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ACCRA AS A SUSTAINABLE SMART CITY: CAN THE QUINTUPLE HELIX OF INNOVATION APPROACH DELIVER?

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DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge it contains no material previously published by another person or material which has been accepted for the award of any other degree of the university, except where due acknowledgement has been made in the text.

DEDICATION

I dedicate my thesis to my mother, Sophia Saakor Nettey, as well as all members of the Quarcoo, Nettey, Nunoo, and Hesse families, as well as my noble mentors, Professor Christian Iaione, Professor Paolo Galizzi, Dr Daniel Appiah, Mr Solomon Nii Aryaa Tetteh, Canon Attoh and Rev, 'd Allotey-Pappoe without whom I would not have progressed this far.

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ABBREVIATIONS & ACRONYMS

AI	Artificial Intelligence
AMA	Accra Metropolitan Assembly
AfDB	African Development Bank
AHIC	African Health Innovation Centre
APIs	Open Application Programming Interfaces
ASIP	Accra Sewage Improvement Project
AU	African Union
BRT	Bus Rapid Transit
CAP	Climate Action Plan
CE	Circular Economy
CDC	Centre for Disease Control and Prevention
CLOGSAG	Civil Service and Local Government Staff Association, Ghana
CPS	Cyber-Physical Systems
CSIR-WRI	Council for Scientific and Industrial Research-Water Research Institute
CSO	Civil Society Organisation
DVLA	Driver, Vehicle Licensing Authority
DE4A	Digital Economy for Africa Initiative
EGDI	E-Government Development Index
EPA	Environmental Protection Agency
EU	European Union
FDA	Food and Drugs Authority
GAMA	Greater Accra Metropolitan Assembly
GAEC	Ghana Atomic Energy Commission

GDP	Gross Domestic Product
GII	Global Innovation Index
GPS-CID	Ghana Police Service- Criminal Investigation Department
GODI	Ghana Open Data Initiative
GSS	Ghana Statistical Services
IBM	International Business Machines Corporation
ICT	Information Communications Technology
ITS	Intelligent Transport Systems
ITU	International Telecommunications Union
KFL	Kenyan Flying Labs
KOICA	Korea International Cooperation Agency
LLMICs	Low-Level Middle-Income Countries
LUSPD	Land Use and Spatial Planning Department
MAG	Modernizing Agriculture in Ghana
MoT	Ministry of Transport
MEST	Ministry of Science, Technology, and Innovation
MLGDRD	Ministry of Local Government, Decentralization, and Rural Development
MSWR	Ministries of Sanitation and Water Resources
NADMO	National Disaster Management Organisation
NBA	National Biosafety Authority
NCCE	National Commission for Civic Education
NGO	Non-Governmental Organization
NITA	National Information Technology Agency
NHIS	National Health Insurance Scheme

NHP	National Housing Policy
NRA	Nuclear Regulatory Authority
NSDF	National Spatial Development Framework
NSS	National Service Secretariat
NUPF	National Urban Policy Framework
OECD	Organisation for Economic Co-operation and Development
PERD	Planting for Export and Rural Development
PWD	Public Works Department
QBS	Quality Bus Service
QH	Quadruple Helix/ Quintuple Helix
RTI	Right to Information
SDG	Sustainable Development Goal
STI	Science, Technology, and Innovation
TFL	Tanzanian Flying Labs
TH	Triple Helix
UAV	Unmanned Aerial Vehicle
UN	United Nations
UNECE	United Nations Economic Commission for Europe
WIPO	World Intellectual Property Office
WMD	Waste Management Department

ABSTRACT

The main objective of this study is to contribute toward a comprehensive understanding of how the quintuple helix approach of innovation could be the tool to support Accra in becoming a sustainable smart city. The quintuple helix consists of the government, industry, academia, media-based culture (media, NGOs, citizens) and the ecosystem. This work shows the characteristics of a sustainable smart city and where Accra, the capital city of Ghana cannot be considered smart, further investigating the current approach of innovation being applied by the city and analysing if all the relevant stakeholders collaborate in their responsibilities towards building Accra as a sustainable smart city. The results reveal that Accra currently uses the quadruple helix approach of innovation and in terms of being sustainably smart, transportation and environment in Accra cannot be recognised as smart. The smart living concept also varies in Accra and is wholly not identified as smart. In understanding the key players, their roles, responsibilities and level of collaboration, the results showed that collaboration exists amongst them. It is also observed that to aid Accra to become sustainably smart, it needed an Accra-based context of the quintuple helix approach which will identify the traditional authorities as relevant and the need to add them to the quintuple helix. The study further explores ongoing projects within the African continent and Accra specifically as they have been deemed useful for future references.

Keywords: quintuple helix , innovation, smart, sustainable, approach, Accra, Accra-based context, traditional authorities, ecosystem.

