguard against excessive centralization, the concept of decentralization naturally finds its place in operations within a federal system. Citizen participation, actively promoted by numerous national programs, has been instrumental in advancing the decentralization of operational responsibilities.

The Information Age has ushered in heightened demands for accountability and transparency, emanating from a multitude of sources. As various avenues for inquiry continue to expand, citizens are seeking greater access to information about numerous societal activities. In the years ahead, the public will anticipate accurate information from both private and public entities. This escalating need for information is being driven by the internet, which has become a platform for extensive discourse, information exchange, and the proliferation of millions of weblogs or "blogs." The internet, as an open network, is contributing to the evolution of open information environments. This concept is permeating society at large, resulting in heightened expectations for accountability from all organizations, whether public or private.

The application of citizen participation has taken on diverse forms to address various issues. Community control has cantered on the localized management of schools and the provision of essential urban services, primarily in non-white urban areas of major American cities. President

Obama commenced his career as a community organizer on the South Side of Chicago after graduating from Harvard Law School. In different contexts, neighbourhood and citizen-action groups have emerged with the aim of preserving neighbourhood identity and at times, undertaking redevelopment projects. This includes concerted efforts to oppose the construction of interstate highways that would disrupt or potentially destroy parts of established urban neighbourhoods, collaborations between cattle ranchers, Native Americans, and antinuclear groups to protest uranium mining by energy corporations, citizen groups rallying against toxic-waste disposal, and residential associations seeking to attract or deter commercial enterprises like Home Depot, McDonald's, or Wal-Mart.

Furthermore, citizen participation has been integrated into formal decision-making mechanisms. At the national level, there has been a growing trend towards public involvement in regulatory proceedings, although there is notable variability in how regulators respond and the opportunities provided to citizen groups, such as consumer and environmental organizations. Agencies and commissions possess discretionary legal authority to determine the extent of public participation (if any) to allow, especially in terms of financing participation for those with limited resources. However, public interest groups (PIGs) have faced significant challenges in gaining access to regulatory proceedings, resulting in considerable frustration. At the local level, participation has become more standardized, particularly in areas such as building code and zoning enforcement, environmental protection, and urban community planning and design.

2.6.4 Importance of Citizen Participation

In terms of embracing citizen involvement, open government encompasses various avenues for citizens' participation, such as citizen ideation and innovation, which aim to tap into external knowledge, predominantly from citizens, to enhance the accomplishments of public administration (Lisa Schmidthuber, et al., 2019). This inclusivity encompasses both citizen sourcing, which entails citizens assisting in routine public administrative tasks without necessarily introducing new ideas, and collaborative democracy, which seeks solutions to normative questions regarding the future development of society (Wijnhoven et al., 2015). Additionally, urban observatories, utilizing Geographic Information Technologies (GIT), play a role in promoting citizen participation by analyzing citizens' interactions with urban phenomena, policies, plans, and projects (Valenzuela-Montes and Carvalho-Cortes-Silva, 2015).

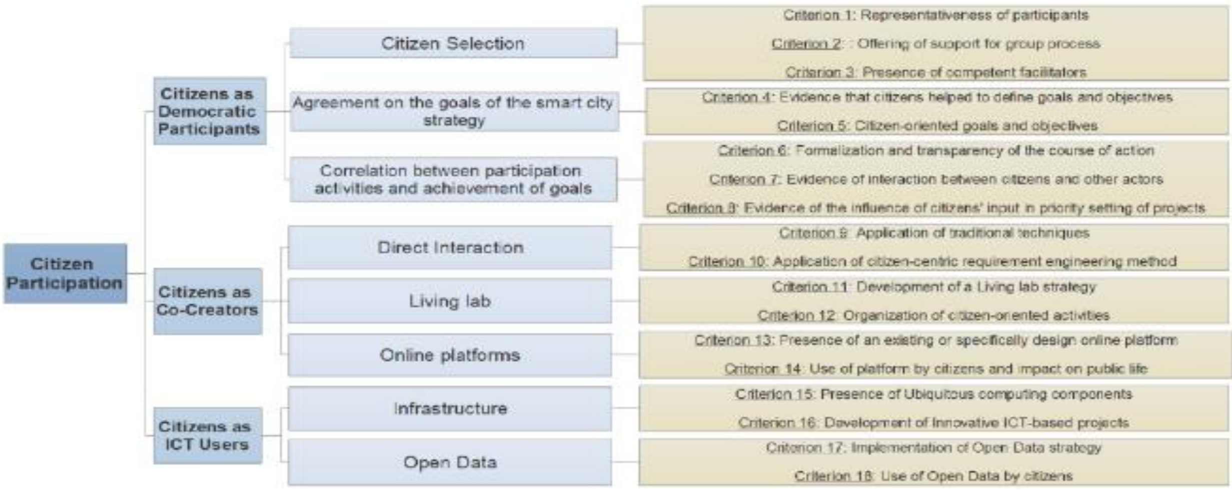
This underscores the significance and depth of citizens' active and interactive role in shaping open public administration, extending beyond mere observation (García and García Jiménez, 2013). In a truly open government framework, citizens could engage with the government through three key domains (Cortés-Sánchez, Cardona, and Wong, 2013): e-enabling, which involves leveraging technology for citizen participation; e-engaging, which utilizes technology to actively involve the citizenry; and e-empowering, utilizing technology to grant greater agency to the citizenry. Each of these forms of participation requires a government that is willing to offer opportunities for citizens to contribute to the formulation of public policies, while also facilitating processes of social innovation.

2.6.5 Citizen Participation in Smart Cities

An examination of the current state of research and development in smart cities reveals a wide-ranging and at times unclear landscape. While emerging technologies and concepts like the Internet of Things, Cloud Computing, and sensor integration will undoubtedly be pivotal in reshaping cities, it is their application that truly defines them as "smart". This forward-thinking approach sets smart cities apart from their conventional counterparts, which may invest in ICT solely to enhance the provision of public services.

In the realm of public administration literature, citizen participation is characterized as the "involvement of citizens in the planning and administrative processes of government". The involvement of citizens in traditional e-government initiatives has already been extensively studied. Within the context of e-government, citizen participation can encompass contributions to the design, execution, or evaluation of a project. The emphasis on citizen participation is further underscored by the Open Government movement, advocating for citizens to be at the forefront of public life through government transparency, active participation, and collaborative efforts among citizens. However, smart cities offer fresh avenues for facilitating this participation. This section delineates the significance of citizen involvement in smart cities and pinpoints the research gaps that this article endeavors to address.

Table 8: City Voice Framework



Source: (Anthony Simonofski, et al., 2019)

2.6.5.1 Gaps in Citizen Participation

While conventional definitions of smart cities acknowledge the role of citizens through "participatory governance," further exploration is needed to understand the contributions they can make. This paper draws a distinction between participation and involvement, concepts derived from the well-studied field of user participation in information systems, encompassing practices like participatory design, user-centred design, and cooperative design. In this context, participation pertains to the actions citizens undertake, while involvement relates to a psychological state of personal significance experienced by citizens.

The concept of citizen participation in smart cities takes on a multifaceted nature and has been categorized into three distinct groups. Firstly, citizens can act as democratic participants in the decision-making process, contributing to "sustainable local communities" where every resident looks out for one another. Secondly, citizens can offer their expertise and skills to propose improved solutions, thereby addressing issues early and reducing the risk of failure. Finally, citizens can continue to participate even after the smart city has been implemented, acting as data collectors through mobile devices or other technologies, thus fostering a sense of belonging within the smart city.

While this categorization has aided in organizing the exploration of facilitators for citizen participation, it doesn't provide exhaustive information about the implementation of each participation category. Additionally, there is a growing need for appropriate evaluation tools and metrics, with a current gap in scientific literature regarding the assessment of citizen participation. The subsequent section endeavours to address these challenges, ensuring that "citizen participation" remains a tangible and integral component of a city's strategy in aspiring to be labelled as "smart." In this regard, an extensive literature review allows for the refinement of categories, expanding "Citizens as providers of competences and experience" to "Citizens as Co-Creators" due to the myriad methods found in co-creation literature for gathering invaluable input from citizens. Moreover, "Citizens as data collectors" is broadened to "Citizens as ICT users" as utilizing ICT extends beyond data collection. Through the iterative validation process of design research, it is anticipated that the framework will be comprehensive enough to assess current smart cities. However, the introduction of new criteria and dimensions remains a possibility given the innovative nature of the smart city domain.

2.6.6 Link between Citizen Participation and ICT Applications

While ICT applications stands as the defining component in smart cities, an overemphasis on it has been identified as a significant shortcoming in several instances. Introducing ICT applications into a city, however, presents a fresh array of possibilities and has the potential to revolutionize the urban environment. The integration of technological support is frequently imperative for the realization of smart city initiatives. Despite the absence of a universally endorsed smart city framework, prevailing architectures typically incorporate a diverse set of technologies and models. This section endeavours to elucidate how citizen engagement can be fostered within the broader scope of ICT applications.

2.6.6.1 Citizen Participation Through ICT-Enabled Interactions

Two existing frameworks were adapted for this research. Linders (2012) initially developed a framework to analyze various types of ICT-mediated interactions between citizens and government, including interactions among citizens. The second framework, originally created by Fung (2006) to assess the level of participation in initiatives, was later modified by Wehn et al. (2015) for application to digital initiatives. While Linders' framework identifies patterns in citizen-government interactions, Fung's (2006) and Wehn et al.'s (2015) framework evaluates these interactions against public participation criteria.

Linders (2012) provides a useful categorization of information flows between citizens and government in the context of ICT-enabled public service provision. It distinguishes between citizen-to-government (C2G), government-to-citizen (G2C), and citizen-to-citizen (C2C) information flows. Researcher, expand this framework by introducing a fourth interaction type - "collaborative planning and groupware" or "government with citizens" (GwC). This involves regular meetings between government officials and citizens to discuss and design policy options using ICT technologies (Forester, 2012; Hoyt et al., 2005). Researcher included this interaction type to encompass the entire spectrum of joint planning approaches. Table 7 provides examples illustrating this framework.

The first type of interaction, citizen sourcing, involves the public aiding the government in becoming more responsive and effective (Linders, 2012: 447). It is part of the broader trend of crowdsourcing, defined as the collective generation of media, ideas, and data voluntarily undertaken by many people (Dodge and Kitchin, 2013: 19). While citizens contribute their knowledge, it is the government's responsibility to manage systems and services (Fung et al., 2013). An example is Peer to Patent, where patents are examined not only by experts, but by anyone with relevant knowledge, to determine if an innovation warrants a new patent (Noveck, 2009).

The second type, "government as a platform," entails information and knowledge flowing from government to citizens (e.g., O'Reilly, 2010). Here, the government assists citizens in enhancing their productivity or achieving specific goals, such as improved healthcare or more sustainable water and electricity consumption. Although it may not initially seem like a form of public participation, it plays a crucial role in establishing government openness, transparency, and trust.

In the third type of interaction, facilitated through social media, open-source software like Open Street Maps (OSM), blogs, and virtual learning platforms, citizens engage in activities, exchange experiences, and self-organize for learning and action (Medema et al., 2014). This allows citizens to share valuable information with each other in real time, potentially serving as an alternative to traditional government responsibilities in protecting and assisting citizens, especially in times of crises like floods and earthquakes (Palen and Liu, 2007). Examples include self-monitoring, where citizens help each other by reviewing hotels, restaurants, or government services (Linders, 2012). Fully independent citizen initiatives include Wikipedia, computer operational systems, and coding languages like LINUX and SETI.

The fourth interaction type, which researcher introduced, refers to ICT-facilitated participatory planning involving face-to-face interaction between citizens and a government representative. Technologies may play a pivotal role in facilitating and qualitatively enhancing these interactions. Examples include spatial decision support for collaborative planning, such as "touch tables" (Arciniegas and Janssen, 2012), and participatory modelling (Forester, 2012).

Additional methods may encompass participatory mapping, transect walks, focus group discussions to generate knowledge, community-based mapping, and NGOs producing knowledge in contested local governance processes (Hoyt et al., 2005). "Groupware" refers to computer-based systems supporting groups engaged in a common task, providing an interface to a shared environment (Hanzl, 2007: 297). Upon systematically categorizing observed interactions in the case studies, researcher apply a three-axis framework developed by Wehn et al. (2015) to evaluate the level of participation in these initiatives. This framework, based on earlier work by Fung (2006), was modified by Wehn et al. (2015) by renaming categories along the "participants" axis and adding two categories of "implicit" and "explicit data collection" to the "communication and decision mode" axis. "Implicit data collection" refers to citizens expressing opinions and ideas in a general form, while "explicit data collection" involves citizens providing crowdsourced information in a more targeted manner. The third axis indicates the authority participants exercise in decision-making as a result of participatory events and remains unchanged by When et al (2015). The search for case studies relied primarily on Google Scholar due to limited results in Scopus and the Web of Knowledge. This approach has some limitations, including potentially non-peer-reviewed publications and the ranking of search results according to Google search frequency. However, most articles in the dataset are peer-reviewed, and google search ranking did not influence dataset compilation. Additionally, the search focused on case studies in English.

2.6.7 Link Between Citizen Participation and Sustainability of Smart City

Smart cities are currently enjoying strong support and significant financial backing from various organizations. Seizing this opportunity and leveraging the multitude of technological capabilities, cities must formulate smart city initiatives, determine how to enhance, and utilize their ICT infrastructure, and maximize their resources. An essential challenge lies in executing these actions in collaboration with the citizens, as the ultimate objective of creating a smart city is to enhance their quality of life. Unfortunately, many smart city initiatives have fallen short of their goals due to inadequate involvement of citizens in their design, or insufficient consideration of the impact on their daily lives.

In a widely respected article, Hollands critiques this approach to smart cities and contends that a true smart city must be founded on more than just the application of ICT. For it to foster social, environmental, economic, and cultural advancement, a genuine smart city, according to Hollands, should originate from the people and human resources of the city, utilizing information technology to facilitate democratic deliberations about the kind of city residents want to inhabit. This profound critique has spurred innovative thinking in academic circles. An integrated definition of a smart city has emerged, encompassing the various dimensions of a smart city as well as this radical perspective: A city can be deemed 'smart' when investments in human and social capital, along with conventional (transport) and contemporary (ICT) communication infrastructure, drive sustainable economic progress and a high standard of living, while prudently managing natural resources, through participatory governance. Although alternative definitions exist, this one enjoys widespread acceptance and application: cities like Amsterdam have adopted this definition as the foundation of their strategy, it ranks among the most frequently cited definitions in academic literature and serves as a cornerstone in most technological infrastructures.

Academic literature recognizes the pivotal role of citizens in smart cities and asserts that the notion of empowering citizens and democratizing innovation should be integrated into this definition. Citizens must have the capacity to identify priorities, formulate strategies, and establish goals for the smart city agenda, and should be regarded as central participants in the implementation and benefits of smart city initiatives.

2.7 Leadership

2.7.0 Definition

Operational Definition: Leadership in a smart city context refers to the effectiveness and strategic direction provided by city officials, administrators, and stakeholders in guiding the development and implementation of smart city projects. It encompasses the ability to set clear goals, mobilize resources, foster collaboration, and adapt to the dynamic nature of technological advancements and urban challenges.

2.7.1 Gaps in Leadership

Municipal governments have to behave as an intermediate actor among various organizations and business involving the citizens as users having benefits for all smart and sustainable oriented initiatives and programs leading cities to the future.

In terms of urban policy, the leadership of the local governor has a great influence on the success or failure of the policy. Lee investigated the success factors of lifelong learning city policy in terms of the leadership of local autonomous governments and concluded that the leadership of the local government heads was able to execute the lifelong learning city policy more successfully, as the leader’s political capacity was stronger.

Neirotti et al. argued that the likelihood of increasing the quality level of a smart city depends on country-specific variables. Among them, leadership is argued to affect a smart city's political level, political risk, and corruption level. In order to reduce delays in implementing smart cities, policy makers in leadership roles must find ways to relieve the path dependence on technology adoption.

Washburn et al. also discussed the qualities of leaders in the smart city era. For example, a CIO (chief information officer), as a digital leader, should exercise their influence in smart city building. In particular, CIOs in the smart city era must show leadership featuring ICT applications knowledge for the sake of successful smart city building, including skills in long-term financing, an appropriate allocation of expertise, employee education, staff accountability, and the standardization and interoperability of systems.

The literature highlights the importance of governance in the achievement of the requisites for becoming a smart city. According to Mosher (1982), organizations will be more responsive to the public if they reflect the demographic characteristics of those they serve. Management literature on gender suggests some differences between the styles of women and men (Duflo, 2012).

Recent regulations echo the concern that discrimination may exist in access to boards, leading to inefficient use of the talent pool. Thus, they recommend increasing the number of female directors on governance boards. Several of these legislations explicitly argue that gender diversity improves the effectiveness of the council. However, emerging literature questions the view that female directors behave differently from their male colleagues (see, for example, Adams and Funk, 2012) and calls for research on the role of women in governance.

Previous literature suggests that male and female local councillors agree that women are more responsive to their constituencies (Beck, 2001); female mayors encourage citizens' participation, communication, and input more than men in that position (Fox & Schuhmann, 1999). The increase in numbers of women in formal political representation, as council members or as mayors in municipalities, has influenced the structure of power and the functioning of municipalities in Spain (Araujo & Tejedo-Romero, 2017). Nevertheless, studies on leadership and gender in municipalities of smart cities still are in their infancy.

2.7.2 Link between Leadership and ICT applications

The integration of Information and Communication Technology (ICT) applications has become a crucial factor in the success and sustainability of modern organizations. Previous research has elaborated on the dynamic relationship between leadership and the effective application of ICT applications within organizational contexts. Leadership plays a pivotal role in shaping the strategy, culture, and utilization of ICT applications, ultimately influencing organizational performance and competitiveness.

According to (McAfee et al., 2008), effective leadership entails aligning ICT initiatives with organizational objectives and goals. Leaders provide a clear vision for how ICT applications can drive business value and competitive advantage. This alignment ensures that technology investments are directed towards areas that directly contribute to the organization's strategic outcomes.

While (Bass & Riggio, 2006), supported that leadership fosters an innovative culture, encouraging the exploration and adoption of emerging technologies. They are instrumental in driving change management efforts during the implementation of new ICT application systems, ensuring that employees adapt and leverage technology effectively.

Leaders play a vital role in cultivating a culture that embraces digital transformation (Westerman et al., 2014). They set the tone for a culture of continuous learning, adaptability, and openness to technological advancements. This culture of digital readiness is crucial for organizations to thrive in rapidly evolving technological landscapes.

Furthermore, (Kotter, 2012) stated that leaders leverage ICT tools to facilitate seamless communication and collaboration within and across teams. They encourage the use of digital platforms and collaborative tools, breaking down silos and enhancing knowledge sharing, ultimately driving organizational productivity.

Other authors supported that leadership is critical for decision-making. Leaders utilize ICT to access and analyze data, enabling them to make informed and data-driven decisions (Davenport & Harris, 2007). They champion the use of analytics and business intelligence tools, ensuring that decisions are grounded in empirical evidence rather than intuition. Meanwhile other supported that leaders leverage ICT to promote inclusivity and diversity within the organization (Laudon & Laudon, 2016). They ensure that technology is accessible to all employees, regardless of their background or abilities, creating an inclusive digital environment.

Thus, the overall literature supports that effective leadership is instrumental in driving the successful application of ICT within organizations. Through strategic alignment, fostering innovation, shaping organizational culture, and promoting data-driven decision-making, leaders play a pivotal role in leveraging technology for organizational success.

2.7.3 Link between Leadership and sustainability of smart city

The emergence of smart cities represents a paradigm shift in urban development, emphasizing the integration of technology, data, and citizen engagement for sustainable and efficient urban living. Leadership, both within local governments and across various stakeholders, plays a critical role in driving the sustainability agenda within smart cities. Other studies have explored the nexus between leadership and the long-term sustainability of smart cities.

Visionary leaders play a pivotal role in setting a clear and comprehensive vision for smart city development (Caragliu et al., 2011). They articulate a strategic roadmap that encompasses technological innovation, citizen well-being, and environmental stewardship. This vision serves as a guiding framework for sustainable urban planning. Furthermore, (Bifulco & Tregua, 2017), supported that leadership in smart cities extends beyond traditional government structures to include collaboration with diverse stakeholders such as private sector partners, academic institutions, and community organizations. Engaging these stakeholders fosters collective ownership of sustainability initiatives and ensures a holistic approach to urban development.

On the other hand, leadership helps in performance monitoring. Leaders leverage data analytics and technology-driven insights to inform decision-making processes (Komninos, 2013). They establish robust data infrastructures that enable real-time monitoring of key sustainability indicators, allowing for adaptive strategies in response to emerging challenges. Leadership involves the development of policies and regulations that incentivize sustainable practices and the adoption of innovative technologies (Yigitcanlar et al., 2015). This includes zoning regulations that encourage energy-efficient building designs, incentives for renewable energy adoption, and guidelines for green infrastructure development.

Smart city leaders recognize the importance of building resilience to climate change and other urban stressors (Meijer et al., 2019). They integrate adaptive strategies into city planning, including resilient infrastructure, green spaces, and disaster preparedness measures. Leadership in smart cities places a strong emphasis on citizen engagement and empowerment (Anthopoulos et al., 2016). Leaders facilitate platforms for citizen participation in decision-making processes, ensuring that urban development aligns with the needs and aspirations of the community. Much more, effective leaders promote a culture of continuous learning and capacity building within the city administration (Cugurullo, 2018). They facilitate knowledge exchange platforms, training programs, and partnerships with academic institutions to enhance the expertise needed for sustainable smart city initiatives.

2.8 Infrastructure

2.8.0 Definition

Operational Definition: Infrastructure in the context of a smart city comprises the interconnected physical and digital systems, facilities, and networks that enable the efficient functioning of the urban environment. This encompasses traditional physical infrastructure like transportation, utilities, and buildings, as well as digital infrastructure such as broadband networks, IoT sensors, and data centers that support smart technologies and services.

2.8.1 Infrastructure Characteristics

The integration of technological advancements gives rise to the establishment of an infrastructure known as "ubiquitous computing". This term is closely associated with sensor technologies and the Internet of Things, signifying the embedding of wireless, intercommunicating microprocessors within everyday objects. These objects are thereby endowed with information processing and communication capabilities, allowing them to capture and manipulate the surrounding environment through sensors or actuators. The criterion "Ubiquitous computing components" outlines all computing elements that could effectively enhance citizen participation. Consequently, it is imperative to establish a connection between each computing element and its prospective function.

The pivotal consideration is to align these technological progressions to serve the citizens. However, these developments may still appear overly abstract to most citizens who are primarily interested in practical applications. The criterion "Innovative ICT-based projects" is introduced to verify that innovative, citizen-centric applications can be integrated into the framework. To illustrate, researcher highlight two pertinent citizen-oriented applications rooted in ubiquitous computing: Augmented Reality (AR) and Citizen Science.

Augmented Reality (AR) systems are described as a "powerful visualization tool, which augments real-world elements with digital information". In the context of a smart city, its significant contribution lies in immersing citizens in a technological environment that supports and motivates their engagement in various applications.

Citizen Science, initially centred on the volunteer collection of biodiversity and environmental data, has broadened its scope to encompass various types of data contributing to an enhanced understanding of a city. Recognized by the European Union as a valuable endeavour, Citizen Science projects are acknowledged for their role in data collection, awareness-raising, capacity-building, and community strengthening. Consequently, many smart cities actively support Citizen Science initiatives. Once again, the city of Santander serves as an exemplar, having developed an application with three key functionalities. First, it facilitates the collection of data from smartphones, including GPS location, temperature, luminosity, and humidity. Second, it empowers citizens to create and report events, such as capturing images of road defects. Lastly, it provides an interface where citizens can access information about events, public transportation, cultural events, and sensor data.

In the context of smart cities, ICT applications forms the backbone. Devoid of ICT applications, the smart city concept would be untenable. Consequently, the design of ICT infrastructure for smart cities must itself be intelligent, incorporating elements of scalability, robustness, and flexibility to ensure its efficacy. This can be achieved through various design network concepts.

2.8.1.1 Automated and Simplified Network Management

This concept entails a unified and centralized approach to network management, streamlining the management of expansive and occasionally complex networks essential for supporting smart cities. Networks adopting this concept address a critical requirement in smart city ICT infrastructure by enabling unified management, thereby diminishing complexity, and enhancing efficiency.

2.8.1.2 Automatic Security Threat Isolation and Remediation

A network security management framework that thwarts threats at their origin without causing the delays and congestion typical of conventional Intrusion Protection Systems (IPS). This should encompass an adaptable Self-Defending Network solution applicable to both wired and wireless networks, ensuring a more secure and enhanced end-user experience.

2.8.1.3 IoT enabled networks

Given that IoT is a crucial component of a smart city, it's imperative to have an ICT network design that facilitates IoT applications. This is particularly relevant for wireless networks, which can lower the expenses associated with wireless installations and offer seamless deployment for IoT devices.

2.8.1.4 Robustness and scalability

Having redundancy is a crucial aspect of any extensive network, particularly for one that underpins the seamless functioning of an entire city. Similarly, scalability holds equal significance as urban areas expand and the demand for smart city applications, both in number and traffic volume, continues to rise.

2.8.1.5 Big Data

However, as indicated in a recent review of literature, while smart and smarter cities have brought about significant transformations in various aspects of human life, there remains a notable gap and shortcomings in integrating the objectives of sustainable development (Chang, V., 2021); (Yongguan Wang, 2023). Additionally, there exists a limited correlation between smart targets and sustainability aims, despite the established role of ICT applications in aiding modern cities in their pursuit of sustainability. As highlighted by it is concluded that the landscapes of smart and sustainable cities exhibit substantial fragmentation both in terms of policy and technical aspects, leaving a multitude of unexplored opportunities for the development of sustainably smart cities. Overall, the approaches of smart and smarter cities pose numerous questions and present substantial challenges within the context of sustainability.

In regard to the application of big data analytics, while research in the realm of smart and smarter cities has been notably active, a significant portion of this work predominantly focuses on economic growth factors (management, efficiency, innovation, productivity, etc.) and on enhancing quality of life through service efficiency and improvement (Allam, Z., & Dhunny, Z.A. (2019); (Osman, 2019). However, it often overlooks and only marginally explores the untapped potential of big data applications for advancing various facets of sustainability. Indeed, many emerging smart solutions do not align with sustainability objectives. Therefore, it is imperative for smart and smarter cities to shift their focus towards harnessing big data applications to enhance their contribution to the goals of sustainable development across urban domains.

2.8.1.6 Open Data

Open Data encompasses publicly generated data that is disseminated without constraints. It encourages the government to function as an open system, engaging with its surroundings, and thereby, welcoming diverse perspectives and soliciting feedback. Open data is centred on various domains like traffic, weather, public sector financial planning, tourist information, and more. The "Open Data strategy" criterion evaluates the city's policy regarding the accessibility of public data. It achieves this by enumerating all datasets that are made accessible and detailing the manner in which they are provided.

Nonetheless, the mere publication of open data does not inherently lead to citizen involvement, as it necessitates substantial changes within the public sector and requires citizens to possess the capability to utilize this data. Moreover, Open Data also encourages citizen involvement in data collection (referred to as Citizen Science) by incorporating them into the data processing framework. Additionally, more proactive citizens, often associated with the "Civic Hacker" community, establish open-source platforms or applications to leverage Open Data, facilitating collaboration among citizens to address issues at various scales (local, city-wide, or even nationwide). The "Use of Open Data by citizens" criterion itemizes all the methods through which the available datasets are utilized by citizens.

2.8.2 Gaps in Infrastructure

The essence of the smart city concept lies in the advancement of Information and Communication Technologies (ICTs) applications like wireless communication, big data, and the Internet of Things (IoT). These new technologies enable possibilities that were previously unimaginable in past urban environments. The continual study of smart technologies, encompassing digital devices and internet networks, has led to a multitude of innovations and services. These were initially developed independently and subsequently integrated with one another. Notably, the concept of a digital city, which initially emerged in discussions surrounding efficient urban problem-solving through ICT applications, has largely given way to the all-encompassing vision of a smart city, aiming to operate cities in an integrated manner.

To elucidate, the use of ICT applications for urban problem-solving constitutes a fundamental endeavour in the construction of smart cities. Sylviane Toporkoff (2019) posits that the progression of digital technology has a far-reaching impact on various aspects of a city, particularly ushering in significant changes in urban administration and development. The substantial volume of data generated by diverse ICT applications systems stands as a pivotal element in the smart city paradigm.

While the technological infrastructure undeniably forms a crucial aspect of a smart city, its efficacy might be limited without the establishment of a corresponding human infrastructure (Lihi Lahat & Regev Nathansohn, 2023). For instance, even the construction of an electricity-generating power plant would be rendered futile without the human infrastructure capable of operating it. Thus, alongside technological infrastructure, the development of human infrastructure assumes paramount importance. Consequently, there is a need for educating individuals in the creation of a smart city to optimally leverage these state-of-the-art technologies.

2.8.2 Link between Infrastructure and ICT applications

The ICT infrastructure and connectivity play a pivotal role in the strategic planning and efficient management of Smart Cities (Shreeansh Mishra & Vaibhav Bhatt 2023). Society's increasing demand for better infrastructure and services, coupled with advancements in technology, has given rise to the concept of smart infrastructure (Ogie et al. 2017); (Soyinka, O., Wai.K, siu, M., Lawanson, T., & Adeniji, O. (2017). Through the integration of physical and virtual realms, facilitated by a robust network of interconnected applications and devices operating on an object-enabled framework, data streams (often referred to as Big Data) can be gathered and transmitted in real-time. This empowers local authorities to enhance their capacity for identifying, monitoring, comprehending, and interpreting various urban phenomena. Real-time monitoring spans critical urban functions including traffic regulation, public transportation, surveillance systems, sensors, and air quality assessment, enabling the proactive resolution or prevention of urban challenges and undesirable events.

Advancements in information management, Internet of Things (IoT) technologies, robust capabilities in Big Data Management & Analytics, and the widespread proliferation of technologies for monitoring diverse facets of the urban environment (ranging from infrastructures and buildings to green spaces and pollution levels) are opening up innovative possibilities for monitoring and control. In this context, envisioning the Smart City as an urban network is plausible (Al-Hader M. & Rodzi A. (2009). In this network, nodes correspond to physical assets such as buildings and infrastructures, which serve as information hubs engaged in a two-way flow of data (both inbound and outbound) with the city. Through IoT and connectivity, these physical assets can interconnect within the urban complex, transforming into units for receiving inputs and disseminating outputs. This significantly elevates the levels of understanding regarding the city, its ongoing and future dynamics, and enhances the efficacy of city management processes (Talamo, et al., 2016).

Role of ICT applications: ICT plays a pivotal role in optimizing the use of physical infrastructure through real-time monitoring, data analysis, and predictive modelling, leading to resource conservation, and reduced environmental impact.

2.8.3 Link between Infrastructure and Sustainability of Smart City

The concept of smart cities has gained prominence as a response to the challenges posed by rapid urbanization and the need for sustainable urban development. Central to the realization of smart cities is the critical role played by infrastructure (Lee et.,2020). Infrastructure forms the bedrock upon which smart cities are built United Nations, Economic and Social Council, 2016); (Hall et a.l. 2000). Smart cities represent a novel approach to urban planning and development, emphasizing the seamless integration of digital technologies, data-driven systems, and sustainable practices to enhance the urban experience for residents and visitors (Caragliu et al.2011).

From transportation networks and energy grids to water supply systems and digital connectivity, robust infrastructure is indispensable for the functioning of any city, let alone a smart one. In the context of smart cities, infrastructure extends beyond traditional physical elements to encompass digital and technological components, such as IoT networks and data centers. Through the integration of cutting-edge technologies like IoT, big data analytics, and smart sensors into urban infrastructure, cities can effectivelt oversee resources, enhance service, and provide effortless access to value-added offerings for residents and tourists, all while maintaining a focus on long-term sustainability (Buhalis & Amaranggana, 2014).

Furthermore, the sustainability of a smart city is multi-dimensional, encompassing economic, environmental, and social aspects. Infrastructure plays a pivotal role in each of these dimensions. Smart city infrastructure fosters economic sustainability by providing a conducive environment for business and innovation. Well-designed transportation networks and digital connectivity facilitate efficient movement of goods and people, thereby bolstering economic activity. Moreover, investments in smart infrastructure attract businesses and stimulate job creation, driving economic growth. Infrastructure choices profoundly impact the environmental footprint of a city. Sustainable transportation systems, energy-efficient buildings, and waste management solutions are integral components of eco-friendly smart cities. Renewable energy sources, coupled with advanced grid management systems, further contribute to reducing carbon emissions and minimizing environmental impact. Accessible and inclusive infrastructure is fundamental to ensuring social equity and inclusivity within smart cities. Well-planned public spaces, accessible public transportation, and affordable housing options enhance the quality of life for all citizens. Moreover, digital infrastructure plays a pivotal role in bridging the digital divide and ensuring that technological advancements benefit all segments of the population.

Despite its pivotal role, ensuring the sustainability of smart city infrastructure is not without challenges. Balancing the need for rapid urban development with long-term sustainability goals requires strategic planning and visionary leadership. Moreover, financing and resource allocation for smart infrastructure projects necessitate innovative funding models and public-private partnerships.

2.9 Fourth Industrial Revolution

2.9.0 Definition

Operational Definition: The Fourth Industrial Revolution in the context of a smart city refers to the transformative era characterized by the integration of advanced digital technologies, artificial intelligence, automation, and IoT devices into various aspects of urban life. It represents a shift towards data-driven decision-making, autonomous systems, and the convergence of physical and digital realms in city planning and management.

2.9.1 Fourth Industrial Revolution Characteristics

The term 'Fourth Industrial Revolution' was initially introduced during the 47th World Economic Forum Annual Meeting in Switzerland in January 2016. This revolution is characterized as the upcoming phase of industrial advancement driven by artificial intelligence (AI), robotics, and life sciences. It represents a technological revolution that amalgamates digital, biotechnology, and physics principles, building upon the foundation laid by the tertiary industrial revolution.

With the advent of the Fourth Industrial Revolution, the approach to tackling intricate and diverse urban challenges has undergone a transformation. Specifically, open innovation within smart city platforms emphasizes a decentralized method of innovation, recognizing that knowledge and expertise are not confined solely within the government, but are widely dispersed across various sectors of society. Artificial intelligence, along with the Internet of Things (IoT), are becoming pivotal components of smart cities as they integrate with urban environments.

2.9.2 Gap in Fourth Industrial Revolution

Digital Divide: Not all regions or demographics have equal access to advanced technologies. There's a significant gap between developed and developing nations, as well as within countries themselves.

Skills Shortage: The rapid pace of technological advancement has created a gap in the skills required to effectively utilize and manage emerging technologies like AI, IoT, and blockchain.

Regulatory Frameworks: Governments and international bodies are still working to establish effective regulatory frameworks to govern the ethical and responsible use of technologies like AI and autonomous systems.

Infrastructure and Connectivity: Rural and underdeveloped regions often lack the necessary infrastructure for high-speed internet and reliable power supply, hindering their ability to fully participate in the 4IR (Batty, et al., 2012).

Sustainability and Environmental Impact: The 4IR has the potential to both exacerbate and mitigate environmental issues. Striking a balance between technological advancement and sustainability remains a significant challenge (Joss, 2018).

2.9.3 Link between Fourth Industrial Revolution (4IR) and ICT applications

The 4IR is characterized by a constellation of technologies that significantly impact the ICT landscape. Artificial Intelligence (AI), a cornerstone of 4IR, empowers ICT applications systems with the ability to learn, reason, and make decisions autonomously. Machine learning algorithms, a subset of AI, have revolutionized data analysis and interpretation, enabling ICT applications to process vast datasets in real-time. Meanwhile IoT is another linchpin of 4IR, extends the reach of ICT applications by interconnecting devices, sensors, and systems. This interconnectedness facilitates the seamless exchange of information, enabling ICT applications to monitor, control, and optimize various processes in real-time.

Smart cities stand as prime exemplars of the synergistic integration between the 4IR and ICT. By leveraging 4IR technologies, smart cities harness the power of AI, IoT, and big data analytics to enhance urban planning, transportation systems, energy efficiency, and public services. For instance, AI-driven traffic management systems utilize real-time data from IoT sensors to optimize traffic flow, thereby alleviating congestion and reducing emissions. The fusion of 4IR technologies and ICT applications has profound implications for economic growth. This amalgamation has spawned new industries and business models, unlocking unprecedented opportunities for innovation and entrepreneurship. Start-ups and established enterprises alike are capitalizing on the transformative potential of 4IR technologies integrated with ICT to develop cutting-edge products and services.

While the integration of 4IR technologies and ICT holds immense promise, it is not without challenges. Concerns surrounding data privacy, cybersecurity, and ethical AI deployment necessitate careful consideration. Moreover, ensuring equitable access to 4IR-driven ICT advancements remains a critical concern, as disparities in digital infrastructure and skills could exacerbate societal inequalities.

2.9.4 Link between Fourth Industrial Revolution and sustainability of smart city

The Fourth Industrial Revolution, characterized by the convergence of digital, physical, and biological technologies, has significantly impacted urban development strategies globally. The integration of cutting-edge technologies, including the Internet of Things (IoT), Artificial Intelligence (AI), and data analytics, has reshaped urban landscapes, offering opportunities to address environmental, social, and economic challenges in smart city contexts. Therefore, concept of "smart city" was supplemented by analysis of technological changes caused by 4^{th} industrial revolution (Kagerman, Lukas and Wahlster, 2011) and impacts the implementation of sustainable smart cities (do Livramento Goncalves, L.; Leal Filho, W.; da Silva Neiva, S.; Borchardt Deggau, A.; de Oliveira Veras, M.; Ceci, F; Andrade de Lima, M.; Salgueirinho Osorio de Andrade Guerra, J.B. 2021).

The Fourth Industrial Revolution plays a pivotal role in enhancing resource efficiency within smart cities (Anton Safiullin, Lyudmila Krasnyuk, Zoya Kapelyuk, 2018). Through the deployment of IoT sensors and AI-driven systems, cities can monitor and optimize resource consumption in real-time. This leads to reduced energy consumption, minimized waste generation, and improved overall resource utilization, ultimately contributing to environmental sustainability. Furthermore, technological advancements associated with the Fourth Industrial Revolution facilitate the seamless integration of renewable energy sources into urban energy grids. Smart grids, coupled with IoT-enabled devices, enable the efficient distribution of energy from renewable sources. This transition reduces dependency on non-renewable energy, mitigates greenhouse gas emissions, and promotes sustainable energy practice. Meanwhile the Fourth Industrial Revolution revolutionizes urban mobility through the implementation of intelligent transportation systems. IoT-driven sensors, combined with AI algorithms, optimize traffic flow, reduce congestion, and promote eco-friendly modes of transportation. This shift towards sustainable mobility options aligns with the goals of smart cities to enhance urban liveability and reduce environmental impact.

Furthermore, smart cities leverage Fourth Industrial Revolution technologies for comprehensive environmental monitoring. IoT sensors collect real-time data on air quality, water quality, noise levels, and other environmental parameters. This data enables early detection of pollution and supports evidence-based decision-making for environmental protection and conservation effort. Thus, the Fourth Industrial Revolution empowers citizens to actively participate in sustainability initiatives. Digital platforms and interactive technologies foster citizen engagement, raise awareness about sustainable practices, and provide educational resources. This heightened citizen involvement contributes to a culture of environmental stewardship within smart cities.

The Fourth Industrial Revolution serves as a catalyst for the sustainability of smart cities, providing a technological framework to address urban challenges. Through the integration of IoT, AI, and data analytics, smart cities can optimize resource management, promote renewable energy, enhance mobility, monitor environmental conditions, engage citizens, and build resilience. This symbiotic relationship between the Fourth Industrial Revolution and urban sustainability underscores the transformative potential of technology in shaping the future of smart cities.

2.10 Political Will

2.10.0 Definition

Operational Definition: Political will in the context of a smart city pertains to the demonstrated commitment and determination of political leaders, policymakers, and governmental bodies to prioritize and invest in the adoption of smart technologies and sustainable urban development practices. It involves the allocation of resources, the creation of supportive policies, and the active promotion of smart city initiatives to enhance urban living conditions.

2.10.1 Lack of Investment in Basic Infrastructure

Despite advocating for the smart city agenda, some developing countries are still held back by the lack of investment in basic infrastructure. Basic urban infrastructure, such as having proper water drainage and sewerage systems, are requisite for any city to thrive, but some cities still face a shortfall in providing these services. In India, smart city adoption is held back by the lack of provision and maintenance in basic infrastructure, which result in uneven development and low-quality infrastructure in some cities, particularly in the slum areas. In addition, the mounting population pressure is making infrastructure such as underground sewerage and water drainage systems unsustainable. Under-provision of door-to-door garbage collection services and inefficient municipal solid waste management systems in some cities in South Asia are also hampering the effort of smart city development, as governments still struggle to meet the basic public service needs of their citizens.

2.10.2 Lack of Technology-Related Infrastructure Readiness

Many developing countries are falling behind developed economies in terms of technology-related infrastructure readiness, and this poses an imminent challenge to smart city adoption. The level of technology-related infrastructure development is heterogeneous among developing countries, and the issues encountered are also different, ranging from lack of internet penetration and lack of internet connection for business information exchange in Ghana for example to the lack of local technical capacity to develop the core technologies needed to drive smart city development. According to Si Ying and Araz Taeihagh (2020) article on sustainability, in large cities like Ahmedabad in India, the development of the smart city is constrained by the low internet penetration rate among the households and unequal access to digital infrastructure among the populations. Likewise, in Ghana, costly internet connection services hinder the widespread adoption of Wi-Fi on privately owned commercial transport systems, which has slowed down information exchange for business owners, especially when travelling between cities. In China, lack of local technical capacity in developing some of the core technologies needed in smart city development has become a concern, as this situation might predispose the country to potential technological risks that affect its national security and sovereignty. Dependence on foreign companies in core technologies such as various dynamic and spatial information systems, database management, and operation solutions potentially leads to security risks concerning the leak of confidential information. These technology-related infrastructure gaps will ultimately result in a digital divide, affect business productivity, and expose cities to unintended risks.

2.10.3 Fragmented Authority

Fragmented authority across various public institutions also presents as a barrier to smart city development in developing countries. As smart city development involves multiple stakeholders from a variety of public and private sectors, forming strong partnerships and having a central authority to steer the entire development process is crucial. The lack of unifying strategies for smart cities led by a central authority and the lack of coordination and cooperation among a city's operational networks inhibit the efforts of governments to roll out smart city projects swiftly and effectively. In India, many smart city projects have been launched independently by different agencies at the state and city levels, and these plans were often not coordinated by a central authority. This has resulted in a divergence of aims, the repetition of smart city plans, and the overlapping of responsibility in the execution of many smart city projects. Likewise, a fragmented institutional mandate and the lack of coordination mechanisms across public service institutions has resulted in the lack of a centralised data controller platform to aggregate data for purposes of analysis. In particular, it has been found that more than one-third of the designated smart cities in India have not been able to collect and report data on various public services. This fragmented authority could result in multiple complications in the governance of smart cities, including the deployment of ineffective policy instruments, operational inefficiency, the reluctance of local governments to concur to the development plans of smart cities, and the formulation of overambitious and unrealistic goals for smart cities.

2.10.4 Lack of Governance Frameworks and Regulatory Safeguards for Smart Cities

In developing countries, a significant hindrance to smart city development is the absence of established governance frameworks and regulatory protections. While many developing nations are embracing smart city initiatives for economic and social benefits, there is a notable dearth of well-defined governance frameworks that delineate policy objectives, development strategies, regulatory standards, and assessment models for smart city projects in numerous cities across these countries. Concerning regulatory safeguards, the potential breach of data privacy and security emerges as a major apprehension among citizens across various nations. The integration of diverse networks within urban areas, coupled with advancements in big data analytics, signifies that numerous individuals could face elevated risks to their informational safety, such as identity theft and other cybersecurity threats. In the absence of clear regulations governing data usage, the privacy and security of extensive real-time data collected from terminal sensors through various means like scanning, imaging, locating, and tracking may be jeopardized. For instance, smart mobility solutions like ride-hailing services and autonomous vehicles continually gather data from users, potentially exposing them to privacy violations and data security breaches through malicious attacks and fraudulent activities on their mobile applications. Even as many public service platforms are interconnected to facilitate resource-sharing and enhance inter-system communication, this could render the system more susceptible to information leaks and data theft, potentially leading to the collapse of the entire information network. In the deployment of satellite-enhanced telemedicine and e-health initiatives in Africa, the governance of numerous legal issues related to patient data ownership, security, and access to clinical information systems by both patients and healthcare providers remains ambiguous and inadequately regulated. Moreover, the expansion of the ICT network creates greater opportunities for the dissemination of terrorist ideologies within cities, underscoring the imperative for governments to establish robust regulatory and governance frameworks to monitor and counter such illicit online activities.

2.10.1 Link between Political Will and ICT applications

Smart city policies have a notable impact on government investment in urban development, as reported in the American Economic Review. By recognising the potential of information and communication technologies (ICT) and data-driven decision-making processes to address urban challenges, these policies encourage governments to allocate resources towards innovative solutions and infrastructure. Government investment in smart city projects often involves funding for research and development, digital infrastructure upgrades, and the implementation of pilot programs to test and refine new technologies and approaches. By prioritising smart city initiatives, governments can signal their commitment to sustainable urban development, attracting additional investments from private and international sources and fostering public–private partnerships (PPPs) to leverage expertise and resources across various sectors.

Government investment plays a critical role in advancing digital infrastructure within smart cities, as highlighted in the American Economic Review. By allocating funds to support the development and deployment of innovative technologies and approaches, governments can help build the necessary digital infrastructure to enable a wide range of smart city applications. These investments can target various aspects of digital infrastructure, such as enhancing connectivity through the rollout of high-speed broadband networks, supporting the integration of Internet of Things (IoT) devices, and upgrading data processing and storage capabilities. Government investment in digital infrastructure not only contributes to the overall resilience and efficiency of urban systems but also sets the foundation for future innovations and growth in the digital economy.

The relationship between smart city policy, government investment, and digital infrastructure, as discussed in the American Economic Review, is both complex and interdependent. Smart city policies drive government investments in innovative solutions and infrastructure, which in turn contributes to the development of advanced digital infrastructure that underpins various smart city application. As digital infrastructure expands and evolves, it facilitates the implementation of smart city initiatives, leading to more sustainable, efficient, and liveable urban environments. This process creates a positive feedback loop that encourages further government investments in innovation and infrastructure development, ultimately fostering a virtuous cycle of growth and improvement in smart cities. By understanding this interconnectedness, policymakers can more effectively design and implement strategies that support the continuous development of digital infrastructure and the overall success of smart city initiatives.

2.10.2 Link between Political Will and sustainability of smart city

Cities are considered as a space of flows (Castells, 1989) as digital communications technologies were used to create dense real-time networks linking businesses, governments, organizations, and individuals around the globe. Policymakers should pay more attention to the evolution of 'smart cities approach' in order to correctly understand regional and urban dimensions of economic development policy.

Previous literature claims that certain political ideologies are more favourable to influencing sustainable policies and consequently the development of smart cities (Steurer & Hametrer, 2010; García-Sánchez & Prado-Lorenzo, 2008; Nam & Pardo, 2011). Nam and Pardo (2011) underline the key components of a smart city, which are technology, people (creativity, diversity, and education), and institutions (governance and policy). Connections exist between these latter two components and smart cities, so that a city is really smart when investments in human and social capital, together with information and communications technology (ICT) infrastructures, fuel sustainable growth and enhance the quality of life. The point of view of this study is that the smart city must provide some sort of interoperable and Internet-based government services that enable ubiquitous connectivity and transform key government processes towards citizens and businesses.

Public choice theory, developed by Mueller (1979, 1989), states that a complex political environment in which voters, interest groups and politicians play an important role in government decisions to adopt particular policies in general influences certain plans in the development of smart cities, in particular. Politicians play the role of agents appointed through an electoral process and always act in order to maximize the number of votes they expect to receive in the next election. According to Bavetta and Padocano (2000), politicians select a number of resources and agents' time to provide policies to voters in exchange for votes, and to interest groups in exchange for resources, insofar as these can be reinvested to affect electoral outcomes.

Batty et al. (2012) point out that intelligent governance is an attribute that is associated with the governmental management of a city only when the city promotes itself as intelligent. Alkandari et al. (2012) indicate that the government should approve the development of the smart city and prioritize some areas, and Winters (2011) argues that urban governments should only promote higher education centres in order to develop smart cities. Finally, Nam and Pardo (2011) emphasize that smart governance is about promoting smart city initiatives.

Moreover, Smith and Fridkin (2008) argue that interparty competition plays a key role in the decision of politicians to devolve institutional power to citizens to a greater or lesser extent so that they have to pay attention to the demands of their constituents. Good governance and good policies can result in strong interactions at the urban level, while focusing on smart collaboration can result in more attention to collaboration issues than actually making things work. The question of what political ideology (for example, conservative or progressive parties) is more effective and more legitimate is a current issue. Anderson and Mizak (2006) relate that the main predictor of a vote for pro-environmental law is whether the American legislator is a liberal (left-wing) Democrat. In this sense, in Spain, Prado-Lorenzo et al. (2011) show that political competition improves cities' sustainability, while a leftist ideology has an inverse impact.

2.11 Conceptual Framework

The essential importance of developing a sustainable smart city in Penang, Malaysia, is the fundamental basis of this research. The research was designed to meet the aim and objectives of identifying the key enablers of smart cities with the mediating effect of ICT applications in the development of sustainability of smart city. The study identified five key enablers of smart cities, which are supported by both theoretical and practical considerations. Along with these five key enablers of smart cities, ICT applications have been identified as a mediating factor which will ensure strengthen the research framework by successfully implementing the key enablers of smart cities. The aim of this research is not just to tackle a research gap, but also to contribute to practice. In that perspective, for this approach to be implemented by city councils/municipals, key enablers and ICT applications are necessary. In practical terms, the research framework establishes a framework that can be applied.

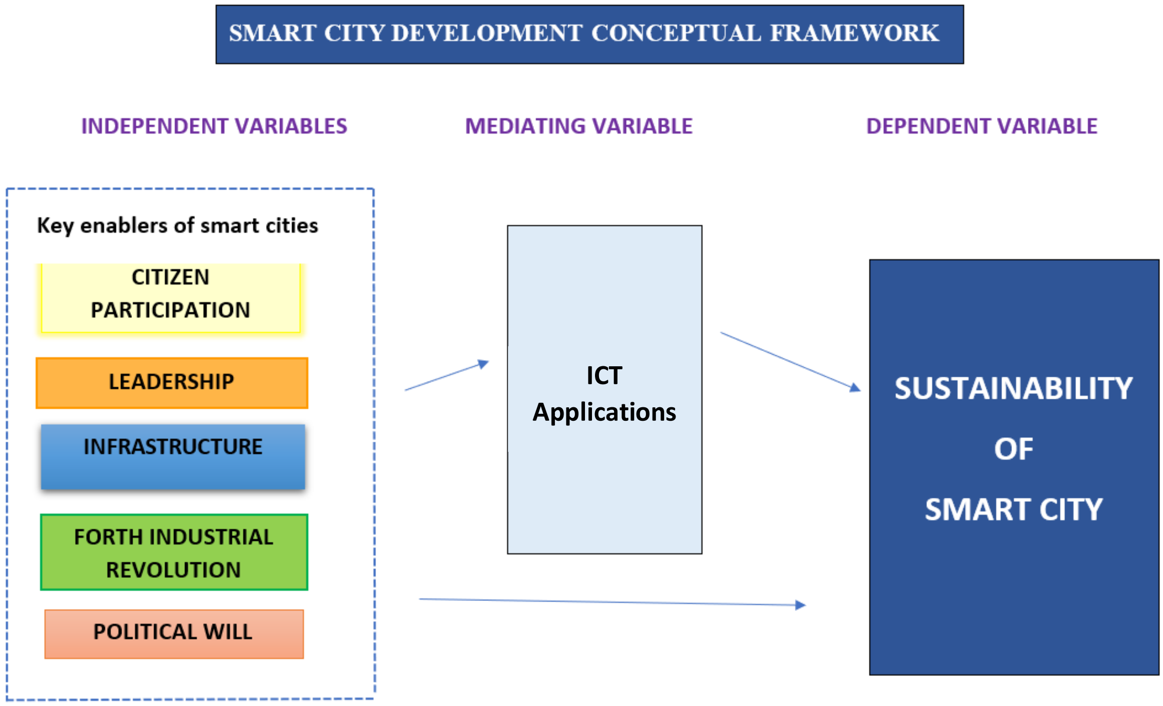


Figure 4: Smart City Development Conceptual Framework

2.11.1 Hypothesis Development

Ha_1: There is a positive relationship between key enablers of smart city and ICT applications.

$Ha_{1.1}$: There is a positive relationship between citizen participation and ICT Applications

$Ha_{1.2}$: There is a positive relationship between leadership and ICT Applications

$Ha_{1.3}$: There is a positive relationship between infrastructure and ICT Applications

$Ha_{1.4}$: There is a positive relationship between fourth industrial revolution and ICT Applications

$Ha_{1.5}$: There is a positive relationship between political will and ICT Applications

Ha_2: There is a positive relationship between key enablers of smart city and sustainability of smart city.

$Ha_{2.1}$: There is a positive relationship between citizen participation and sustainability of smart cities

$Ha_{2.2}$: There is a positive relationship between leadership and sustainability of smart cities

$Ha_{2.3}$: There is a positive relationship between infrastructure and sustainability of smart cities

$Ha_{2.4}$: There is a positive relationship between fourth industrial revolution and sustainability of smart cities

$Ha_{2.5}$: There is a positive relationship between political will and sustainability of smart cities

Ha_3: There is a positive relationship between ICT applications and sustainability of smart city

Ha_4: Model fit relationship of key enabler of smart cities and sustainability of smart city mediated by ICT applications

$Ha_{4.1}$: There is a positive relationship between citizen participation and sustainability of smart cities mediated by ICT applications

$Ha_{4.2}$: There is a positive relationship between leadership and sustainability of smart cities mediated by ICT applications

$Ha_{4.3}$: There is a positive relationship between infrastructure and sustainability of smart cities mediated by ICT applications

$Ha_{4.4}$: There is a positive relationship between fourth industrial revolution and sustainability of smart cities mediated by ICT applications

$Ha_{4.5}$: There is a positive relationship between political will and sustainability of smart cities mediated by ICT applications

2.12 Conclusion of the literature review.

After conducting an extensive literature review on the key enablers influencing the sustainable development of Smart Cities, with a specific focus on Penang, Malaysia, several critical insights have emerged.

First and foremost, it is evident that Information and Communication Technology (ICT) infrastructure forms the backbone of any Smart City initiative. Robust and well-integrated ICT application systems are essential for enabling the seamless operation of various technologies, including the Internet of Things (IoT), artificial intelligence, and data analytics. This technological foundation is indispensable for optimizing urban processes, enhancing citizen services, and achieving sustainability goals.

Furthermore, governance frameworks and regulatory safeguards are identified as crucial factors in the successful implementation of Smart City projects. Clear policies, development strategies, and regulatory norms provide the necessary guidelines for effective urban planning and management. Moreover, they instil confidence among citizens and stakeholders, addressing concerns related to data privacy, security, and ethical use of technology.

Open data initiatives also emerge as a pivotal enabler for Smart Cities. By making public data readily available and accessible, cities can foster transparency, accountability, and innovation. Open data encourages citizen engagement, enables collaborative problem-solving, and supports the development of citizen-centric applications and solutions.

In addition, the involvement of stakeholders, including citizens participation, businesses, and government agencies, is emphasized as a key driver for sustainable Smart City development. Engaging these diverse groups in the planning, decision-making, and implementation processes ensures that projects are aligned with the needs and aspirations of the community.

Environmental considerations and the adoption of green technologies are central to the sustainable development of Smart Cities. Incorporating energy-efficient solutions, renewable energy sources, and eco-friendly infrastructure not only reduces environmental impact but also contributes to economic savings and enhanced quality of life for residents.

In conclusion, the literature review underscores that a holistic approach, integrating technological innovation, effective governance, stakeholder engagement, and environmental consciousness, is paramount for driving the sustainable development of Smart Cities. The case study of Penang, Malaysia, within this context, presents a valuable opportunity to apply these key enablers in a real-world urban setting, paving the way for a more sustainable and resilient future. However, it is essential to recognize that the dynamic nature of Smart City development requires continuous adaptation, learning, and responsiveness to emerging challenges and opportunities.

CHAPTER III: RESEARCH METHODOLOGY

3.0 Introduction

Research methodology is the path through which researchers need to conduct their research. It shows the path through which these researchers formulate the problem and objective and present their result from the data obtained during the study period. This research design and methodology part also shows how the research outcome at the end will be obtained in line with meeting the objective of the study. This chapter hence discusses the research methods that were used during the research process. It includes the research methodology of the study from the research strategy to the result dissemination.

For emphasis, in this section of the research, the researcher outlines the research strategy, research design, research methodology, the study area, data sources such as primary data sources and secondary data, population consideration and sample size determination such as questionnaires sample size determination and workplace site exposure measurement sample determination, data collection methods like primary data collection methods including data collection through questionnaires, data collection tools pre-test, secondary data collection methods, methods of data analysis used such as quantitative data analysis, data analysis software, the reliability and validity analysis of the quantitative data, inclusion criteria, ethical consideration and dissemination of result and its utilization approaches.

In order to satisfy the objectives of the study, a quantitative research method is apprehended in general. The study used these strategies because the data were obtained from specific aspects of the data source during the study time. Therefore, the purpose of this methodology is to satisfy the research plan and target devised by the researcher.

To address the key research objectives, this research used the quantitative methods and combination of primary and secondary sources. The result obtained delude from the quantitative data. The study area, data sources, and sampling techniques were discussed under this section.

3.1 The Study Area

According to Fraenkel and Warren (1996, 2002, 2012), population refers to the complete set of individuals (subjects or events) having common characteristics in which the researcher is interested. The population of the study was determined based on random sampling system. This data collection was conducted from April 2022 to September 2022, in Penang. The respondents were selected based on the level of sustainability and connectivity (ICT Influence).

3.2 Research Approach

Research approaches are plans and the procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation. The selection of a research approach is also based on the nature of the research problem or issue being addressed, the researchers' personal experiences, and the audiences for the study. For this research paper, the researcher has developed hypothesis which were derived from the proposition of the theories as well enabled to develop an initial conceptual framework.

3.2.1 Quantitative Research – Selected Approach of the Research

The quantitative Research is an approach for testing objective theories by examining the relationship among variables that are enablers of developing sustainable smart city. These variables, in turn, are measured, and collected through survey questionnaire of 10-point Likert scale, so that numbered data can be analysed using statistical procedures. This research paper has a set structure consisting of introduction, literature and theory, methods, results, and discussion.

3.3 Research Design

The research design is intended to provide an appropriate framework for the study. A very significant decision in research design process is the choice to be made regarding research approach since it determines how relevant information for a study will be obtained; however, the research design process involves many inter-related decisions. This study employed a survey method. The study consisted of a series of well-structured questionnaires for management, focus group people, and technician involved municipal, city council and government bodies. Participants were informed that their participation in the survey was voluntary and free-willed, and they could choose to not answer or dropout from the participation in the survey.

This study adopts the quantitative method. Here data will be obtained using a scientific approach and will provide more accurate result. Thou it can be time consuming to collect data through this method, yet it will be more accurate in providing results. This analysis would be quantitative in reporting factual information on publications by presenting trends and comparative analysis. The procedure for data collection and analysis will be conducted rigorously using SPSS software.

Hence, this study employs a descriptive research design; Saunders et al. and Miller say that descriptive research portrays an accurate profile of persons, events, or situations. This design offers to the researchers a profile of described relevant aspects of the phenomena of interest from an individual, organizational, and industry-oriented perspective. Therefore, this research design enabled the researchers to gather data from a wide range of respondents on the key enablers influencing sustainable development of smart city

3.3.1 Quantitative Designs

One type of nonexperimental quantitative research is causal-comparative research in which the researcher compares two or more groups in terms of a cause (or independent variable) that has already happened. Another nonexperimental form of research is the correlational design in which investigators use the correlational statistic to describe and measure the degree or association (or relationship) between two or more variables or sets of scores (Creswell, 2012). These designs have been elaborated into more complex relationships among variables found in techniques of structural equation modelling, hierarchical linear modelling, and logistic regression. More recently, quantitative strategies have involved complex experiments with many variables and treatments (e.g., factorial designs and repeated measure designs). They have also included elaborate structural equation models that incorporate causal paths and the identification of the collective strength of multiple variables. In this research, focus will be survey.

3.3.1.1 Survey research

The Survey Research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population. It includes cross-sectional and longitudinal studies using questionnaires for data collection—with the intent of generalizing from a sample to a population (Fowler, 2008).

3.3.3.1 Justification of Choosing Quantitative Method Design

Quantitative methods approach was selected to help the researcher to make collection of data using questionnaire, it aids to test the actual state of the phenomenon to come up with generalized conclusion. Yet it is also important to state that the quantitative method is exempt of biasness as the result are based on evidence coming from the scientific analysis. The basis of the research will focus on inquiry on the assumption that collecting diverse types of data best provides a more complete understanding of a research problem. The study begins with a broad survey in order to generalize results to a population.

3.4 Population and Sampling Method

3.4.1 Research Population

According to research undertaken by the Malaysian government (2014), Touristic locations are the most important actor regarding Smart City development. An active government forms the basis of this development, both in a facilitating and initiating role (Slegh, 2013). Some of the most tasks for Smart City development, such as making zoning plans and planning infrastructure, lay with the municipality (Rijksoverheid, 2014). Furthermore, municipalities are important because they can initiate public-private cooperation at the local level. These cooperatives are important for sustainable Smart City development. This research includes State Government, Local Government Department and municipalities and city councils IT Department in Penang, as actors/stakeholders in developing a sustainable smart city.

3.4.2 Sampling

There are numerous methods for determining the required sample size; however, the population for this study is unknown, and there is no prior evidence of similar research in this area or the development of a smart city in Penang, Malaysia. As a result, the formula technique was used, whereby the Cochran Formula, to calculate the required sample size for the required level of precision, confidence level, and anticipated proportion of the attribute present in the population (Miaoulis and Michener, 1976).

Cochran's formula is found to be most ideal for a large population where the researchers can tailor the sample size based on the precision type and the type of research (Nanjundeswarasmy & Divakar, 2021). This research consider a sample size was identified as 196 with 95% confidence level, 0.5 standard deviation and margin of error of +/- 7%.The researcher distributed 350 responses, with an expected outcome of over 56% response rate, which is highly acceptable in the field of academic research, At the end of the survey, researcher did manage to meet the expected outcome by achieving 270 participants, resulting in a healthier 73% percentage. However, 6 participants provided information in parts of the survey, resulting the completed response from participants ended up to 264 from 350 respondents, which a success response rate of 74%.

This sample size provides a well-rounded representation of the various stakeholder groups involved in the Smart City development process. The target population for the survey are the managerial position (senior manager, managers) with at least 3 years' experience and involved in city-related, smart city-related planning and projects.The respondents were further stratified based on different criteria including age, occupation, level of technological proficiency, and level of involvement in Smart City initiatives, ensuring a balanced representation of opinions and insights. As such, an even distribution across these criteria, the sample composition includes 40% of local authorities, 20% of local government, 20% of urban planners and 20% of Technology experts.

The main aim of this distribution was to capture different perspectives ranges and expertise which are relevant to Smart City development in Penang, Malaysia. With this sample size and composition, the study had the opportunity of gathering a comprehensive dataset for a detailed analysis of the key enablers contributing to the sustainable development of Smart Cities in the context of Penang, Malaysia.

3.4.2.1 Non-Probability Sampling

Non-probability sampling is where the samples for a study are gathered in a process that does not give all the individuals in the population equal chances of being selected.

For most cases it is associated to the case study design as well as the qualitative research. Case studies which tend at focussing on very small samples while examining phenomena in real life situation, not like it is the case with statistical inferences which has a much wider population (Case study research, design and methods, Newbury Park, CA, Sage, 2003). The non-probability sampling includes four main methods: the convenience, judgemental, the quota and snowball methods.

However, for this study, the researcher adopted non-probability sampling for quantitative research, as researcher has chosen participants that have specific expertise and insight regarding development of sustainable development of smart city in Penang, Malaysia. The target population for the survey are the set of people involved in city-related, smart city-related planning and projects, as their views are specifically meeting the criteria of the development of a smart city. Researcher mitigate the potential biases arising from the sampling method by selecting participants at random. This way, the set of people (in the municipal : IT department, planning department, local government department) has an equal chance of being included in the sample group.

Further, to address any potential social desirability bias or acquiescence bias, researcher has designed questions neutral manner (general and narrow in) without negative connotation, communicated and emphasized on anonymity. As a result, when respondents understand that their data collection and questionnaire responses will not be linked to their names or any other aspects of their identity, they may be more likely to react honestly rather than favourably. The disclaimer was expressed and included at the top of the questionnaire when it was given to remind participants of the importance of confidentiality and anonymity.

3.4.2.1.1 Purposive Sampling

Purposive sampling is a non-probability sampling technique that is commonly used in qualitative research, similarly for this quantitative research, it is used as researcher selected specific participants who possess particular characteristics or experiences relevant to the research study. In the context of this study and as stated in literature review on "Key Enablers Influencing Sustainable Development of Smart City: Penang, Malaysia," purposive sampling has been employed in several ways:

Case Studies: If the research included specific case studies of Smart City projects in Penang, Malaysia, the selection of these case studies may have been purposeful. They would likely have been chosen to represent a diverse range of projects, each with unique characteristics and challenges relevant to the study.

Stakeholder Selection: In the examination of stakeholders in Smart City development, certain key stakeholders were chosen purposefully based on their roles and influence in the development process. These include to municipalities IT Department, Local Government, and citizens.

Specific Demographic Groups: If the study considered the perspectives of specific demographic groups (e.g., urban residents, professionals, policymakers), participants may have been purposefully selected to ensure representation from these groups. For example, residents from different neighborhoods or professionals from different sectors may have been included.

3.5 Research Instrument

The instrument that is being used in this research is a questionnaire.

3.5.1 Questionnaire Construction

The questionnaire survey is the collection method that is being use in this research to collect data. Respondents linked to municipalities IT Department, Local Government, and users will be consulted through a questionnaire.

Researcher will apply both primary and secondary data to arrive to final results of the study (Flick & U., 2011). The aim of the study is to examine the impact of key enablers with ICT in the development of a sustainable smart city in Penang.

- Sustainability strategy - Adapted from Mauro Romanelli, (2017)
- Key enablers/ Determinant Factors in Smart City Development – Adapted from Seunghwan Myeong, Yuseok Jung and Eunuk Lee (2018)

Before questionnaire handed to the participants, questions will be asked to identify qualified participants for the survey base on the number of years of experience (at least 3 years' experience), participant to hold managerial position and involved in city-related, smart city-related planning and projects). The questionnaire will first be sent to test people involved in Smart City development during the pilot test, which may lead to some small changes in the way the questions to be asked. The Local Government Department will help distribute the questionnaires. This department is a platform that brings together different actors involved in Smart City development and focuses mostly on the role of municipalities but also tried to involve business organisations and research units.

Table 9: Previous Research Sources of the Questionnaire Construction Development

Section	Variables	No of Items	Authors
Section A	**Demographic**	**4**	
Section B	**Sustainable Development of Smart City**	**13**	
Section C	**Mediating Variable: ICT Applications**	**8**	Determinants of open innovation adoption in public organizations: a systematic review Ben De Coninck, Mila Gascó-Hernández, Stijn Viaene & Jan Leysen, Public Management Review, (Ben De Coninck, et al., 2023) Torfing, Jacob. "Collaborative Innovation in the Public Sector: The Argument." Public Management Review 21 (1): 1–11. (Torfing, 2021) Yongdong Shen, Yuan (Daniel) Cheng & Jianxing Yu (2023) Evrim Tan & A. Paula Rodriguez Müller (2023)
Section D	**Independent Variable 1: Citizen Participation**	**7**	Kupriyanovsky V, Bulancha S, Kononov V, Chernykh K, Namiot D and Dobrynin A, International Journal of Open Information Technologies 4 (2) 41–52 (Kupriyanovsky V, et al., 2016) Pshenichnikov V and Babkin V, Quality Management, Transport and Information Security, Information Technologies", IT and QM and IS 267–273 (Pshenichnikov V V & Babkin A V, 2017) Anton Safiullin 1*, Lyudmila Krasnyuk 2 , Zoya Kapelyuk 3, Integration of Industry 4.0 technologies for Integration of Industry 4.0 technologies for "smart cities" development IOP Conf. Series: Materials Science and Engineering 497 (2019) 012089 (Anton Safiullin, et al., 2019)
Section E	**Independent Variable 2: Leadership**	**5**	Alessandro Sancino and Lorraine Hudson, Leadership in, of, and for smart cities – case studies from Europe, America, and Australia, Public Management Review (Alessandro Sancino & Lorraine Hudson, 2020) Acuto, M., S. Parnell, and K. C. Seto. 2018. "Building a Global Urban Science." Nature Sustainability 1 (1): 2 (Acuto, M., et al., 2018) Angelidou, M. 2017. "The Role of Smart City Characteristics in the Plans of Fifteen Cities." Journal of Urban Technology (Angelidou, 2017) Bryson, J. M., L. H. Edwards, and D. M. Van Slyke. 2018. "Getting Strategic about Strategic Planning Research." Public Management Review (Bryson, J. M., et al., 2018)
Section F	**Independent Variable 3: Infrastructure**	**6**	Giorgia Nesti & Paolo Roberto Graziano, Public Management Review; The democratic anchorage of governance networks in smart cities: an empirical assessment (Giorgia Nesti & Paolo Roberto Graziano, 648-667) Krista Timeus, Jordi Vinaixa & Francesc Pardo-Bosch, Public Management Review, "Creating business models for smart cities: a practical framework" (Krista Timeus, et al., 2020) Lihi Lahat & Regev Nathansohn, Challenges and opportunities for equity in public management: Digital applications in multicultural Smart cities, Public Management Review (Lihi Lahat & Regev Nathansohn, 2023)
Section G	**Independent Variable 4: 4th Industrial Revolution**	**6**	Giuseppe Grossi, Albert Meijer & Massimo Sargiacomo, A public management perspective on smart cities: 'Urban auditing' for management, governance and accountability, Public Management Review (Giuseppe Grossi, et al., 2020) Carlos Ferreira, Kevin Broughton, Kate Broadhurst & Jennifer Ferreira, Collaborative innovation in a local authority – 'local economic development-by-project'? Public Management Review (Carlos Ferreira, et al., 2020)
Section H	**Independent Variable 5: Political Will**	**5**	**Edouard Geffary and Jean-Bernard** Auby, "The political and legal consequences of smart cities", *Field Actions Science Reports* [Online], Special Issue 16 | 2017, Online since 01 June 2017, connection on 14 December 2023. URL: http://journals.openedition.org/factsreports/4281 (Auby, 2017) Giorgia Nesti & Paolo Roberto Graziano, The democratic anchorage of governance networks in smart cities: an empirical assessment, Public Management Review, (Giorgia Nesti & Paolo Roberto Graziano, 2020) Ben De Coninck, Mila Gascó-Hernández, Stijn Viaene & Jan Leysen; Determinants of open innovation adoption in public organizations: a systematic review (Ben De Coninck, et al., 2023)

Further other factors such as language is considered while developing the research instrument. The questionnaire was written in English, which is a mutually understood language and the medium of communication in Malaysia. Moreover, questions are designed to be clear and simple to understand.

3.5.2 Measurement

Measurement is a process of assigning numbers to some characteristics or variables or events according to scientific rules. It is the process observing and recording the observations that are collected as part of a research effort. Measurement means the description of data in terms of numbers – accuracy, objectivity, and communication. The combined form of these three is the actual measurement.

Accuracy: The accuracy is as great as the care and the instruments of the observer will permit.

Objectivity: Objectivity means interpersonal agreement. Where many persons reach agreement as to observations and conclusions, the descriptions of nature are more likely to be free from biases of particular individuals.

Communication: Communication is the sharing of research between one person with another one.

3.5.3 Scaling of Measurement

3.5.3.1 The advantages of using 10-point Likert scale

A 10-point scale was preferred as it gives a wider distribution of scores around the mean for more discriminating power. The enhanced discriminating power enables more reliability to isolate respondents into various respondent learner categories (Allen & Rao, 2000).

Furthermore, it offers more variance than a smaller Likert scale e.g., 7-point or 5-point Likert scales. In addition, it offers higher degree of measurement precision; hence it increases accuracy.

Besides that, 10-point Likert scales provides better opportunity detect changes and more power to explain a point of view. 10-point Likert scale can improve measurement reliability, reduced multicollinearity problems and minimized skewness in the distribution of the data (Wittink and Bayer,2003).

Theoretically, a larger scale offers greater variability of responses, and it is easier to defend the use of these type of statistical procedures. An even number scale rather than an odd number, you get the samples opinion towards negative or positive. Lastly, a 10-point scale allows the establishment of covariance between two variables with greater dispersion around their means. This covariance was critical to establish strong multivariate dependence models used in key indices assessments, as this research analysis uses the structural equation modelling package (AMOS software). When using the structural equation modelling for data analysis, data with five or fewer point scale was usually assumed as an ordinal scale.

3.5.3.2 Measuring Scale Rationale

The ten-point interval scale commonly used in most survey research was applied in this research, which ranges from 1 to 10 with 1 representing strongly disagree to 10 representing strongly agree. This 10-point scale was preferred as it gives a wider distribution of scores around the mean for more discriminating power. The enhanced discriminating power enables more reliability to isolate respondents (Allen & Rao, 2000) into various learner categories. Besides this reason, the 10-point scale allows the establishment of covariance between two variables with greater dispersion around their means. This covariance was critical to establish strong multivariate dependence models used in key indices assessments, as this research analysis uses the structural equation modelling package (AMOS software). When using the structural equation modelling for data analysis, data with five or fewer point scale was usually assumed as an ordinal scale (Allen & Rao, 2000).

3.5.3.3 Justification of Choosing Likert Scaling

A Likert scale is a psychometric scale commonly used in questionnaires and is the most widely used scale in survey research. When responding to a Likert questionnaire item, respondents specify their level of agreement to a statement. The scale is named after its inventor, psychologist Rensis Likert. The Likert scale can also be used to measure attitudes of people. When responding to a Likert questionnaire item, respondents specify their level of agreement or disagreement on a symmetric agree-disagree scale for a series of statements.. Often five ordered response levels are used, although many psychometricians advocate using seven or ten levels. For this study, the researcher used a 10-point Likert scale to eliminate central tendency bias and yield a more responsible response. Many experts say that there is no substantial difference in the outcomes of 5 or 10 point scales (Dawes, 2008); however, an empirical study by Taherdoost (2019) validates that increasing the number of scale points improves both the reliability and validity of responses. Apart for demographics, all questions employed a bi-polar 10 likert-type scale with the generally used phrasing of "strongly disagree to strongly agree".

3.5.4 Validity

One of the primaries aims of this research paper was to guarantee that the measurement tools used in the research accurately and successfully measured the desired research concept and construct.

To develop the theoretical Construct, the researcher applied both face validity and content validity in this research. Face validity is the most commonly used form of validity, particularly in developing nations (Sangoseni et al, 2013). To maintain face validity, the researcher reviewed the questionnaire items and arranged them such that the measuring items correspond to and measure the conceptual domain and the intended aims of this study. Furthermore, the pilot study provided the researcher with adequate time to assess how respondents perceive the questions, which helped assure the questionnaire's applicability.

The content validity of the questionnaire has been established, ensuring that the content all relevant factors influencing development of sustainability of smart city. The content was than reviewed and after the needful changes was done; then the questionnaire was validated by Dr Vikineswaran Maniam, lead supervisor prior to the pilot study to ensure that the questionnaire effectively aims to identify the key enablers influencing the development of sustainability of smart city as well as leveraging on ICT applications for the city of Penang, Malaysia..

In addition, Construct validity was applied to ensure that the measurement is accurately capturing into the relevant concepts (Saunders, et. Al., 2009). Researchers make certain the measurement items were carefully developed according on existing knowledge. DeVellis (2003) recommends using validated measurement concepts to ensure construct validity. Following this suggestion, Table 8 shows the sources of previous studies on the enablers influencing smart city development and the impact of ICT applications, which were considered when developing the research instrument. Therefore, it was ensured that the measurement items included effective aspects influencing smart city development based on past research and the questionnaire only asked pertinent questions to establish construct validity.

3.6.5 Reliability

To conduct the pilot test, the researcher selects a small sample of 20 employees who are employees of the IT department to elucidate the importance of and priorities in developing smart city, for the State Government of Penang, Malaysia. It was sent through an emailed questionnaire and provide direct feedback in the duration of approximately a week from 01 March 2022 and received by 07 March 2022.

The 2nd week onwards, the corrective action will be taken to revise the wordings of the items to improve the readability, applicability, understandability, operation ability and content validity. Once that is done, the researched will proceed with actual data collection using electronic means - Google forms. To ensure participants completed the survey via the google forms, a follow-up to be conducted.

After the pilot test, the researcher analyses the responses and examines the results as well as pay close attention to several key aspects.

Clarity of Questions: The researcher assesses whether the questions are clear, easy to understand, and unambiguous for the participants. Any confusing or misleading questions are identified.

Relevance of Items: The researcher evaluates whether the items in the questionnaire are relevant to the research objectives. Irrelevant or redundant items may need to be revised or removed.

Response Patterns: The researcher observes how participants respond to different items. This helps identify any patterns or biases in the data that may need to be addressed.

Time Taken: The researcher notes the time taken by participants to complete the survey. This provides insights into the feasibility of data collection in the main study.

Feedback from Participants: The researcher solicit feedback from participants about their experience in completing the survey. Participants' comments and suggestions are invaluable for refining the questionnaire.

Based on the findings from the pilot test, the researcher makes necessary revisions to the survey questionnaire. The researcher rephrases unclear questions and eliminate redundant items. By conducting this pilot test, the researcher ensures that the survey instrument is valid, reliable, and well-suited for gathering data on enablers of developing sustainable smart city. In this research paper specifically the State of Penang, Malaysia.

The present research used the SPSS statistic to analyse the data obtained from the survey questionnaire. The statistical and analysis performed will consist of Descriptive Statistics, Factor Analysis, Correlation Analysis and Regression Analysis. Lastly report writing, result interpretation and data analysis will be conducted based on the reports generated from the SPSS statistical software. This software provide result that can be reproduce again and again under same situation if same data are being produce. Thus, the consistency in obtaining same result translate about the reliability of the data.

This pilot study sample represented the diversity of the city's population in terms of age, occupation, and socio-economic status. The participants of the pilot study were from different level of position/ activity sector and age. Below graphs shows general profile of the participants from the pilot study:

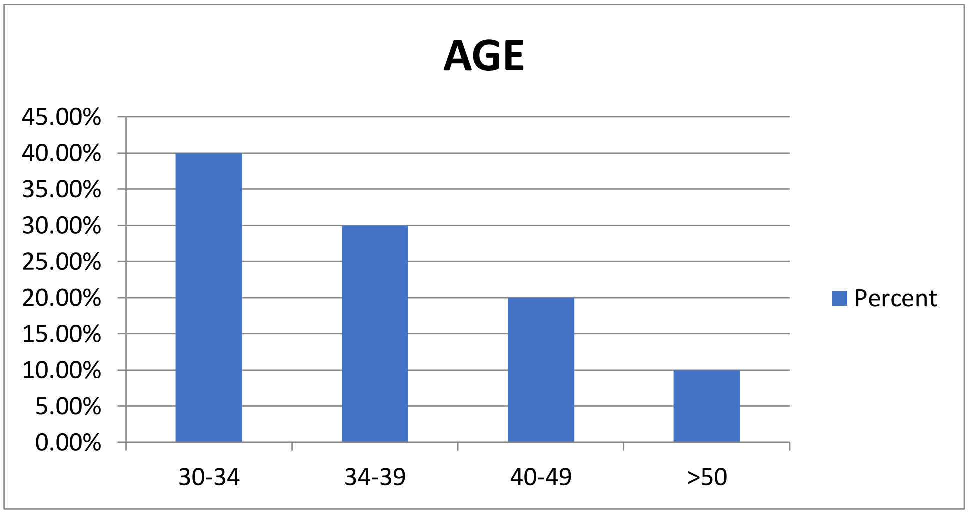


Figure 5: Pilot Test Age

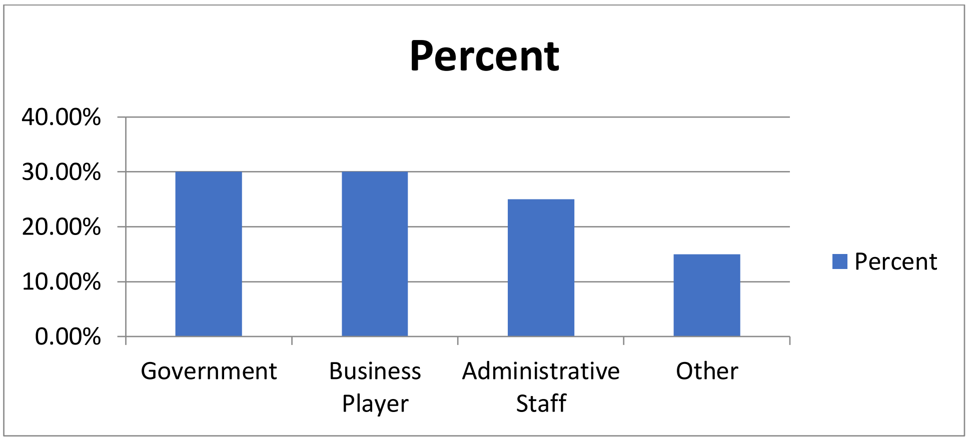


Figure 6: Pilot Test Activity Sector

3.6.5.1 Reliability Test Results

The reliability of the survey questionnaire was assessed using Cronbach's alpha coefficient, a widely used measure of internal consistency. The analysis was conducted on responses obtained from a sample of 20 respondents of Penang, Malaysia.

The overall Cronbach's alpha for the survey questionnaire was found to be 0.76. This indicates a high level of internal consistency among the items, suggesting that the questionnaire reliably measures the construct of enablers in the context of sustainable Smart City development.

Furthermore, the alpha coefficients for individual sections of the questionnaire were as follows:

Table 10: Reliability Test Results

Section	Variables	Cronbach's Alpha
Section B	Sustainable Development of Smart City	0.80
Section C	Mediating Variable: ICT Applications	0.78
Section D	Citizen Participation	0.81
Section E	Leadership	0.79
Section F	Infrastructure	0.82
Section G	Forth Industrial Revolution	0.79
Section H	Political Will	0.81
Overall	For all variables: (Section B – Section H)	0.76

These results indicate that each section of the questionnaire demonstrates good internal consistency. The high alpha coefficients suggest that the items within each section are correlated and measure a coherent aspect of satisfaction of the enablers with development of smart city

Overall, the reliability test results provide confidence in the survey instrument's ability to yield consistent and dependable data on the satisfaction levels with regard to the enablers with ICT applications within the context of development of sustainable smart city.

3.7 Data Collection

3.7.1 Justification: Selection of Primary Data

Keeping in view the advantages and disadvantages of sources of data requirement of the research study and time factor, the main source of data collection is the primary data. Because it will be specific and relevant in bringing accuracy to the subject matter (Flick & U., 2011). Despite its time-consuming nature, it is relevant to bring about more details and accuracy regarding the particular research and context of the research study.

Having the focus at the main aim of this study which is to examine the impact of key enablers with ICT applications in the development of a sustainable smart city in Penang.

- Sustainability strategy - Adapted from Mauro Romanelli, (2017)
- Key enablers/ Determinant Factors in Smart City Development – Adapted from Seunghwan Myeong, Yuseok Jung and Eunuk Lee (2018)
- ICT from (Francesco Bifulco, Marco Tregua, Christina Caterina Amitrani & Anna D'Auria, 2015)

3.7.2 Collection Process

The researcher approached the survey participants through her professional network. The goal of the survey and how confidentiality will be maintained were explained to the participants. The survey request was well received.

The respondents were given the link to the Google form. The researchers sent out multiple reminders, which helped the researcher get a high response rate. The data collection was started on 11 April 2022 and was collected during 21 weeks of time ending on 12 September 2022.

Over this time, researcher engage various departments involved in the ICT applications and development of sustainable smart city.

Table 11: List of Participant Department

1	Office of Executive Council (EXCO) for Housing, Town & Country Planning and Local Government
2	Office of Executive Council (EXCO) for Infrastructure, Transport and Digital
3	Local Government Department
4	Department of State Information and Communication Technology
5	Department of Development Planning, Penang Island City Council
6	City Planning Department, Seberang Perai City Council
7	Information and Communication Technology Department, Seberang Perai City Council

3.8 Data Analysis Methods

3.8.1 Multivariate Analysis

Researcher performed the simple and multiple regression analysis.

3.8.1.1 Research Objectives Measurement

The following measurement tools were used to analyse and measure the research objectives.

Research Objective 1:

The relationship between the key enablers of smart city and ICT applications in the context of developing sustainability of Smart City.

<u>Measurement:</u>

Correlation was used to measure the following relationship:

(a) Among the key enablers and Development of Sustainable Smart City
(b) Key enablers and ICT applications and
(c) ICT applications and Development of Sustainable Smart City

Further, measure the perception on the key enablers affecting development of sustainable smart city in the Penang, Malaysia.

<u>Measurement:</u>

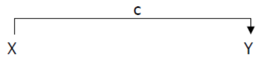
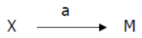
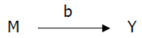
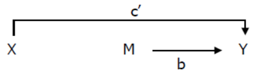
Simple regression was used to measure the perception on the key enablers affecting development of sustainable smart city, in Penang, Malaysia.

Research Objective 2:

Whether or not ICT applications is a mediating variable for the relationship of the independent variables and Development of Sustainable Smart City.

<u>Measurement:</u>

Table 12: Analysis

	Analysis	*Visual Depiction*
Step 1	Conduct a simple regression analysis with X predicting Y to test for path *c* alone, $Y = B_0 + B_1X + e$	
Step 2	Conduct a simple regression analysis with X predicting M to test for path *a*, $M = B_0 + B_1X + e$.	
Step 3	Conduct a simple regression analysis with M predicting Y to test the significance of path *b* alone, $Y = B_0 + B_1M + e$.	
Step 4	Conduct a multiple regression analysis with X and M predicting Y, $Y = B_0 + B_1X + B_2M + e$	

Research Objective 3:

Whether or not ICT applications has a positive influence on Development of Sustainable Smarty City in the Penang, Malaysia.

<u>Measurement:</u>

Correlation test was used to measure the relationship between ICT applications and development of sustainable smart city.

Multiple regression was used to identify the key enablers of developing sustainable smart city, in Penang, Malaysia.

Research Objective 4:

The fitness of the development of sustainable smart city model among key enablers, ICT applications and development of sustainable smart city in Penang, Malaysia.

<u>Measurement:</u>

Multiple regression was used to test fitness of the development of sustainable smart city model among key enablers, ICT applications and development of sustainable smart city in Penang, Malaysia.

3.8.2 Findings of Pearson R co relation

3.8.2.1 Pearson Correlation

The Table 13 below shows that the correlation values ranges are between .326 to .566. As per the result, there is no correlation values that has a value which is above 0.90 in therefore, it can be concluded that there is no multi-collinearity problem. Therefore, it can be concluded that there is a significance relationship between the variables.

Table 13: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.745[a]	.556	.326	.8115887

This strength of relationship, regardless or directions, was interpreted using the guidelines provided by Cohen (1988); thus, obtaining a result of .81 illustrate that there is a very high relationship among variables.

3.8.3 Sobel Test to Evaluate Mediation Effect

Sobel (1982) proposed this simple test statistic. Researcher test this hypothesis using the Sobel test, whereby a third variable mediates and influences the relationship between the independent (X) and dependent (Y) variables. The researcher used simple regression model formula and multiple regression analysis formula as shown in Table 12 above, to quantify the total relation between the variables without consideration of other variables.

There are 4 Steps in Mediating Analysis:

Step 1: Before proceeding with any regression and mediation analysis, it is essential to evaluate the data for normality of all variables.

Step 2 and Step 3: Now to establish there is a ground for mediation by confirming the following conditions:

(a) the independent variable (X) predicts the dependent variable (Y); that is, "c' is statistically significant.
(b) the independent variable (X) predicts the mediator (M); that is, "a" is statistically significant.
(c) the mediator (M) predicts; that is, "b' is statistically significant.

Step 4: Next, after confirming the conditions for mediation are established, researcher examine if the mediating variable is a statistically significant using the Sobel test, to determine both "a" and "b" unstandardized regression coefficients and their standard errors.

In other words, Sobel test examines whether the inclusion of a mediator (M) which is the ICT applications in this study in the regression analysis considerably reduces the effect of independent variable (the key enablers) on the dependent variable (development of sustainable smart city). The result of this study is that using ICT applications is mediator between key enablers and development of Sustainability of Smart City. It can be achieved that ICT Applications is positively related to Development of Sustainability of Smart City.

3.9 Ethical Considerations

The University of Wales Trinity Saint David's Research Ethics and Integrity Code of Practice is adhered by the research methodology used in this thesis. Before underrating any research activity, the university's Research Degree Committee approved the thesis' ethical standards, on the 31 March 2021. As per the university guideline ethical standard, the following ethical principles codes were addressed.

3.9.1 Honesty

Researcher strived for honesty in all scientific communications. Honestly report data, results, methods and procedures, and publication status. There will be no fabrication, falsification, or misrepresent of data.

3.9.2 Details of Research Activity

Ensured ethical approval on various aspects were obtained, which included:

(i) Research Aim, Purpose, and Research Objectives

(ii) Data Collection proposed start and end day

(iii) Research design, Data Collection proposed methods

3.9.3 Integrity

It was declared act with sincerity; strive for consistency of thought and action. Carefulness: Avoid careless errors and negligence; carefully and critically examining the work. Keep good records of research activities, such as data collection, research design, and correspondence with agencies or confidential information without the participant’s specific consent.

3.9.4 Openness

Share data, results, ideas, tools, resources. Be open to criticism and new ideas. Respect for Intellectual Property: Honour patents, copyrights, and other forms of intellectual property. Do not use unpublished data, methods, or results without permission. Give credit where credit is due. Give proper acknowledgement or credit for all contributions to the research. Never plagiarize.

3.9.5 Confidentiality

Protect confidential communications, such as anonymity of the participants was maintained. Participants were assured that their information will be kept in the utmost of confidentiality and that, in the event that it gets published, it won't be identified as being provided by them.

3.9.6 Data Protection and Storage

In the pursuit of understanding the critical factors influencing the sustainable development of Smart Cities in Penang, Malaysia, safeguarding the integrity and confidentiality of collected data is paramount. Rigorous measures have been instituted to guarantee the security of all gathered information. Firstly, all data, spanning responses from surveys, undergo encryption using industry-standard protocols. This protective measure ensures that data remains secure both during transit and while at rest. Furthermore, access to this sensitive information is restricted exclusively to authorized personnel actively involved in the research process. Access is fortified by unique login credentials, and stringent protocols are in place to forestall unauthorized access or potential data breaches.

Additionally, to fortify respondent privacy, any personally identifiable information (PII) such as name and contact details is either entirely removed or substituted with unique identifiers. This precautionary step precludes any individual from being identifiable based on their responses. The stored data itself is housed on a dedicated server, ensconced within a physically secure environment, and protected by password access. This server is fortified with firewalls, intrusion detection systems, and subjected to regular security updates to thwart any unauthorized entry.

All these data protection measures align with pertinent local and international data protection regulations, including GDPR (General Data Protection Regulation) and any applicable Malaysian data protection laws. Additionally, participants are furnished with transparent information regarding how their data will be utilized and stored. Informed consent is diligently obtained, and participants are assured that their responses will be treated with the utmost confidentiality. Through these stringent measures, this study not only ensures that the collected information is reliable and valid, but also underscores its commitment to upholding the highest standards of privacy and security. These collective measures contribute substantively to the overall trustworthiness and credibility of the research findings.

CHAPTER IV: RESEARCH FINDINGS

4.0 Introduction

4.1 Respondents Profile

4.1.1 Age

Table 14: Age

	Frequency	Percent	Valid Percent	Cumulative Percent
21-25	10	3.8	3.8	3.8
25-29	47	17.8	17.8	21.6
30-34	45	17.04	17.04	38.64
34-39	86	32.6	32.6	71.24
40-49	58	21.96	21.96	93.2
50 >	18	6.8	6.8	100

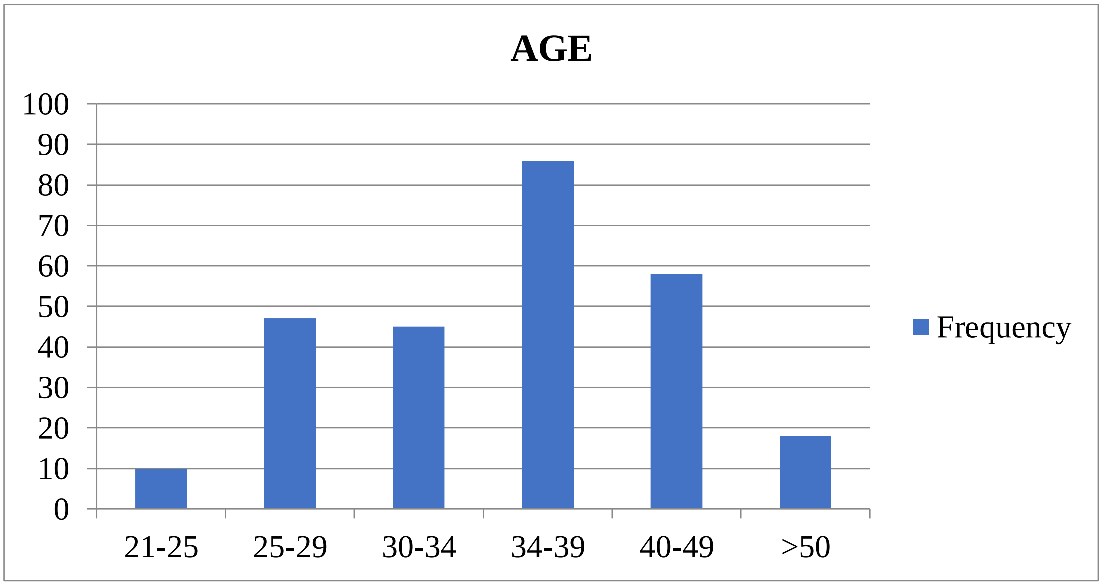


Figure 10: Age Breakdown

The respondents' Ages was divided in diverse groups which recorded each: 21-25 (3.8%), 25-29 (17.8%), 30-34 (17.04%), 34-39 (32.6%) 40-49 (21.96%) and 50 years and above (6.8%). This infer that the highest age category in this investigation is those comprise between 34 to 39 years old with 32.6% people that participated.

4.1.2 Activity Sector

Table 15: Activity Sector

	Frequency	Percent	Valid Percent	Cumulative Percent
Government	128	48.5	48.5	48.5
Business Player	38	14.4	14.4	62.9
Administrative Staff	81	30.7	30.7	93.6
Other	17	6.4	6.4	100

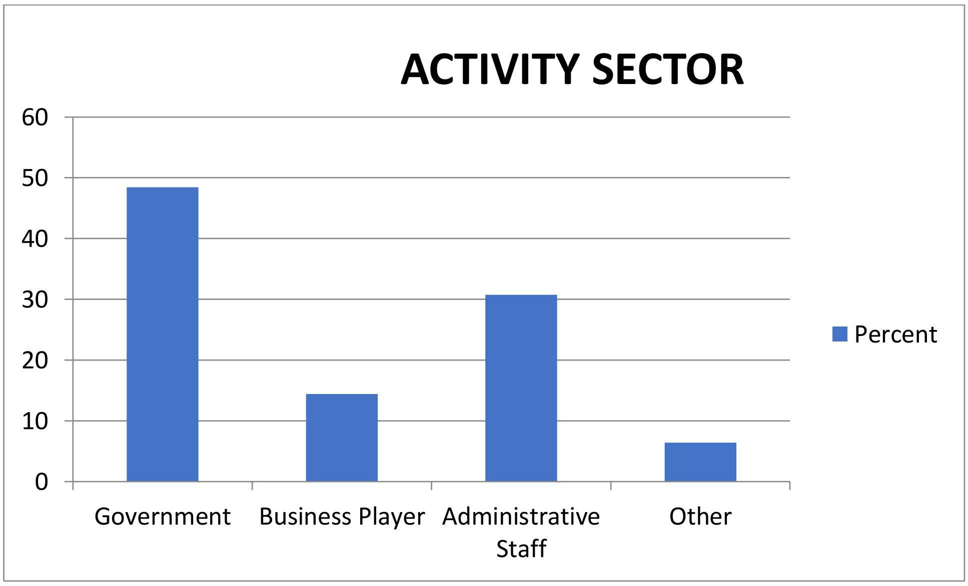


Figure 11: Activity Sector Breakdown

The figure 11 above infer that the sector of activity which were most represented in this investigation are the people from the government with 48.5%, followed by the administrative staff with 30.7%, the business player followed with 14.4% and other sector of activity were also represented with only 6.4%.

4.1.4 Smart City

Table 16: Understanding of Smart City

	Frequency	Percent	Valid Percent	Cumulative Percent
It is a city that uses information and communication technology (ICT) to improve operational efficiency.	28	10.6	10.6	10.6
It is a city that share information with the public and provide a better quality of government service and citizen welfare.	36	13.6	13.6	24.2
It is a city that makes optimal use of all the interconnected information available today to better understand and control its operations and optimise the use of limited resources.	7	2.7	2.7	26.9
All the Above	193	73.1	73.1	100

The table 16 above infer that the participant understanding of smart city is large. Over 73.1% of all participant support that all the statement proposes to define smart city are good. While 10.6% stated that smart city is a city that use ICT in other to improve operational efficiency while 13.6% stated that smart stated that smart city is a city sharing information with public and provide also provide a better quality of welfare as well as better quality regarding the government service. Meanwhile 2.7% of the participants stated that smart city is a city uses all interconnected information available in other to betterment the understanding as well as the control of their operation while also optimizing the utilization of limited resources.

4.2 Analysis to Measure the Research Objectives

4.2.1 Multivariate Analysis

In this research, the author established four specific objectives and measured these objectives, based on various statistical analyses to draw a valid conclusions and recommendations. For each objective different analysis have been performed.

Table 17: Correlation among the Independent Variables

	Citizen Participation	Leadership	Infrastructure	4th Industrial Revolution	Political Will
Citizen Participation	1	0.875**	0.885**	0.458**	0.676**
Leadership		1	0.745**	0.557**	0.755**
Infrastructure			1	0.850**	0.640**
4th Industrial Revolution				1	0.840**
Political Will					1
****Correlation is significant at the 0.01 level (2-tailed).**					

The table 17 above indicates that there is a positive relationship among all the independent variables. Citizen participation has a strong correlation with leadership (r=0.875) with Infrastructure as well with (r=0.885), while 4th Industrial revolution (r=0.458), Political will (r=0.676) also have a moderate to medium level of correlation with Citizen participation, all of them are statistically significant. The study identified that there is a moderate relationship between 4th Industrial revolution (r=0.557), Political will (0.755) and leadership, which remains statistically significant at the 1% level of significance. Notably, 4th Industrial revolution displays a strong correlation with Political Will (r=0.840).

4.2.2 Statistical Analysis for Research Objective 1: To determine the relationship between key enablers of smart city and ICT applications in the context of developing sustainability of smart city.

The research study here will evaluate the correlation analysis regarding research objectives of this research, which focused on examining the relationship between key enablers of smart city and the sustainable development of smart cities in Penang Malaysia. The research objective was divided into three distinct parts as follow:

a. The relationship between the key enablers of smart city and ICT applications
b. The relationship between the key enabler of smart city and development of sustainability of smart city and
c. The relationship between ICT applications and development of sustainability of smart city.

4.2.2.1 The relationship among Key enablers (IVs) and ICT Applications (MV)

The table below represent the correlation between the independent variable and mediating variable as represented in part (a) of the first research objective.

Table 18: Correlation between Mediating Variable and Independent variables

	Citizen Participation	Leadership	Infrastructure	4th Industrial Revolution	Political Will
ICT Applications	0.344**	0.322**	0.545**	0.445**	0.387**
****. Correlation is significant at the 0.01 level (2-tailed).**					

The table 18 above illustrate that Citizen Participation(r=0.344), Leadership (r=0.322), Infrastructure (r=0.545), 4th Industrial Revolution (r=0.445), and Political Will (r=0.387) demonstrate a weak positive relationship with the mediating variable, but it is not statistically significant.

The first alternative hypothesis of the study posited that "The independent variables have a positive relationship with ICT Applications." Based on the findings in Table 18, it is evident that all independent variables do indeed have a positive relationship with ICT Applications, which all of the variables show a statistical significance.

4.2.2.2 The relationship among Key enablers of smart city (IVs) and Development of sustainability of smart city (DV)

Correlation in Table 19 has been done for part (b) of the first objective (The relationship among the key enablers of smart city and Development of Sustainability of Smart City).

Table 19: Correlation between Dependent Variable and Independent variable

	Citizen Participation	Leadership	Infrastructure	4^{th} Industrial Revolution	Political Will
Sustainable Development of Smart City	0.544**	0.681**	0.894**	0.823**	0.754**
****. Correlation is significant at the 0.01 level (2-tailed).**					

Table 19 above represents the correlation existing between the dependent variable and the independent variables. The analysis reveals that there is a consistent positive relationship between all the independent variables and the dependent variable. Specifically, Citizen Participation displays a moderate relationship with the dependent variable (r=0.554). Additionally, Leadership (r=0.681) illustrate a moderate relationship while, Infrastructure (r=0.894) and 4^{th} Industrial Revolution (r=0.823) exhibit a high positive relationship, and Political Will (r=0.754) exhibit moderate relationships with the dependent variable.

The second alternative hypothesis of this study stated that "The independent variables have a positive relationship with the dependent variable." Based on the findings, it can be concluded that this hypothesis is supported, indicating a positive relationship between the independent variables and the dependent variable.

4.2.2.3 The relationship among ICT Applications (MV) and Development of Sustainability of Smart City (DV)

The table below represent the correlation table between the mediating variable and the dependent variable as represented in part (c) of the first research objective.

Table 20: Correlation between Dependent variable and Mediating Variable

	ICT Applications
Development of Sustainability of Smart Cities	0.355*
***. Correlation is significant at the 0.05 level (2-tailed).**	

Table 20 demonstrates a statistically significant weak positive relationship (r=0.355) between the Development of Sustainability of Smart Cities (dependent variable) and ICT Applications (mediating variable).

The third alternative hypothesis of the study stated that "Development of Sustainability of Smart Cities is positively influenced by ICT Applications." The findings from the correlation table support this hypothesis, indicating a positive and statistically significant relationship between the Development of Sustainability of Smart Cities (dependent variable) and ICT Applications (mediating variable). Therefore, the third alternative hypothesis is valid.

4.2.3 Statistical Analysis for Research Objective 2: The relationship between key enablers of smart city and development of sustainability of smart city

Hereby, conducting a regression analysis to assess the key enablers factor influencing Development of Sustainability of Smart City in Penang Malaysia.

Table 21: Model Summary for all Independent Variables without Considering Mediating Variable

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.792	0.627	0.489	0.98724	2.144
Predictors: (Constant), Citizen Participation, Leadership, Infrastructure, 4th Industrial Revolution, Political Will					
Dependent Variable: Development of Sustainability of Smart City					

The table 21 shows that Citizen Participation, Leadership, Infrastructure, Fourth Industrial Revolution, and Political Will, collectively account for 62.7% of the variance in and Sustainable Development of Smart City. Additionally, the Durbin-Watson statistic of 2.144, which is greater than 2, indicates the absence of autocorrelation.

Table 22: Multiple Regression analysis for all Independent Variables

Coefficient							
Model	Coefficients		p-value	95.0% Confidence Interval for		Collinearity Statistics	
	B	Std. Error		Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	2.144	0.461	<0.001	1.255	3.056		
Citizen Participation	0.397	0.059	<0.001	0.246	0.532	0.334	3.220
Leadership	-0.138	0.063	0.016	-0.259	-0.038	0.652	1.574
Infrastructure	0.414	0.065	<0.001	0.282	0.549	0.271	3.781
Fourth Industrial Revolution	-0.038	0.094	0.720	-0.236	0.167	0.175	5.452
Political Will	-0.094	0.092	0.345	-0.283	0.096	0.189	5.068
Dependent Variable: Development of Sustainability of Smart City							

Table 22 above indicates that a one-unit increase in Leadership leads to a non-significant 0.397 unit increase in Development of Sustainability of Smart City. On the other hand, a one-unit increase in Leadership results in a statistically significant decrease of 0.138 unit in Development of Sustainability of Smart City. Additionally, a one-unit increase in Infrastructure leads to a significant 0.414 unit increase in Development of Sustainability of Smart City.

In contrast, a one-unit increase in Fourth Industrial Revolution leads to a non-significant decrease of 0.038 unit in Development of Sustainability of Smart City. Similarly, a one-unit increase in Political Will leads to a non-significant decrease of 0.09 unit in Development of Sustainability of Smart City.

Based on these findings, it can be concluded that Infrastructure emerges as the most crucial key enabler influencing the Development of Sustainability of Smart City. Additionally, the absence of multicollinearity among the predictors is supported by the observed VIF values.

4.2.4 Statistical Analysis for Research Objective 3: To evaluate development of sustainability of smart city mediated by ICT applications.

In this study, the third research objective was "Whether or not ICT applications is a mediating variable for the relationship of the independent variables and development of sustainability of smart city (dependent variable). To measure this objective the well-established 4-step method for mediation analysis has been performed on five independent variables:

(i) Citizen Participation
(ii) Leadership
(iii) Infrastructure
(iv) Fourth Industrial Revolution
(v) Political Will

4.2.4.1 (i) Direct Effect of the model for 1st Independent Variable: Citizen Participation

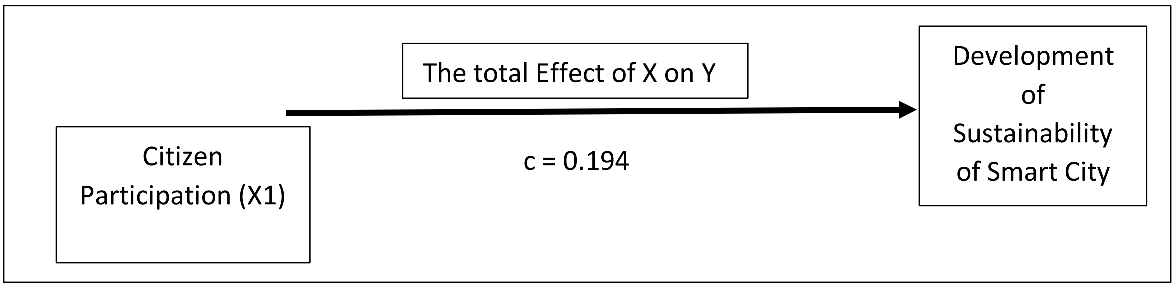


Figure 12: Presentation of the Direct Effect Model for Citizen Participation (1st IV)

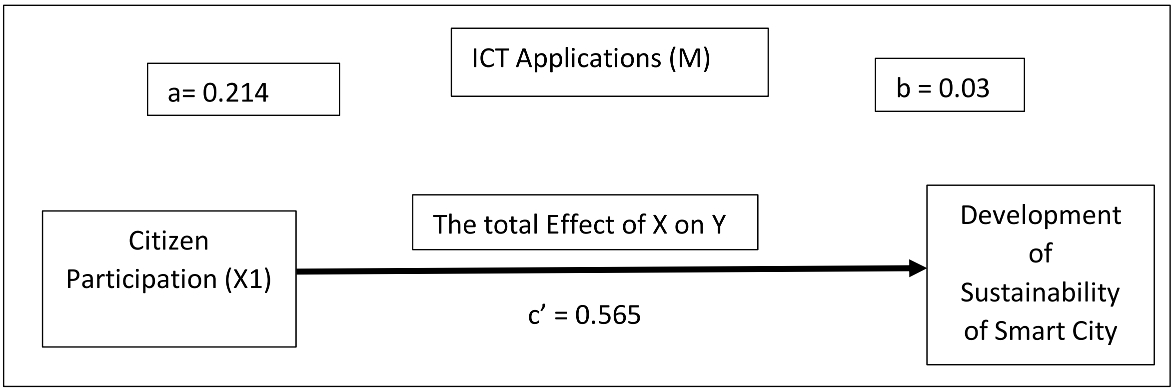


Figure 13: Presentation of the Basic Mediation Model for the 1st IV Citizen Participation

c represents the overall effect of X1on Y.

c = c´ + ab

c´ signifies the direct effect of X1 on Y after adjusting for M (c´= c-ab)

ab stands for the indirect effect of X1 on Y.

Step 1: Assessing the relationship of X1 on Y (Citizen Participation on Development of Sustainability of Smart City).

Table 23: Model Summary for the 1st IV (Citizen Participation) in Step-1

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.765	0.432	0.458	0.765
Predictors: (Constant), Citizen Participation				
Dependent Variable: Development of Sustainability of Smart City				

The table 23 above revealed that Citizen Participation explains 4.3% on Development of Sustainability of Smart City.

Table 24: Simple Regression for the 1st IV (Citizen Participation) in Step-1

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	3.290	0.286	<0.001	2.827	3.952
Citizen Participation	0.560	0.045	<0.001	0.492	0.668
Dependent Variable: Development of Sustainability of Smart City					

The table 24 Illustrated that while increasing one unit of Citizen Participation, it positively increases the Development of Sustainability of Smart City by 0.56 unit which result in it being statistically significant.

Step 2: Estimate the relationship existing between X_1 on M (Citizen Participation on ICT Applications) - Path "a" must be significantly different from 0; independent variable and mediator must be related.

Table 25: Model-a Summary for the 1st IV (Citizen Participation) in Step-2

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.194	0.035	0.027	1.40604
Predictors: (Constant), Citizen Participation				
Dependent Variable: ICT Applications (Mediating Variable)				

The table 25 above illustrated that Citizen Participation explain 3.5% on Sustainable Development of Smart City.

Table 26: Simple Regression for the 1st IV (Citizen Participation) in Step-2

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	4.166	0.397	<0.001	3.254	4.875
Citizen Participation	0.214	0.055	0.008	0.047	0.293
Dependent Variable: ICT Applications (Mediating Variable)					

Table 26 illustrated that while increasing of one of the units from Citizen Participation, it will result in increasing Development of Sustainability of Smart City by 0.214 unit and this result is statistically significant.

Step 3: Estimate the relationship between M on Y (ICT Applications and Development of Sustainability of Smart City) -Path "b" has to be significantly different from 0; dependent variable and the mediator have to be related.

Direct Effect Model of Mediating Variable on the Dependent Variable

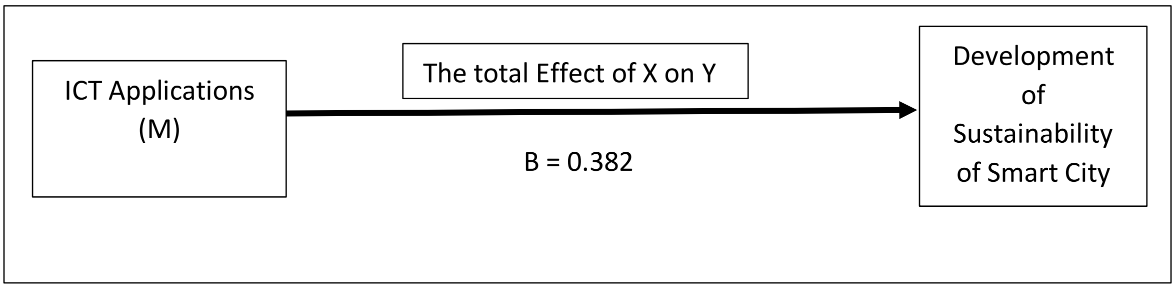


Figure 14: Direct model for the Mediating and the Dependent Variable

Table 27: Model Summary for the Mediating Variable on the Dependent Variable in Step-3

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.308	0.095	0.092	1.09483
Predictors: (Constant), ICT Applications (Mediating Variable)				
Dependent Variable: Development of Sustainability of Smart City				

According to the table 27 above, detected that ICT Applications explain 9.5% on Development of Sustainability of Smart City.

Table 28: Simple Regression analysis for the Mediating Variable on the Dependent Variable

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	9.151	0.540	<0.001	8.107	10.194
ICT Applications (Mediating Variable)	-0.382	0.085	<0.001	-0.545	-0.221
Dependent Variable: Development of Sustainability of Smart City					

The table 28 illustrate that by increasing one unit of ICT Applications, it results in decreasing the Development of Sustainability of Smart City by 0.382 unit and the outcome is highly significant. It revealed that there is an inverse relationship existing between ICT Applications (Mediating Variable) and Development of Sustainability of Smart City (Dependent Variable).

Step 4: Estimate the relationship between M on Y regulating for X_1 (ICT Applications on Development of Sustainability of Smart City, controlling for Citizen Participation) -Path "b" has been significantly diverse from 0; the mediator and the dependent variable have to be related. Thus, the impact of X_1 (Citizen Participation) on Y (Development of Sustainability of Smart City) declined with the inclusion of M (ICT Application) in the model.

Table 29: Model-b Summary for the 1st IV (Citizen Participation) in Step-4

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.655	0.433	0.434	1.03927	1.913
Predictors: (Constant), ICT Applications (Mediating Variable), Citizen Participation					
Dependent Variable: Development of Sustainability of Smart City					

The table 29 detected that the ICT Applications and Citizen Participation explain 43.3% of the Development of Smart City. It was also found the existence of a little autocorrelation (DW=1.913 < 2).

Table 30: Simple Regression for the 1st IV (Citizen Participation) in Step-4

Coefficient							
Model	Coefficients		p-value	95.0% Confidence Interval for		Collinearity Statistics	
	B	Std. Error		Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	3.265	0.351	<0.001	2.551	3.943		
Citizen Participation	0.565	0.044	<0.001	0.486	0.658	0.958	1.033
ICT Application (Mediating Variable)	0.032	0.052	0.522	-0.058	0.142	0.958	1.033
Dependent Variable: Development of Sustainability of Smart City							

The table 30 illustrated that when there is an increase of one unit of citizen participation, the Development of sustainability of Smart City increase by 0.565 unit; this result is statistically significant; additionally, an increase of one unit of ICT Applications, will result in increasing Development of Sustainability of Smart City by 0.032 unit which result is statistically insignificant. Furthermore, it is observed from VIF (VIF=1.033<3) that among the predictors there is no multicollinearity.

From the observed results along this research, it demonstrated that the total impact of the model has a significant positive relationship existing between Citizen Participation (X_1) and Development of Sustainability of Smart City (Y). While the model 'a' shows that Citizen Participation (X_1) is also positively significant to Development of Sustainability of Smart City (M). And model 'b' revealed that ICT Applications (M) positively forecasts Development of Sustainability of Smart City (Y) when regulating for Citizen Participation (X_1).

Since the relationship between ICT Applications (M) and Development of Sustainability of Smart City (Y) is significant while controlling for Citizen Participation (X_1) but there is change in coefficient, this suggests that ICT Applications (M) does mediate the relationship.

Furthermore, in order to test if the mediation impact is significance or not, a Sobel test was undertaken.

Table 31: Sobel Test for 1st IV (Citizen Participation)

Sobel test statistic	**Std. Error**	**Two-tailed probability**
0.64559697	0.02947044	0.54096872

The table 31 above illustrate the Sobel test result. It was found that the p-value is higher than 0.05 (p>0.05); this indicates that the test is not significant. Furthermore, the mediator variable with the independent variable is not significantly in describing the dependent variable (Development of Sustainability of Smart City).

The third alternative hypothesis of this study was "ICT Applications mediates the relationship existing between the independent variable(Citizen Participation) and the dependent variable (Development of Sustainability of Smart City)" from the above table it was found that the impact of independent variable (Citizen Participation) on dependent variable (Development of Sustainability of Smart City) does not mediate significantly by the third variable (ICT Applications); this means that the null hypothesis may not be rejected.

4.2.4.1 (ii) Direct Effect of the model for 2nd Independent Variable: Leadership

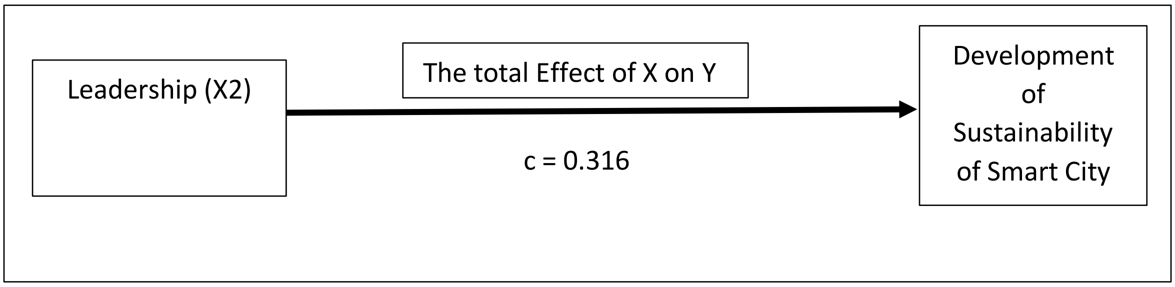


Figure 15: Presentation of the Direct Effect of the Model for Leadership (2nd IV)

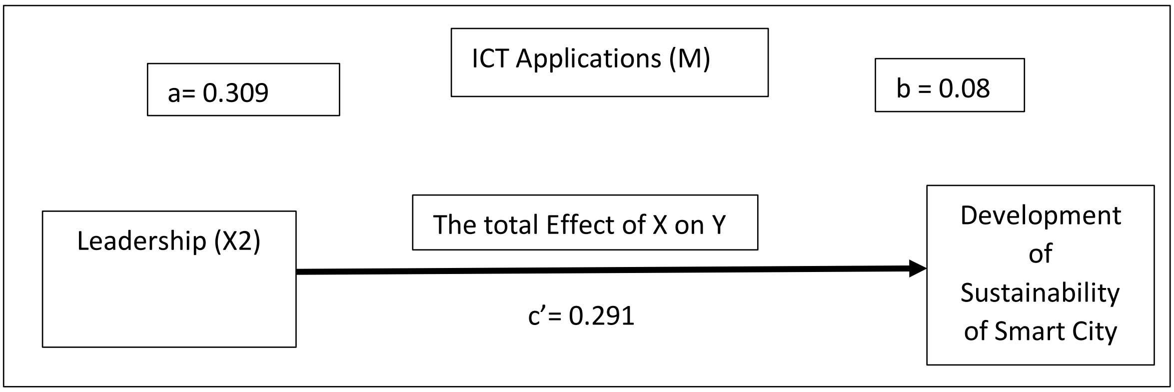


Figure 16: Presentation of the Basic Mediation Model for the 2nd IV Leadership

Here,

c = the total consequence of X_2 on Y

c = c´ + ab

c´ = the direct consequence of X_2 on Y later regulating for M; c´= c-ab and

ab = the indirect consequence of X_2 on Y.

The above figure is the standard mediation model. Perfect mediation occurs when the impact of X2 on Y is decreases to zero (0) with M in the model, while partial mediation occurs when the impact of X2 on Y is decreases by a nontrivial amount with M in the model.

Step 1: Assessing the relationship of X2 on Y (Leadership on Development of Sustainability of Smart City).

Table 32: Model Summary for the 2nd IV (Leadership) in Step-1

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.291	0.089	0.084	1.34242
Predictors: (Constant), Leadership				
Dependent Variable: Development of Sustainability of Smart City				

The table 32 above revealed that Leadership explains 8.9% on Development of Sustainability of Smart City

Table 33: Simple Regression for the 2nd IV (Leadership) in Step-1

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	5.078	0.469	<0.001	4.164	5.971
Leadership	0.318	0.083	<0.001	0.182	0.465
Dependent Variable: Development of Sustainability of Smart City					

The table 33 Illustrated that while increasing one unit of Leadership, it positively increases the Development of Sustainability of Smart City by 0.318 unit which result in it being statistically significant.

Step 2: Estimate the relationship existing between X_2 on M (Leadership on ICT Applications) - Path "a" must be significantly different from 0; independent variable and mediator must be related.

Table 34: Model-a Summary for the 2nd IV (Leadership) in Step-2

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.447	0.082	0.077	1.38724
Predictors: (Constant), Leadership				
Dependent Variable: ICT Applications (Mediating Variable)				

The table 34 above illustrated that Leadership explain 8.2% on Sustainable Development of Smart City.

Table 35: Simple Regression for the 2nd IV (Leadership) in Step-2

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	3.239	0.484	<0.001	2.405	4.182
Leadership	0.309	0.087	0.007	0.168	0.470
Dependent Variable: ICT Applications (Mediating Variable)					

Table 35 illustrated that while increasing of one of the units from Leadership, it will result in increasing Development of Sustainability of Smart City by 0.309 unit and this result is statistically significant.

Step 3: In this research, considered five (5) independent variables, 1 dependent variable and 1 mediating variable. In step-3 modelled between mediating and dependent variable which is same for all five (5) independent variables; that already shown for first independent variable in Table 27 and Table 28.

Step 4: Estimate the relationship between M on Y regulating for X2 (ICT applications on Development of Sustainability of Smart City, controlling for Leadership) - Path "b" must be significantly diverse from 0; mediator and dependent variable must be related. The repercussion of X2 (Leadership) on Y (Development of Sustainability of Smart City) decreases with the inclusion of M (ICT Applications) in the model.

Table 36: Model-b Summary for the 2nd IV (Leadership) in Step-4

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.292	0.088	0.087	1.33999	1.345
Predictors: (Constant), ICT Applications (Mediating Variable), Leadership					
Dependent Variable: Development of Sustainability of Smart City					

The table 36 above showed that ICT Applications and Leadership explains 8.8% of the Development of Sustainability of Smart City. It was also observed that there is a little autocorrelation exist (DW=1.345 < 2).

Table 37: Simple Regression for the 2nd IV (Leadership) in Step-4

Coefficient							
Model	Coefficients		p-value	95.0% Confidence Interval for		Collinearity Statistics	
	B	Std. Error		Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	4.792	0.508	<0.001	3.798	5.778		
Leadership	0.291	0.077	<0.001	0.144	0.444	0.929	1.077
ICT Application (Mediating Variable)	0.083	0.066	0.217	-0.048	0.222	0.929	1.077
Dependent Variable: Development of Sustainability of Smart City							

Table 37 reveals that an increase of one unit in Leadership leads to a 0.291 unit increase in Development of Sustainability of Smart City, and this result is statistically significant.

Conversely, an increase of one unit in ICT Applications results in a 0.083 unit increase in Development of Sustainability of Smart City, but this outcome is statistically insignificant. The observation of a VIF value of 1.077 (<3) indicates the absence of multicollinearity among the predictors.

Furthermore, the comprehensive model highlights a significant positive correlation between Leadership (X2) and Development of Sustainability of Smart City (Y). Model 'a' additionally illustrates a positive relationship between Leadership (X2) and ICT Applications (M). Meanwhile, model 'b' demonstrates that ICT Applications (M) positively predicts Development of Sustainability of Smart City (Y) when controlling for Leadership (X2).

Given that the relationship between ICT Applications (M) and Development of Sustainability of Smart City (Y) remains significant, albeit with a change in coefficient, when controlling for Leadership (X2), it suggests that ICT Application (M) serves as a mediator in this relationship.

To ascertain the significance of this mediation effect, the Sobel test was employed.

Table 38: Sobel Test for 2^{nd} IV (Leadership)

Sobel test statistic	**Std. Error**	**Two-tailed probability**
1.19038745	0.02032634	0.23877809

The Sobel test results indicate that the p-value exceeds 0.05 ($p>0.05$), signifying that the test is not statistically significant. Additionally, it suggests that the mediator variable, in conjunction with the independent variable, does not significantly account for the dependent variable (Leadership). In light of these findings, the third alternative hypothesis, whereby ICT Applications mediates the relationship between the independent variable and the dependent variable, that is the null hypothesis and may not be rejected.

4.2.4.1 (iii) Direct Effect model for Infrastructure (The 3rd Independent Variable)

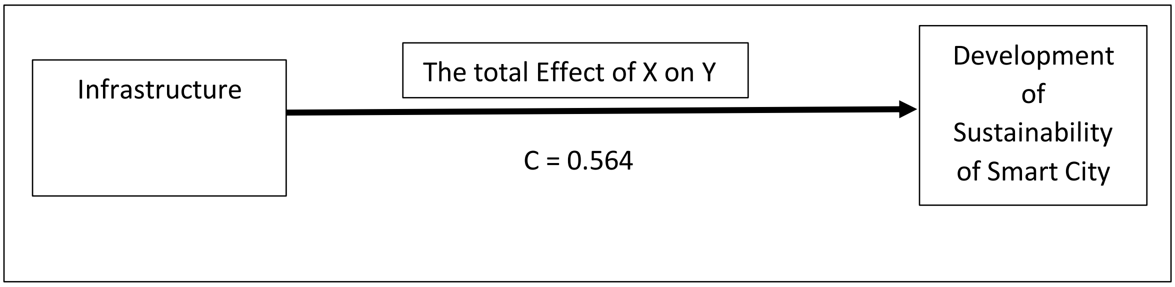


Figure 17: Presentation of Direct effect model for Infrastructure (3rd Independent Variable)

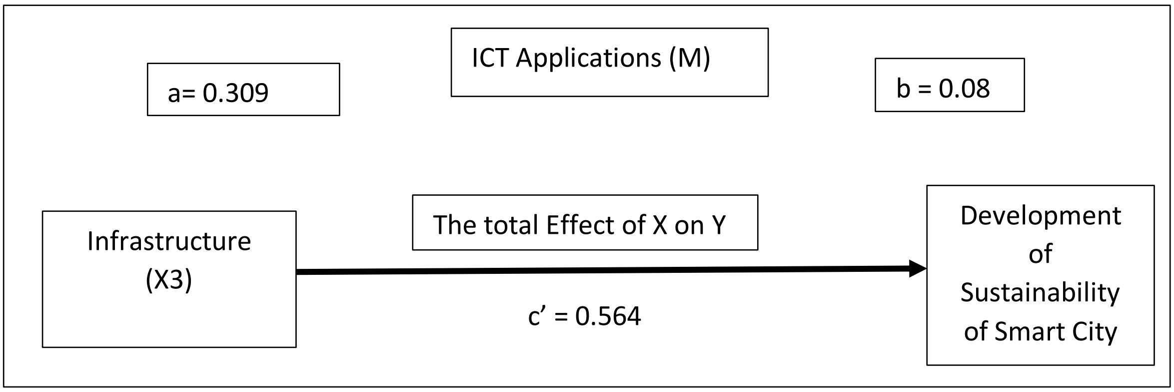


Figure 18: Presentation of Basic Mediation Model for Infrastructure (3rd IV)

In this context,

c = the total consequence of X_3 on Y

c = c´ + ab

c´ = the direct consequence of X_3 on Y later regulating for M; c´= c-ab and

ab = the indirect consequence of X_3 on Y.

The standard mediation model shown above illustrates that perfect mediation occurs when the effect of X on Y decrease to zero (0) in the presence of M, while partial mediation arises when the effect of X3 on Y decreases by a nontrivial amount with M in the model.

Step 1: Author estimated the relationship between X_3 on Y (Infrastructure on Development of Sustainability of Smart City)

Table 39: Model Summary for 3rd IV (Infrastructure) in Step-1

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.744	0.560	0.508	0.971344
Predictors: (Constant), Infrastructure				
Dependent Variable: Development of Sustainability of Smart City				

In this context, the R-square value of 0.560 indicates that approximately 51% of the overall variability in Development of Sustainability of Smart City is accounted for by the model, specifically by the variable Infrastructure.

Table 40: Simple Regression analysis for 3rd IV (Infrastructure) in Step-1

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	2.261	0.343	<0.001	1.733	2.899
Infrastructure	0.559	0.048	<0.001	0.495	0.655
Dependent Variable: Development of Sustainability of Smart City					

As per the findings presented in Table 40, it is evident that a one-unit alteration in Infrastructure corresponds to an average increase of 0.559 units in Development of Sustainability of Smart City, a relationship that holds statistical significance at the 1% level.

Step 2: Estimate the relationship between X3 (Infrastructure) and M (Development of Sustainability of Smart City)- Path "a" should exhibit a significantly different from zero (0), indicating the independent variable and the mediator must be related.

Table 41: Model-a Summary for 3rd Independent Variable (Infrastructure) in Step-2

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.056	0.004	-0.002	1.42694
Predictors: (Constant), Infrastructure				
Dependent Variable: ICT Applications (Mediating Variable)				

From R-square=0.004, It can be concluding Infrastructure has no significant control over ICT Applications.

Table 42: Simple Regression for 3rd Independent Variable (Infrastructure) in Step-2

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	4.757	0.487	<0.001	3.823	5.593
Infrastructure	0.046	0.067	0.422	-0.058	0.159
Dependent Variable: ICT Applications (Mediating Variable)					

Here, p-value > 0.05 at 5% level of significance; this means that Infrastructure has no significant effect on ICT Applications.

Step 3: In this research, considered five (5) independent variables, 1 dependent variable and 1 mediating variable. In step-3 modelled between mediating and dependent variable which is same for all five (5) independent variables; that already shown for first independent variable in Table 27 and Table 28.

Step 4: Estimate the relationship between M on Y regulating for X3 (ICT Applications on Development of Sustainability of Smart City and controlling for Infrastructure). In order for Path "b" to be considered significantly different from zero, indicating mediating and dependent variable must be related. Additionally, the effect of X3 (Infrastructure) on Y (Development of Sustainability of Smart City) decreases with the inclusion of M (ICT Applications) into the model.

Table 43: Model-b Summary for 3rd Independent Variable (Infrastructure) in Step-4

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.745	0.554	0.521	0.96059	1.928
Predictors: (Constant), ICT Applications (Mediating Variable), Infrastructure					
Dependent Variable: Development of Sustainability of Smart City					

According to R-square, 55.4% of the total variation in Development of Sustainability of Smart City explained by the combination of ICT Applications and Infrastructure.

It has been also found little autocorrelation existing (DW=1.928< 2). There is a need of checking on the VIF to evaluate the multicollinearity.

Table 44: Simple Regression for 3rd Independent Variable (Infrastructure) in Step-4

Coefficient							
Model	Coefficients		p-value	95.0% Confidence Interval for		Collinearity Statistics	
	B	Std. Error		Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	1.744	0.397	<0.001	0.976	2.489		
Infrastructure	0.575	0.039	<0.001	0.492	0.649	0.998	1.004
ICT Applications (Mediating Variable)	0.112	0.047	0.018	0.023	0.203	0.998	1.004
Dependent Variable: Development of Sustainability of Smart City							

In Table 44, it is evident that both ICT Applications and Infrastructure both have a significant effect on Development of Sustainability of Smart City at a 5% significance level. This implies that a one-unit increase in Infrastructure leads to an average increase of 0.575 units in Development of Sustainability of Smart City, and a one-unit increase in ICT Applications results in an average increase of 0.112 units in Development of Sustainability of Smart City. The Variance Inflation Factor (VIF=1.004<3) indicates the absence of multicollinearity among the predictors.

The observation made here highlights that the comprehensive model displays a notable positive correlation between Infrastructure (X3) and ICT Applications (Y). Model 'a' further illustrates a positive relationship between Infrastructure(X3) and ICT Applications (M). Meanwhile, model 'b' reveals that ICT Applications (M) effectively predicts Development of Sustainability of Smart City (Y) while adjusting for Infrastructure(X3).

Given that the relationship between ICT Applications (M) and Development of Sustainability of Smart City (Y) remains significant even when accounting for Infrastructure (X3), albeit with a change in coefficient, it suggests that ICT Applications (M) indeed acts as a mediator in this relationship.

In other to evaluate the mediation effect significance; a Sobel test will be performed.

Table 45: Sobel Test for 3rd Independent Variable (Infrastructure)

Sobel test statistic	**Std. Error**	**Two-tailed probability**
2.38177063	0.02628465	0.01722963

The Sobel test yielded a p-value of less than 0.05 ($p<0.05$), signifying its significance. This indicates that both the mediator variable and the independent variable significantly contribute to explaining the dependent variable, Development of Sustainability of Smart City.

The third alternative hypothesis posited in this study, stating that ICT Applications serves as a mediator between the independent variable and the dependent variable," finds support in the above table. It demonstrates that the impact of the independent variable (Infrastructure) on the dependent variable (Development of Sustainability of Smart City) is indeed mediated significantly by the third variable (ICT Applications). Consequently, the alternative hypothesis may not be rejected.

4.2.5.1 (iv) Direct effect model for 4th Independent Variable (Fourth Industrial Revolution)

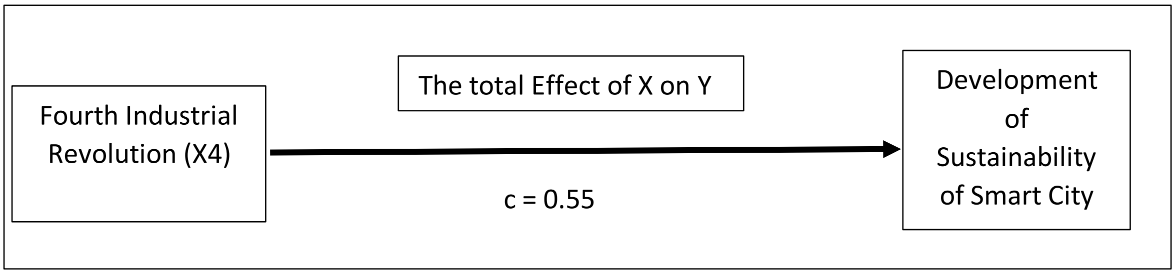


Figure 19: Presentation of Direct effect model for Fourth Industrial Revolution (4th Independent Variable)

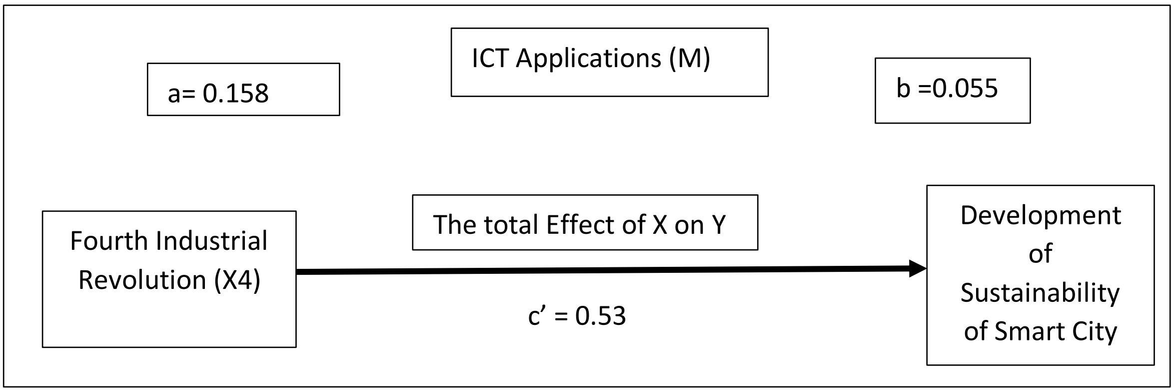


Figure 20: Basic Mediation Model for 4th Independent Variable (Fourth Industrial Revolution)

Here,

c = the total consequence of X_4 on Y

c = c´ + ab

c´ = the direct consequence of X_4 on Y later regulating for M; c´= c-ab and

ab = the indirect consequence of X_4 on Y.

The standard mediation model, as depicted in the figure above, demonstrates that perfect mediation occurs when the impact of X4 on Y becomes zero (0) when M is included in the model. Partial mediation occurs when the impact of X4 on Y decreases by a nontrivial amount when M is included in the model.

Step 1: Estimate the relationship between X4 (Fourth industrial revolution) on Y (Development of Sustainability of Smart City) was calculated.

Table 46: Model Summary for 4th Independent Variable (Fourth Industrial Revolution) in Step-1

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.565	0.453	0.534	1.05822
Predictors: (Constant), Fourth Industrial Revolution				
Dependent Variable: Development of Sustainability of Smart City				

R Square=0.565 indicates that the Fourth Industrial Revolution explain 45.3% of total variation of Development of Sustainability of Smart City.

Table 47: Simple Regression analysis for 4th Independent Variable (Fourth Industrial Revolution) in Step-1

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	1.782	0.358	<0.001	1.036	2.565
Fourth Industrial Revolution	0.720	0.055	<0.001	0.548	0.744
Dependent Variable: Development of Sustainability of Smart City					

Table 47 illustrates that for every one-unit rise in the Fourth Industrial Revolution score, there is a corresponding increase of 0.720 units in Sustainable Development of Smart City. This relationship is statistically significant.

Step 2: Estimate the relationship between X4 (Fourth Industrial revolution) on M (ICT Applications on Development of Sustainability of Smart City). The "Path 'a'" must be significantly different from zero (0), indicating independent variable and the mediator must be related.

Table 48: Model-a Summary for 4th Independent Variable (Fourth Industrial Revolution) in Step-2

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.154	0.023	0.019	1.52407
Predictors: (Constant), Fourth Industrial Revolution				
Dependent Variable: ICT Applications (Mediating Variable)				

The R square value of 0.023 provided in Table 48 suggests that only a small proportion, specifically 2.3%, of the overall variation in ICT Applications can be accounted for by Fourth Industrial Revolution.

Table 49: Simple Regression for 4th Independent Variable (Fourth Industrial Revolution) in Step-2

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	3.825	0.565	<0.001	2.725	5.017
Fourth Industrial Revolution	0.155	0.058	0.028	0.018	0.279
Dependent Variable: ICT Applications (Mediating Variable)					

Table 49 above presents the data indicating that a one-unit increase in Fourth Industrial Revolution score leads to a 0.155 unit increase in ICT Applications (coefficient=0.155, Confidence Interval: 0.018-0.279).

Step 3: In this research, considered five (5) independent variables, 1 dependent variable and 1 mediating variable. In step-3 modelled between mediating and dependent variable which is same for all five (5) independent variables; that already shown for first independent variable in Table 27 and Table 28.

Step 4: Estimate the relationship between M (ICT Applications) on Y regulating X4 (Development of Sustainability of Smart City, controlling for Fourth Industrial Revolution) – for "Path 'b'" must be significantly different from zero (0), signifying a significant relationship between the mediator and the dependent variable must be related. Additionally, it is expected that the effect of X4 (Fourth Industrial Revolution) on Y (Development of Sustainability of Smart City) decreases when M (ICT Applications) is included in the model.

Table 50: Model-b Summary for 4th Independent Variable (Fourth Industrial Revolution) in Step-4

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.668	0.422	0.437	1.05981	1.884
Predictors: (Constant), ICT Applications (Mediating Variable), Fourth Industrial Revolution					
Dependent Variable: Development of Sustainability of Smart City					

The table 50 above illustrates that ICT Applications and Fourth Industrial Revolution explaines 42.2% of the variance of Development of Sustainability of Smart City. Additionally, it was observed that there is a slight presence of autocorrelation (Durbin-Watson statistic = 1.884, which is less than 2).

Table 51: Simple Regression for 4th Independent Variable (Fourth Industrial Revolution) in Step-4

Coefficient							
Model	Coefficients		p-value	95.0% Confidence Interval for		Collinearity Statistics	
	B	Std. Error		Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	1.735	0.452	<0.001	0.734	2.535		
Fourth Industrial Revolution	0.545	0.051	<0.001	0.531	0.732	0.985	1.031
ICT Applications (Mediating Variable)	0.056	0.053	0.293	-0.049	0.154	0.985	1.031
Dependent Variable: Development of Sustainability of Smart City							

The table 51 above illustrates findings indicating that an increase of one unit in Fourth Industrial Revolution leads to a significant 0.545 unit increase in Development of Sustainability of Smart City. However, ICT Applications shows no significant effect on Development of Sustainability of Smart City (coefficient = 0.056, P=0.293). The VIF value (VIF=1.031<3) also affirms the absence of multicollinearity among the predictors.

In the total effect model, a strong positive association is observed between Fourth Industrial Revolution (X4) and Development of Sustainability of Smart City (Y). Model 'a' additionally reveals a positive link between Fourth Industrial Revolution (X4) and ICT Applications (M). On the other hand, model 'b' demonstrates that ICT Applications (M) positively predicts Development of Sustainability of Smart City (Y) even when accounting for Fourth Industrial Revolution (X4).

The fact that the relationship between ICT Applications (M) and Development of Sustainability of Smart City (Y) remains significant after controlling for Fourth Industrial Revolution (X4), but is ultimately found to be insignificant, suggests that ICT Applications (M) does not mediate this relationship.

To validate this, The Sobel Test should be conducted in order to assess the significance of the mediation effect.

Table 52: Sobel Test for 4th Independent Variable (Fourth Industrial Revolution)

Sobel test statistic	**Std. Error**	**Two-tailed probability**
0.61568695	0.03825043	0.54066953

The p-value obtained from the aforementioned table ($p>0.05$) suggests that the conducted test is not statistically significant. This implies that the mediator variable, in conjunction with the independent variable, does not adequately explain the dependent variable (Development of Sustainability of Smart City).

Regarding the third alternative hypothesis of the study, which posited that "ICT Applications mediates the relationship between the independent variable and the dependent variable," the table indicates that the impact of the independent variable (Fourth Industrial Revolution) on the dependent variable (Development of Sustainability of Smart City) is not significantly mediated by the third variable (ICT Applications). In other words, that is the null hypothesis may not be rejected.

4.2.4.1 (v) Direct effect model for 5th Independent Variable (Political Will)

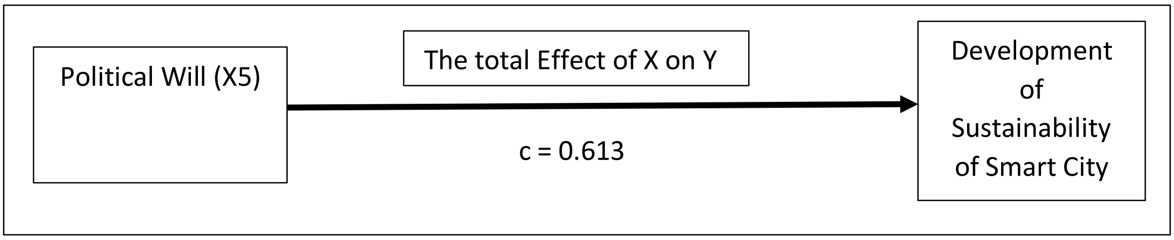


Figure 21: Presentation of Direct effect model for Political Will (5th Independent Variable)

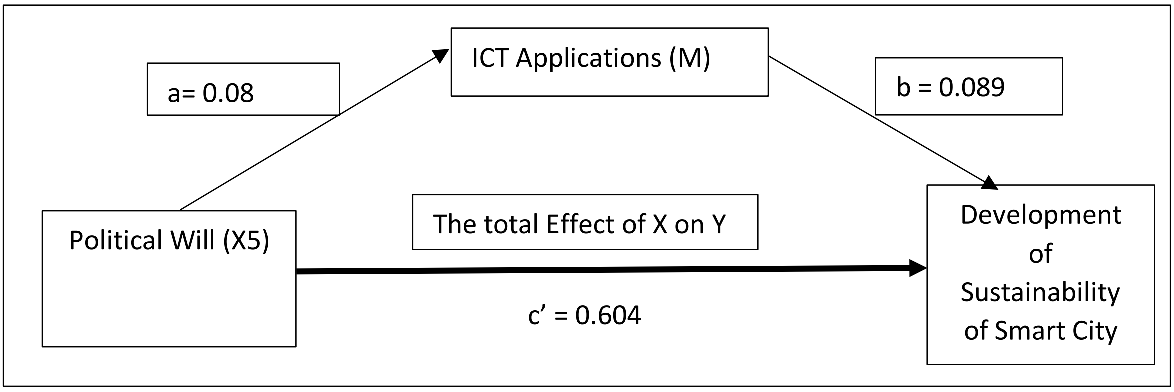


Figure 22: Presentation Basic Mediation Model for 5th Independent Variable (Political Will)

In this context:

- 'c' represents the overall impact of X5 on Y (Political Will on Development of Sustainability of Smart City).
- 'c' can be broken down into 'c´' and 'ab', where 'c´' signifies the direct effect of X5 on Y after accounting for M (Mediator), calculated as c-ab.
- 'ab' denotes the indirect effect of X5 on Y through the mediator.

The standard mediation model, as depicted in the figure above, illustrates perfect mediation when the effect of X5 on Y decreases to zero with the inclusion of M in the model. Partial mediation occurs when the effect of X5 on Y decreases by a meaningful amount with M in the model.

Step 1: The author estimate the relationship between X5 (Political Will and Y (Development of Sustainability of Smart City).

Table 53: Model Summary for 5th Independent Variable (Political Will in Step-1

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.664	0.44	0.432	1.07090
Predictors: (Constant), ICT Applications (Mediating Variable), Political Will				
Dependent Variable: Development of Sustainability of Smart City				

The table 53 above revealed that Political Will explain 44.1% on Development of Sustainability of Smart City.

Table 54: Simple Regression analysis for 5th Independent Variable (Political Will) in Step-1

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	1.734	0.432	<0.001	0.984	2.567
Political Will	0.624	0.057	<0.001	0.527	0.722
Dependent Variable: Development of Sustainability of Smart City					

Table 54 demonstrates that a one-unit increase in Political Will leads to a statistically significant 0.624 unit increase in Development of Sustainability of Smart City.

Step 2: Estimate the relationship between X5 (Political Will) on M (ICT Applications). It is imperative for "Path 'a' must be significantly different from zero (0), indicating the independent variable and the mediating variable must be related.

Table 55: Model-a Summary for 5th Independent Variable (Political Will) in Step-2

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.094	0.088	0.008834	1.3805
Predictors: (Constant), Political Will				
Dependent Variable: Development of Sustainability of Smart City				

The table 55 detected that Political Will explain only 0.9% Development of Sustainability of Smart City.

Table 56: Simple Regression for 5th Independent Variable (Political Will) in Step-2

Coefficient					
Model	Coefficients		p-value	95.0% Confidence Interval for	
	B	Std. Error		Lower Bound	Upper Bound
(Constant)	4.477	0.578	<0.001	3.258	5.589
Political Will	0.090	0.059	0.179	-0.039	0.234
Dependent Variable: ICT Applications (Mediating Variable)					

Table 56 shows that by increase of one unit of Political Will, will increase ICT applications by 0.09 unit but the result is statistically insignificant.

Step 3: In this research, considered five (5) independent variables, 1 dependent variable and 1 mediating variable. In step-3 modelled between mediating and dependent variable which is same for all five (5) independent variables; that already shown for first independent variable in Table 27 and Table 28.

Step 4: Estimate the relationship between M on Y regulating for X5 (ICT Applications on Development of Sustainability of Smart City, controlling for Political Will) – for Path 'b' must be significantly different from zero (0), mediating and dependent variable must be related. The effect of X5 (Political Will) on Y (Development of Sustainability of Smart City) decreases with the inclusion of M (ICT Applications) in the model.

Table 57: Model-b Summary for 5th Independent Variable (Political Will) in Step-4

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.649	0.421	0.421	1.04811	1.836
Predictors: (Constant), ICT Applications (Mediating Variable), Political Will					
Dependent Variable: Development of Sustainability of Smart City					

The table 57 detected that ICT Applications and Political Will explain 42.1% of the Development of Sustainability of Smart City. Researcher also found that there is a little autocorrelation exist (DW=1.836 < 2).

Table 58: Simple Regression for 5th Independent Variable (Political Will) in Step-4

Coefficient							
Model	Coefficients		p-value	95.0% Confidence Interval for		Collinearity Statistics	
	B	Std. Error		Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	1.318	0.489	0.003	0.495	2.373		
Political Will	0.590	0.053	<0.001	0.508	0.705	0.994	1.008
ICT Applications (Mediating Variable)	0.093	0.054	0.070	-0.008	0.189	0.994	1.008
Dependent Variable: Development of Sustainability of Smart City							

Table 58 illustrates that increase of one unit in Political Will, will increase Development of Sustainability of Smart City by 0.590 units whereby the outcome is statistically significant and increase of one unit of ICT Applications, will increase Development of Sustainability of Smart City by 0.093. The VIF value of 1.008 signals that there is no of multicollinearity among the predictors.

In the overall effect model, there is a substantial positive relationship between Political Will (X5) and Development of Sustainability of Smart City (Y). Model 'a' shows a positive relation between Political Will (X5) and ICT Applications (M). Furthermore, model 'b' shows that ICT Applications (M) positively predicts Development of Sustainability of Smart City (Y) when regulating for Political Will (X5).

The relationship between ICT Applications (M) and Development of Sustainability of Smart City (Y) remains significant while controlling Political Will (X5). The change in coefficient, implies that ICT Applications (M) does mediate in this relationship.

The Sobel test was conducted in order to assess the significance of the mediation effect.

Table 59 Sobel Test for 5th Independent Variable (Political Will)

Sobel test statistic	**Std. Error**	**Two-tailed probability**
1.78420254	0.03119601	0.07439076

As per the results obtained from the Sobel test as per the table 59 above, the p-value surpasses 0.05 ($p>0.05$), indicating a lack of statistical significance. This suggests that the mediator variable, in tandem with the independent variable, is not significantly describing the dependent variable.

The third alternative hypothesis in this study proposed that "ICT Applications functions as a mediator between the independent variable and the dependent variable." However, based on the available information, it has been concluded that the impact of the independent variable (Political Will) on the dependent variable (Development of Sustainability of Smart City) is not significantly mediated by the mediating variable (ICT Applications). Consequently, null hypothesis may not be rejected.

4.2.5 Statistical Analysis for Research Objective 4: To evaluate the model fit of the strategy framework, of key enablers of smart city and development of sustainability of smart city mediated by ICT applications.

The table 60 below illustrate the evaluation for the suitability of the model for development of sustainability of smart city among the key enablers of smart city that was the fourth research objective (The fitness of Development of Sustainability of Smart City model among the key enablers of smart city, ICT applications and development of sustainability of smart city) of this research study.

Table 60: ANOVA Test for Overall Regression

ANOVA					
Model	Sum of Squares	df	Mean Square	F	p-value
Regression	249.548	6	41.809	55.674	<0.001
Residual	159.486	208	0.759		
Total	409.034	214			
Dependent Variable: Development of Sustainability of Smart City					
Predictors: (Constant), Citizen Participation, Leadership, Infrastructure, Fourth Industrial Revolution, Political Will					

From the table above, it can be seen that the model is significant for the independent variables (p-value<0.001)

Table 61: Model Summary for Overall Regression

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.779	0.607	0.598	0.86717	2.143
Predictors: (Constant), Citizen Participation, Leadership, Infrastructure, Fourth Industrial Revolution, Political Will					
Dependent Variable: Development of Sustainability of Smart City					

The table above indicates that Citizen Participation, Leadership, Infrastructure, Fourth Industrial Revolution, Political Will collectively account for 61% of the variance in Development of Sustainability of Smart City. Additionally, the author noted the absence of autocorrelation, with a Durbin-Watson statistic of 2.133, which exceeds the threshold of 2.

4.3 Hypothesis Testing

Table 62: Correlation between Dependent Variable and Independent variables

	Citizen Participation	Leadership	Infrastructure	Fourth Industrial Revolution	Political Will
Sustainable Development of Smart City	0.655**	0.292**	0.732**	0.649**	0.657**

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

The table 62 above displays the correlation between the dependent variable and independent variables. The analysis reveals that all independent variables exhibit a positive relationship with the dependent variable. Specifically, Citizen Participation demonstrates a moderate relationship (Hinkle et al., 2003) with the dependent variable (r=0.655). Similarly, Fourth Industrial Revolution (r=0.649), Political Will (r=0.657) also have a moderate relationship with the dependent variable. On the other hand, Leadership shows a weak positive relationship with the dependent variable, whereas Infrastructure exhibits a strong positive relationship.

H_{a1}: The first hypothesis in this research study posited that "Key enablers have a positive relationship with the Development of Sustainability of Smart City." As per the findings in the table above, evidence have been gathered that support the hypothesis. This suggests that there is indeed a positive relationship between the independent variables and the dependent variable.

Table 63: Correlation between Mediating Variable and Independent variables

	Citizen Participation	Leadership	Infrastructure	Fourth Industrial Revolution	Political Will
ICT Applications	0.179**	0.259**	0.056	0.151*	0.093

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

According to Table 63, it is noted that Citizen Participation (r=0.179), Leadership (r=0.259), and Fourth Industrial Revolution (r=0.151) have a modest positive relationship with the mediating variable, and this relationship is statistically significant. On the other hand, Infrastructure (r=0.056), and Political Will (r=0.093) demonstrate a very weak positive association (Hinkle et al., 2003) with the mediating variable, but it is not statistically significant.

H_{a2}: The second hypothesis in this research study posited that "The independent variables have a positive relationship with ICT Applications." As per the findings in Table 64, it is observed that all independent variables do indeed have a positive relationship with Development of Sustainability of Smart City However, among the independent variables, three (Citizen Participation, Leadership, Fourth Industrial Revolution) demonstrate a statistically significant relationship, while two (Infrastructure and Political Will) are found to be insignificant.

Table 64: Correlation between Dependent variable and Mediating Variable

	Sustainable Development of Smart City
ICT Applications	0.164*

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

Based on the findings in Table 64, it has been identified a statistically significant, while weak, positive relationship (r=0.164) between Development of Sustainability of Smart City (dependent variable) and ICT Applications (the mediating variable).

H_{a3}: The third alternative hypothesis in this study Stated that "ICT Applications is positively associated with Development of Sustainability of Smart City." Based on the correlation table above, it is evident that there is a statistically significant positive relationship between Development of Sustainability of Smart City (dependent variable) and ICT Applications (mediating variable). Therefore, the third alternative hypothesis can be accepted.

H_{a4}: The fourth alternative hypothesis of this study proposed that "ICT Applications acts as a mediator between the independent variable and the dependent variable." This hypothesis was assessed individually for each independent variable:

- **For the First Independent Variable (Citizen Participation):**

In other to test if there is any mediation among the variables, the Sobel test was done.

Table 65: Sobel Test for the 1st Independent Variable (Citizen Participation)

Sobel test statistic	Std. Error	Two-tailed probability
0.63578695	0.02857045	0.54076954

Based on the Sobel test results presented above, the p-value exceeds 0.05 (p>0.05), indicating that the test is not statistically significant. This implies that the mediator variable, in conjunction with the independent variable, does not significantly explain the dependent variable (Development of Sustainability of Smart City).

The third alternative hypothesis of this study posited that "ICT Applications serves as a mediator between the independent variable and the dependent variable." However, based on the information provided, it has been determined that the influence of the independent variable (Citizen Participation) on the dependent variable (Development of Sustainability of Smart City) is not significantly mediated by the third variable (ICT Applications). Therefore, there is no compelling reason to reject the null hypothesis.

- **For the Second Independent Variable (Leadership):**

In other to test if there is any mediation among the variables, the Sobel test was done.

Table 66: Sobel Test for 2nd Independent Variable (Leadership)

Sobel test statistic	**Std. Error**	**Two-tailed probability**
1.19045857	0.02232846	0.24877807

Based on the Sobel test results presented above, the p-value exceeds 0.05 ($p>0.05$), indicating that the test is not statistically significant. This suggests that the mediator variable, in conjunction with the independent variable, does not significantly account for the variation in the dependent variable (Leadership).

The third alternative hypothesis of this study posited that "ICT Applications serves as a mediator between the independent variable and the dependent variable." However, based on the information provided, it has been determined that the influence of the independent variable (Leadership) on the dependent variable (Development of Sustainability of Smart City) is not significantly mediated by the third variable (ICT Applications). Therefore, there is no compelling reason to reject the null hypothesis.

- **For the Third Independent Variable (Infrastructure)**

In other to test if there is any mediation among the variables, the Sobel test was done.

Table 67: Sobel Test for 3rd Independent Variable (Infrastructure)

Sobel test statistic	Std. Error	Two-tailed probability
2.46387056	0.02439576	0.01634854

Based on the Sobel test results presented above, the p-value is less than 0.05 ($p<0.05$), indicating that the test is statistically significant. This suggests that the mediator variable, in conjunction with the independent variable, significantly explains the variation in the dependent variable (Development of Sustainability of Smart City).

The third alternative hypothesis of this study posited that "ICT Applications serves as a mediator between the independent variable and the dependent variable." According to the findings in the table above, it has been determined that the effect of the independent variable (Infrastructure) on the dependent variable (Development of Sustainability of Smart City) is indeed significantly mediated by the third variable (ICT Applications). Therefore, there is no basis to reject the alternative hypothesis.

- **For the Fourth Independent Variable (Fourth Industrial Revolution)**

In other to test if there is any mediation among the variables, the Sobel test was done.

Table 68: Sobel Test for 4th Independent Variable (Fourth Industrial Revolution)

Sobel test statistic	Std. Error	Two-tailed probability
0.64758677	0.02745044	0.5409673

Based on the Sobel test results presented above, the p-value exceeds 0.05 (p>0.05), indicating that the test is not statistically significant. This implies that the mediator variable, in conjunction with the independent variable, does not significantly account for the variation in the dependent variable (Fourth Industrial Revolution).

The fourth alternative hypothesis of this study posited that "ICT Applications serves as a mediator between the independent variable and the dependent variable." However, based on the information provided, it has been determined that the influence of the independent variable (Fourth Industrial Revolution) on the dependent variable (Development of Sustainability of Smart City) is not significantly mediated by the third variable (ICT Applications). Therefore, there is no compelling reason to reject the null hypothesis.

- **For the Fifth Independent Variable (Political Will)**

In other to test if there is any mediation among the variables, the Sobel test was done.

Table 69: Sobel Test for 5th Independent Variable (Political Will)

Sobel test statistic	Std. Error	Two-tailed probability
1.69520445	0.03228704	0.08258854

Based on the Sobel test results presented above, the p-value exceeds 0.05 (p>0.05), indicating that the test is not statistically significant. This implies that the mediator variable, in conjunction with the independent variable, does not significantly account for the variation in the dependent variable (Development of Sustainability of Smart City).

The third alternative hypothesis of this study posited that "ICT Applications serves as a mediator between the independent variable and the dependent variable." However, based on the information provided, it has been determined that the influence of the independent variable (Political Will) on the dependent variable (Development of Sustainability of Smart City) is not significantly mediated by the third variable (ICT Applications). Therefore, there is no compelling reason to reject the null hypothesis.

Table 70: Hypotheses test at a Glance

Sl. No.	**Null Hypothesis**	**Alternate Hypothesis**	**Significance Level**	**Acceptance**
1	*The independent variables have no positive relationship with the dependent variable*	*The independent variables have a positive relationship with the dependent variable*	5%	Do not reject $\mathbf{H_{a1}}$
2	*The independent variables have no positive relationship with ICT Applications*	*The independent variables have a positive relationship with ICT Applications*	5%	Do not reject $\mathbf{H_{a2}}$
3	*ICT Applications is not positively related to Development of Sustainability of Smart City*	*ICT Applications is positively related to Development of Sustainability of Smart City*	5%	Do not reject $\mathbf{H_{a3}}$
4	*ICT Applications does not mediate the relationship between the independent variable and the dependent variable*	*ICT Applications mediates the relationship between the independent variable and the dependent variable*	5%	Alternative Hypothesis may not be accepted for 1st IV
				Alternative Hypothesis may not be accepted for 2nd IV
				Alternative Hypothesis may be accepted for 3rd IV
				Alternative Hypothesis may not be accepted for 4th IV
				Alternative Hypothesis may not be accepted for 5th IV

4.4 Hypothesis Conclusion

The results that are illustrated in the table above was tested based on the significance level of p> 0.05. The significance level (p) represents the probability of accepting the null hypothesis in the case it is true.

From those hypotheses which was tested by (Nina Tura & Ville Ojanen, 2022), it was demonstrated that ICT applications, Citizen Participation, Leadership, Infrastructure, Fourth Industrial Revolution, and Political Will have a positive influence on the sustainable development of smart cities. Furthermore, this present research discovered something new as compare with previous ones; That political will positively influence the whole variable and especially leadership as compare with the study of Dazmin (2011) who rejected the hypothesis (Dazmin Daudz & Hoo Yee, 2011).

CHAPTER V: DISCUSSION OF RESULTS

5.1 Introduction

The competitiveness of urban landscape leading to development of smart city is a subject of growing attention as cities strive to become the best places to support enterprises, economic development, and high quality living while preserving environmental resources. Similarly for the city of Penang, Malaysia, as it has a significant multiplier effect on economic growth activity and the present level strikes a balance between the sustainability aspects (economic, environmental, and social well being) of city people.

The socioeconomic standing and physical environment of the neighbourhood are significantly impacted by the increase in the urban population in Penang State, causing cities to spread into the countryside and the development of formerly undeveloped regions. Hence, the author conducted this study to understand and identify the key enablers that influence development of smart city by considering the mediation effect of ICT applications. The main aim of this study was to develop an effective model which will deliver a better city administration whereby authorities can adapt and leverage on technical tools achieving sustainable smart city for their growth.

Though there have been several recent studies on the characteristics of smart city, however the area still requires exploring and lacks holistic view. Most of literature focus on urban advancement rather than smart city development. There is a lack of research on the factors driving smart city development and the impact of ICT applications in Penang, Malaysia. Some of the available research that has been considered show that they lack innovation, engagement, and development practices to use smart city services in the country. (Hamamurad, Q.H.; Jusoh, N.M.; Ujang, U., 2022). Furthermore, no seminal research has been conducted in the past on the development of smart cities in the state of Penang. These findings highlight the urgent need for researchers to further investigate into the effective enablers of smart cities in the development of sustainable smart cities.

Various statistical analyses were conducted during the relationship development process to gather analytical observations related to business practices. This study reveals that the drivers and barriers identified here do not possess independent dimensions; thus, further confirming the connection among the sustainable development of smart city (SDSC) dimensions. As highlighted in the literature, there is an obvious overlap of dimensions. For instance, concerning the challenge of 'lack of updated infrastructure. With regards to urban infrastructure and governance, scholars have expressed concerns about the existing inefficiency of human resources that are technologically comprehensive. For example, (Pike, 2019) pointed out the relevance of developing data management capacity. The inadequacy of IT knowledge is regarded as a capacity challenge; therefore, it is a responsibility of the government which falls under leadership. Asides the challenge of operational IT workforce, scholars have equally expressed concerns regarding the inadequacy of IT knowledge within policy makers and public authorities which otherwise can influence digital transformation.

The significance of governance for Sustainable Development of Smart City has been emphasized in this study. Nearly all the data analysis revealed that over (94%) emphasized not-less-than one governance driver or barrier (at least 63% drivers and 60% barriers). Few of these barriers are directly related to the absence of an enabler. As highlighted by some scholars, 'information and knowledge sharing' make up for Sustainable Development of Smart City success driver. Other scholars also emphasized that conflicts of interests and lack of Citizen Participation are both influenced by lack of information sharing. Additionally, political instability remains another critical aspect of governance. A great way to alleviate the impacts of this barrier would be to develop a proper city vision as well as to develop strategic planning; especially considering that this factor is not directly related to any particular political party. This would serve as a sustainable long-term initiative. Further, another governance function is in the implementation of policies that support multi-domain aspects connected to mobility, health, security, and education; economic growth driven by social inclusion and innovation.

Because of the 'smart' aspect of SDSCs, several studies are technologically focused. The study's outcome indicates that the SDSC academic literature prioritizes ICT over urban physical infrastructure; nevertheless, there is a relationship regarding the aspects of infrastructure. Again, some of the identified drivers have the potential to cause side effects. For example, design, monitoring, and service provision can be enhanced by big data. However, there is still a challenge regarding the alignment of city infrastructure with the use of these technologies.

Therefore, as a result, this research will be a key work in the subject of smart city development for Penang, Malaysia's municipal and policymakers. The state can effectively become a smart city by implementing these enablers and tapping on ICT applications. ICT applications was chosen as an effective mediator for the development of smart cities, as with the use has a significant impact on the quality of life of Penang citizens, particularly not using ICT applications would be a waste of resources (Thomas, V.; Wang, D.; Mullagh, L.; Dunn, N. 2016). Cities of the future will require more efficient infrastructure to facilitate the growth of smart cities.

Many cities implement smart projects/ initiatives, but that does not make the city smart. This study takes the first crucial steps toward understanding these characteristics of Penang's smart city by adding enablers such as citizen participation and political will (municipal/policymakers) desires to use smart city services based on ICT applications. The findings offer valuable guidance to decision-makers involved in developing sustainable smart city. By recognising and understanding the barriers identified, policymakers, urban planners, and stakeholders can make informed decisions and developed targeted strategies. The strategies can address the specific challenges posed by inadequate infrastructure, limited funding, regulatory complexity and cybersecurity concerns. Further, holistically the municipals can embed further smart services encompassing technical solutions and measures by expanding services in the city (to begin with i.e; e-government services). By integrating ICT applications with development of smart city, the researcher has not only strengthened both the fields of ICT applications and development of sustainable smart city but has also established a comprehensive framework from what agencies can benefit from.

5.2 Research objective 1: There is positive relationship between Key enablers of smart city and development sustainability of smart city

The outcome of this study also indicates that innovations are indeed critical to the development of sustainable smart cities; the prevalence of several ICT tools can significantly contribute to addressing several challenges of sustainable urban development. Previous studies indicate that smart city innovations are often times perceived from Nam and Pardo (2011) categorization of technology innovation (fourth industrial revolution), organization innovation or infrastructure), and policy innovation (Samih, 2019). However, with the evolving nature of smart cities, there has been increased adoption of technology, thus portraying smart cities as innovation ecosystems (Hämäläinen, 2020). Such varying innovation mechanisms range from tech solutions that enhance user engagement and renewal procedures (Angelidou, 2019).

According to (Lim, 2019) smart city projects generally comprise numerous innovative dimensions and initiatives aimed at achieving city development and sustainability. Even though numerous papers cite SOIs from a technological perspective, other innovations are required to effectively tackle the various economic, ecological, and social challenges on an urban scale. Such innovations include social, policy, managerial and strategic aspects (Zeng, 2021). The results from the review reveal that smart city SOIs are significantly connected to the creation of effective citizen engagement, innovation networks as well as open innovation practices. This was supported by Toppeta (2010) who emphasizes the relevance of innovative solutions in managing complex systems such as a smart city project (Oke, 2022).

Considering the extensive nature of the literature's analysis, four primary perspectives were first identified. Here, discussions of the smart city SOI dimensions were conducted by some scholars as follows; technology perspective, organizational perspective, social innovation perspective as well as citizen engagement, system-level changes, and innovation ecosystems. This was followed by the recognition of various focused themes under each of these perspectives. References were also made concerning related literature sources.

Because of the 'smart' factor in sustainable smart cities (SSCs), majority of the studies were technologically focused. The outcome reveals that the SSC academic literature gives more priority to ICT over urban physical infrastructure; however, these infrastructure aspects are related. Furthermore, some identified driver aspects also had the potential to cause side effects. For instance, availability of big data can help enhance design, monitoring, and service provision; still, the city infrastructure must align with the usage of these technologies.

5.3 Research Objective 2: There is a positive relationship between key enablers of smart city and ICT applications

Asides technological innovations, the transformation towards more sustainable smart cities calls for adequate innovative planning, management, and operations (Bisht, 2020); (Angelidou, 2020); (Gravagnuolo, 2019). Some scholars gave more focus to strategic innovations towards management, design, and particularly governance (Berke, 2019) regarding the implementation of various technologies, services and business approaches that can effectively enhance transition towards smart cities (Androniceanu, 2019); (García-Fuentes, 2021), as well as towards the achievement of sustainable development goals (Doost Mohammadian, 2020). Yet, other scholars emphasized on the need to support regulations, policies and governance aimed at achieving smart cities SOIs (Fraske, 2020). Emphasis was made by (N Tura, 2022) regarding the significance of innovation management capabilities (or leadership) in the planning, development, and sustainability of smart cities. These capabilities are equally required in innovation management and SOI literature. They are categorized under five dimensions including strategy, organization, processes, linkages, and learning (C Crovini, 2019). In addition, the significance of dynamic capabilities was identified (Lee, 2020) as well as the relevance in developing capacity for radical and disruptive innovation in order to exploit the advantages associated with ICT (Mora, 2019).

The significance of governance for sustainable smart city (SSC) development was emphasized by the results of this study. 94% of all analysed papers buttressed at least one governance driver or barrier (63% drivers and 60% barriers). Some of these barriers were linked to the absence of an enabler. For instance, 'information and knowledge sharing' were emphasized as drivers of SSC success by some scholars. In the same vein, other scholars opined that lack of information sharing promotes conflicts of interests and thus lack of engagement. Political instability represents another relevant aspect of governance. A great way to address this challenge is to properly define a city vision and also create strategic planning which is not bound to any particular political party in order to have a sustainable (long-term) initiative. Another governance aspect is the use of policies, which must contemplate multidomain aspects related to mobility, health, security, and education; stimulating social inclusion and innovation to drive economic growth.

5.4 Research Objective 3: There is a positive relationship between ICT application and development of sustainability of smart city

ICT applications plays a major role in a sustained economic and industrialization all over the world (Henderson, 2003). ICT applications also supports businesses and households towards accessing information and knowledge, it helps to reduce transaction costs, while taking advantage of advanced technologies such encompassing industrial clusters, big data and IoT which help the development of smart cities. Thus, findings revealed that regions that have a better public infrastructure access are becoming the highly attractive regions for productive activities.

Despite its diverse positive impacts on the economy, ICT applications without the commensurate development and revolution in the area of technology and infrastructure as well as public policy all contributed to different negative outcomes, which include increasing urban development costs as well as negative environmental influence.

Thus, in various nations of the world, Cost associated towards the development of smart cities represent large contribution of the revenue of household, thus negatively affect the quality of life within the cities. In other to mitigate and reduce the negative impacts that the development of smart cities has on the environmental, there is a need to implement appropriate policies both in developed nations and the developing nations as well.

With such consideration, the ICT adoption help to ensure the sustainability of smart cities. On the basis of the ICTs, smart transport represents a driver towards the reduction of carbon emissions, considered to be the main drawback of the macro-environmental of urbanization. Smart cities need a high ICT penetration level. ICT fundamentally helps prerequisite automation, smart technologies, and the IoT (Internet of Things), making the human activities (or citizen) work and in life more efficient. However, smart technologies and ICTs does not a panacea which enable the continuation of different conventional growth of the economy without having negative outcomes on the environment. For example, the production as well as the operation of ICTs' devices and equipment, and related recycling process, which include massive detrimental effects on the environment.

5.5 Research objectives 4: There is a positive relationship between Key Enabler of smart city with ICT Applications as mediator and development of sustainability of smart city

Several articles from our data set (104 out of 159) highlighted that technology-oriented innovations are an essential dimension when it comes to sustainability-oriented innovation. In specific terms, several authors perceived smart cities SOI development as the application of several ICTs (Van den Buuse, 2019); (Oliveira, 2020); (Szarek-Iwaniuk, 2020) (Guma, 2021) (Thornbush, 2021). Additionally, other authors emphasized the relevance of implementing different innovations that help sustain the environment (eco-/green innovations) (Cheshmehzangi, 2022), as well as process innovations (Atta, 2020). Generally, technological innovations promote information and also make available tools that support sustainable cities activities measurement and management (e.g., low-carbon energy systems) (D'Amico, 2020). Opportunities and possibilities for innovations are also provided in order to promote sustainable citizens actions (Kahya, 2021).

Key enablers of smart cities sustainability include technology and innovation (D'Auria, 2018); (Lopez-Carreiro, 2018). The integration of new technology in the management and operation of cities provide innovative solutions to barriers such as economic growth, sustainability, and equity in urban region cities (Haarstad, 2019) (Vaz, 2021). As succinctly put by (Miller, 2020); there exists a connection of smart cities and techno-political projects which are linked to economic advancement, innovation, and sustainability commitment. Hence, innovation can be perceived as a tool or software that enables city managers to effectively assimilate urban policies alongside sustainability (e.g., air quality control, city level water and land use) (Pardo-García, 2019). In recent terms, technological innovations like IoT and 6G network have been emphasized as contributing to enhanced city resilience; a situation promoted by the COVID-19 pandemic. The pandemic revealed the relevance of several digital and smart services such as; people tracking and remote work (working from home) (Allam, 2021); (Khanjanasthiti, 2021); (Newman Ao, 2020). Further, technological innovations serve as criteria for system-level innovation

(Zhang et al., 2020), such as the enhancement of transportation systems (Angelaki et al., 2020; Bosich et al., 2020; Valdez et al., 2018; Yigitcanlar et al., 2019c), food systems (Baena et al., 2020) as well as low-carbon energy systems (Pardo-García et al., 2019; Galvão, 2017; Zhuang et al., 2020).

Asides analysed papers that described the opportunities promoted through new technologies, other papers focused on the risks associated with new data-driven technologies with regards to smart city. Although technologies are known to provide several solutions; in reality, the speed at which it develops does not correspond with the human angle considerations, thus increasing already existing challenges of the eco-system (Cao et al., 2020). Similarly, these short cycles of technological innovation contribute to enormous e-wastages as well as sustainability challenges (Das et al., 2020). Critical perspectives related to data-driven smart urbanism (associated risks and implications), have raised many critical questions regarding social and environmental sustainability, as well as techno-centric policies and technocratic governance (Bibri, 2021a, Bibri, 2021b, Bibri, 2021c). Challenges associated with the use of 6G technologies were identified by Allam and Jones (2021) to include limitations in infrastructure capacity, security of network, energy efficiency, high costs, etc.

According to Treude (2021); considering the evolving nature of technology, sustainability is not always the outcome of every smart city; for instance, energy efficiency, whereby there is a possibility for an opposite impact. There have been security concerns regarding several new smart city technologies (Budrin et al., 2020); for instance, autonomous vehicles (Cugurullo et al., 2020), real-time monitoring, as well as cloud computing (D'Amico et al., 2020; Haque et al., 2021). Other instances include the blockchain technology which may come with social acceptance related challenges (Belli et al., 2020; Mora et al., 2021); energy consumption sustainability (Parmentola et al., 2021). The so-called digital divide was emphasized by Shin et al. (2021) as a user engagement related gap that came with novel technologies. In line with their Korea survey outcome (Shin et al., 2021), socio-demographic issues such as age, religion, income etc. can be responsible for such city digital divide. Again, according to suggestions by Mann et al. (2020) regarding technology sovereignty; public and common interests were emphasized over private interests in the development of smart urban cities.

CHAPTER VI: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Based on thorough review of extensive literature comprising 169 articles, this research gave focus to the question; "What are the main enablers and challenges for the development of Smart Sustainable Cities?" This study created an opportunity to identify drivers (57) and barriers (63) that impede the development of Sustainable Development of Smart City (SDSC), classified under the major SDSC domains (including economic, social, governance, environmental and urban infrastructure). The outcomes here indicate that that there are SDSC nuances which are not generally applicable to smart cities. Adding the term 'sustainable' to smart city promotes the impression of an idea which fulfils present needs while at the same time not jeopardizing future generational abilities.

Further, this research endorses the fact that SDSC is not a research field; rather it remains a concept that joins other disciplines. Considering several identified factors and references that emphasize each SDSC domain; the factor of governance can be regarded as the major domain for the development of sustainable smart cities, leading the way for economic, social, urban infrastructure and environmental growth. As such, the outcomes reveal a connection between several identified drivers and barriers, which goes to suggest that several SDSC barriers are avoidable and addressable through good governance. Besides, the development of SSC is a complicated issue that calls for wide and holistic attention.

Research on development of smart city is mostly occurred in developed countries. The lack of theoretical establishment on this topic in the field of smart cities in Malaysia implies that it is derived from academic fields mostly in the Western world. As a result, the findings and conclusions of this study can help to advance the development of smart cities, particularly in the Asian region. In academic study, there are a lot of scope to develop on the theory derive from this research. And considering these factors, academician may develop a special theory for sustainable development of smart city in Malaysia. The study made a novel contribution to the body of knowledge by incorporating citizen participation i.e.: city stakeholders, as a key enabler of smart city development. Citizens' trust in the government reflects their belief in the development of smart cities. The city competency is primarily reliant on the municipal / state leaders that run it. Users of smart city services (integrated with ICT applications) in a developed smart city, will find and recognise the value and importance of safety and security.

The researcher has found that there is significant lack of study in the enabler of citizen participation in developing smart city. Hence this study makes significant contribution to the fields of literature especially for Malaysia context.

6.2 Recommendations

Regarding contributions, this present study is geared towards addressing the existing challenge impeding Sustainable Development of Smart City through providing a comprehensive illustration of such drivers and barriers. Hence, the study possesses the potential to enable varying stakeholders comprising of decision makers, public administrators, and practitioners to effectively identify factors to focus on during Sustainable Development of Smart City initiatives that can create benefits on the long-run.

Relevant managerial implications regarding the construction of smart cities are embedded in this study’s findings. Firstly, the basis of Research Objective 3 for the development of smart cities remains ICT applications, as well as the enhancement of individual behavioural data; this is usually accommodated actively or passively in the network of smart cities. It is relevant to note that data storage and transmission requires high level security and confidentiality. Further, the residential network security environment remains the grounds for enhancing the usefulness and convenience experience as well as SWB.

Secondly, Research Objective 2, significant key enablers such as political will which is directly associated with governance, i.e.: individuals who possess the power to develop strategic planning and as such, aim for services that fulfil such needs and interests. The focus of this study is on the willingness and attitude of citizen participation, thus impacting their happiness directly. Consequently, smart city development gives attention to the general needs of urban residents and fulfils their individual needs – a vital aspect of improve smart cities future well-being.

Potential challenges or barriers in the real-world context of Penang, may include the level of readiness as to multidisciplinary issues and the cost element for municipal administrations, as they may not prioritise profit, but pursuing efficient and high-quality services that meet expectations of users i.e. residents make development of smart city a significant endeavour. Hence, which may outweigh the advantages/ benefits of incorporation ICT applications into the current services in order to become a smart city as a whole.

On a final note, the needs of people are effectively fulfilled when innovative services address them. This is serves as a reminder for governments, enterprises, and relevant institutions to be more deliberate hen embarking on smart city development. For instance, economic developments that motivate domestic demand and also enhance enterprise performance. In the same vein, the study also acknowledges the presence of several limitations, thus creating possibilities for future research directions.

6.3 Suggestion for future research

At the beginning, a self-reported survey and convenient sample research approach were adopted to effectively obtain relevant data on a representative sample of inhabitants, that is the people, municipal and state government official staff, which is the limitation of this research which researcher acknowledges. However, the findings of this research can contribute to the advancement of sustainable development of smart cities. By leveraging these insights, decision makers can navigate the complexities, address the challenges and unlock the transformative potential of smart city initiatives that can develop the state to be smart city.

Further, in the future, mixed method approach can be adopted along with broadening the sample size data collected for the population of Penang and engaging diverse stakeholders would help validate and expand upon the findings. Further, 'people' aspect on smart cities subjective well-being is impacted by three experiences which include safety experience, usefulness experience and convenience experience. Generally, peoples' experiences are complex and evolving; hence there may possibilities for other dimensions of peoples'/residents' experiences which impact their subjective well-being. This gap is therefore open to future research and exploration.

Malaysia has 13 states and three federal territories. This study focuses on one state, Penang. Many other cities have begun or plan to begin a smart city strategy, and municipal leaders want to make sure that citizens are willing to support such an effort for a higher quality of life. Hence, researcher encourage future research to expand the geographical sample scope

Finally, the independent variables in this study hardly possess any substantial effect on subjective well-being. In follow up studies, these factors should be considered. Additionally, individuals' perceptions and attitudes regarding life and work can also be influenced by regional culture and specific life events. Further, subsequent studies can equally consider and conduct more detailed investigations in this field to build on this work and drive the progress of smart cities toward a smarter and more sustainable future. This will help expand the scope when exploring possible differences regarding sudden and long-term factors.

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APPENDIX I

EC815 PG2 Ethics form Approved - DALBEER SINGH, ARVIN KAUR 1713747

Yahoo/Inbox

Postgrad Research <pgresearch@uwtsd.ac.uk>
To: liz_saini@yahoo.co.uk, liz_saini@yahoo.co.uk
Cc: vikines@hotmail.com, wnhayate@unisza.edu.my, Jill Venus, Uma Mohan, Noha Khawam and 4 more...

Wed, 31 Mar 2021 at 21:39

Dear Arvin Kaur Dalbeer Singh,

I am pleased to confirm that the submission of the Ethical Approval on your research 'Key enablers that influences Sustainable Development of Smart City in the State of Penang, Malaysia' has been APPROVED by the University's Ethics Committee.

Please ensure that you are aware of, and use, the University's Research Data Management Policy and the extensive resources on the University's Research Data Management web pages (http://uwtsd.ac.uk/library/research-data-management/).

Please do not hesitate to contact the office should you require any further information on this matter.

Kind regards

Steve Davies

Cymraeg

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APPENDIX II

Questionnaire

<u>Key Enablers that Influence the Sustainable Development of Smart City, Penang, Malaysia</u>

Aim: This research is carried to understand and identify key enablers that influences the sustainable development of smart city.

Objective: All responses will be essential in developing an effective strategic framework model for a sustainable smart city in Penang, Malaysia.

This questionnaire is designed to collect primary data for the Doctor of Business Administration Programme's final thesis. The information gathered from the questionnaire will be used solely for research purposes and will be kept strictly confidential. Utmost confidentiality is assured in all your responses and the organisation for which you work.

SECTION A: DEMOGRAPHY		
This section records the general questions and necessary demographic data of the respondents.		
Kick tick (✓) in the space provided. All information will be kept strictly confidential.		
1.	**Kindly indicate your Gender**	
		Female
		Male
2.	**Kindly indicate your age**	
		21 years – 25 years
		25 years – 29 years
		30 years – 34 years
		35 years – 39 years
		40 years – 49 years
		50 years and above
3.	**Kindly indicate your occupation?**	
		Government
		Business player
		Administrative Staff
		Other

4.	**What is a smart city?**	
		It is a city that uses information and communication technology (ICT) to improve operational efficiency
		It is a city that share information with the public and provide a better quality of government service and citizen welfare
		It is a city that makes optimal use of all the interconnected information available today to better understand and control its operations and optimise the use of limited resources.
		All of the Above

SECTION B: DEPENDENT VARIABLE: SUSTAINABLE DEVELOPMENT OF SMART CITY											
Please, concerning the statements below, kindly use scale 1 to 10 where: *1: Strongly disagree and 10: Strongly Agree*											
5.	**To what extend do you agree that a smart and sustainable city goal is to:**	**1** **Strongly Disagree**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10** **Strongly Agree**
	Improve quality of citizens										
	Improve well-being of its citizens by ensuring access to social and community services										
	Ensure economic growth with better employment opportunities										
	Establish an environmentally responsible and sustainable approach to development										
	Ensure efficient service delivery of basic services and infrastructure such as public transportation, water supply and drainage, telecommunication, and other utilities										
	Provide an effective regulatory and local governance mechanism ensuring equitable policies										
	Ability to address climate change and environmental issues										
6.	**To what extend do you agree that ICT is the fundamental enabler for smart city?**										
	ICT in the smart city is used to enhance the quality, performance, and interactivity of services										
	ICT in the smart city is used to reduce costs and resource consumption, and improve contact between citizens and city stakeholders										
7.	**How will your community primarily implement smart city technologies**										
	Build/operate systems internally										
	Operate solutions from consultants										

	Outsource solution development and operation activities to consultants										
	All of the above										
8.	**For each of the following sectors, to what extend do you agree that smart city technologies represent for your community?**										
	Public safety level of priority is towards smart city is high										
	Technology represents high level of priority towards the development of smart city										
	Telecommunications represent a high level of priority towards the development of a smart city										

SECTION C: MEDIATING VARIABLE: ICT APPLICATIONS											
Please, concerning the statements below, kindly use scale 1 to 10 where: *1: Strongly disagree and 10: Strongly Agree*											
9.	**To what extend do you agree that ICT Applications is a key enabler of the development of a smart city?**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
		Strongly Disagree									**Strongly Agree**
	IoT and Cloud computing are key determinant element influencing ICT										
	Urban Computing help in improving citizen lives										
10.	**To what extend do you agree that ICT Applications influence the sustainable development of a smart city**										
	Information system, IoT, cloud computing all contribute to the sustainable development of smart city										
11.	**To what extend do you agree that ICT Applications enabled citizen interaction**										
	Citizen Participation Through ICT-Enabled Interactions										
	ICT Applications facilitated the provision of public service										
	ICT Applications improve citizen sourcing										
	ICT Applications facilitated citizen-government interaction										
	ICT Applications enable citizen interaction through the use of social media										

SECTION D: INDEPENDENT VARIABLE 1: CITIZEN PARTICIPATION											
Please, concerning the statements below, kindly use scale 1 to 10 where: *1: Strongly disagree and 10: Strongly Agree*											
12.	**To what extend do you agree that a citizen participation is a key enabler of the development of a smart city?**	**1** **Strongly Disagree**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10** **Strongly Agree**
	Citizen participation also is incorporated into formal mechanisms for decision making										
	Citizen participation help in gathering external knowledge, mostly from citizens, which improve the achievements by the public administration										
13.	**To what extend do you agree that ICT influence citizen participation in a development of a smart city**										
	ICT enable the empowerment capability of citizen activists										
	Internet facilitates the proliferation of an unlimited number of alternative public spaces, or counter-public spheres										
	Infrastructure and technological development help to enhance citizen life										
	Open data automatically led to citizen participation										
	ICT enable interaction between citizen and government										

SECTION E: INDEPENDENT VARIABLE 2: LEADERSHIP											
Please, concerning the statements below, kindly use scale 1 to 10 where: *1: Strongly disagree and 10: Strongly Agree*											
14.	**To what extend do you agree that a citizen participation is a key enabler of the development of a smart city?**	**1** **Strongly Disagree**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10** **Strongly Agree**
	Leadership affects a smart city's political level										
	Leadership affects a smart city's political risk										
	Leadership affects a smart city's corruption level										
15.	**To what extend do you agree that ICT influence leadership in a development of a smart city**										
	Policy makers in leadership should find ways to relieve the path dependence on technology adoption										
	Policy makers in leadership need to increase the ease at utilising ICT										

SECTION F: INDEPENDENT VARIABLE 3: INFRASTRUCTURE											
Please, concerning the statements below, kindly use scale 1 to 10 where: *1: Strongly disagree and 10: Strongly Agree*											
16.	**To what extend do you agree that infrastructure is a key enabler of the development of a smart city?**	**1** **Strongly Disagree**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10** **Strongly Agree**
	Smart technologies such as digital devices and Internet networks enable the development of smart cities										
	Technology infrastructure is an important factor of a smart city, the effect of the technology infrastructure depends on human infrastructure development										
17.	**To what extend do you agree that ICT influence infrastructure in a development of a smart city**										
	Automated and Simplified Network Management concept allow the network to be managed as a single entity, reducing complexity, and increasing efficiency										
	Automatic Security Threat Isolation and Remediation network security management provide a more secure and improve end-user experience										
	IoT application is essential to reduce the costs of wireless installations										

SECTION G: INDEPENDENT VARIABLE 4: FOURTH INDUSTRIAL REVOLUTION											
Please, concerning the statements below, kindly use scale 1 to 10 where: *1: Strongly disagree and 10: Strongly Agree*											
18.	**To what extend do you agree that the fourth industrial revolution is a key enabler of the development of a smart city?**	**1** **Strongly Disagree**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10** **Strongly Agree**
	Open innovation within smart city platforms focuses on a decentralized approach to innovation										
	Fourth Industrial Revolution help to solve the paradigm complex										
19.	**To what extend do you agree that ICT influence forth industrial revolution in a development of a smart city**										
	Artificial intelligence, IoT are becoming key elements of smart cities as they are merged with cities										
	Big data technology has a high influence on smart cities development										
	Automated and Simplified Network Management enable the network to be well manage, reduce complexity, and increase efficiency										

	ICT technologies play a key role in revitalizing the economy as a new growth engine for smart city development										

SECTION H: INDEPENDENT VARIABLE 5: POLITICAL WILL											
Please, concerning the statements below, kindly use scale 1 to 10 where: *1: Strongly disagree and 10: Strongly Agree*											
20.	**To what extend do you agree that political will is a key enabler of the development of a smart city?**	**1** **Strongly Disagree**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10** **Strongly Agree**
	Policymakers should pay more attention to the evolution of 'smart cities approach' in order to correctly understand regional and urban dimensions of economic development policy										
	Institutions (governance and policy) are key component of smart city										
	Smart governance is about promoting smart city initiatives										
	Governments struggle to meet the basic public service needs of their citizens negatively influence development of smart city?										
21.	**To what extend do you agree that ICT influence political will in a development of a smart city**										
	Policymakers should favour ICT integration for the good development of smart city										
	Technology-related infrastructure readiness poses an imminent challenge to smart city adoption										