CHAPTER ONE

INTRODUCTION

1.1 Background Of The Study/Problem Statement

1.1 Background Of The Study/Problem Statement

Throughout the last decades, the introduction of Information Communication Technologies has created a trend of providing daily objects with smartness, intending to make human life more comfortable[1]. The paradigm of Smart Cities comes up as a response to the goal of building the city of the future, where (1) the well-being and rights of their citizens are guaranteed, (2) industry, and (3) urban planning is assessed from an environmental and sustainable perspective (Sa'nchez-Corcuera et al., 2019). In 2020, Accra won the grant of the International Business Machines (IBM) Smarter Cities Challenge, but there is still a lot to be done in terms of equality, inclusion, diversity, social justice, as well as in terms of technology to include the aspect of smart energy, smart citizens, smart health, and other technological dimenstions despite this achievement[2]. This problem might emanate from not recognizing the importance of conceiving the city as a complex system and therefore the role actors diferrent than governments and private companies play in the game, especially citizens, knowledge institutions, and non-governmental organizations (Frey et al., 1985). The Quintuple Helix Model of Innovation, which codifies the principles, tools, and processes of collaboration amongst these five actors, the various roles they play, and how they interact, might contribute to the development of an inclusive, sustainable, smart, climate-neutral city. At least this is the research hypothesis that I will pursue in this study.

1.2 Justification Of The Study

The study is motivated by the need to understand if and how the relationships and forms of cooperation between the actors and interests that make up the quintuple helix of innovation model can be applied in African cities and in particular whether they can help transform Accra

[1] https://www.pewresearch.org/internet/2019/10/28/4-the-internet-will-continue-to-make-life-better/

[2] https://www.thesmartcityjournal.com/en/articles/smart-city-accra-ghana-gold-coast

into an inclusive sustainable smart city. In addition, it will serve as a guide to policymakers in Ghana on how to implement smart innovation, sustainability and climate-neutrality in all aspects of development. A literature review on the Quintuple Helix of Innovation and sustainable smart cities reflects increasing research on both developed and developing cities. This illustrates that the findings acquired will play a crucial role addressing the gap and serve as a guide to policymakers in Ghana on implementing smart innovation and sustainability in all aspects of development. Generally, studies look at the smart city initiative with Africa in focus yet this study would consider one city, that is Accra, and carefully analyze measures that are being put in place to build it as a smart city. The study would also look at how to incorporate political, social, and economic elements with institutional and policy frameworks necessary to make the city of Accra a role model of an inclusive sustainable smart city for other African countries.

1.3 Research Objectives

The study's main objective is to find out whether Accra is a smart city and how it can support the city in becoming smart by understanding its approach to innovation. To achieve this, the following specific objectives seek to:

I. Examine the characteristics of a Sustainable smart city and analyze the aspects where Accra does not meet up as a smart city.
II. Investigate the current approach of innovation being used to build Accra as a sustainable smart city.
III. Analyze whether all the relevant actors collaborate in their responsibilities toward building Accra as a sustainable smart city.

1.4 Research Question

"Could collective action, self-organization, and technology that enables self-sustainability, social norms & informality be the recipe that African cities and in particular Accra adopt and contribute to the global quest for smartness and sustainability in cities ?"

1.5 Research Method

This considers the research design, instrumentation, data analysis, ethical considerations, and limitation of the study. The chapter discusses different methods such as the sampling method and data collection method used in collecting and analyzing the data.

1.6 Relevance Of The Study For Accra

By 2050, the world's population is estimated to exceed 10 billion people, with 67 percent of them living in cities, up from 54 percent in 2016[3].Furthermore, the ongoing urban transformation puts more strain on the environment. The earth's resource base frequently causes negative social externalities and diseconomies of scale agglomeration. These considerations have heightened the necessity to guide the transformative process of cities as a driver for sustainability (Rincón et al., 2021). Even though smart cities are a relatively new topic of research and implementation,(Tura & Ojanen, 2022) the literature on the subject is already extensive and growing. Given the potential utility of smart cities, the COVID-19 pandemic has contributed an extra push to smart city research, as projected. For dealing with the situation, smart city solutions are available through the use of artificial intelligence and machine learning mechanisms. As a result, a substantial body of study has been conducted in the last year or two, publishing several papers in this field. This is an excellent opportunity for examining whether and how smart city solutions can be implemented, based on a growing body of literature. Modern technologies have aided in the fight against the epidemic and the development of resilience (Sharifi et al., 2021). During the pandemic, most cities put smart measures to help fight the deadly novel virus. Accra also implemented a technological collection of data within health centers, at the airports, hotels and guest houses, and other vantage points. Due to not having a globally accepted & standardized mode of measuring the smartness of a city, currently, the position of Accra is not known. Accra has been chosen for this study because it is the capital of Ghana and the seat of both local and central government. It is thus appropriate that if a method of innovation is to be studied, Accra be considered, and it is also one of the few African cities that has achieved the majority of the sustainable development goals.The underlying issue is that the level of smartness of Accra is not

[3] https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

scientifically or empirically known, the model of governance used cannot also be determined and is slowing the progress rate to become a smart city. This is relatable to issues of poor governance and policy instruments, lack of cooperation, clarity, and definition of roles amongst the actors, just to mention a few. In this context, this study addresses the implication of the introduction of the quintuple helix theory of innovation towards building a sustainable smart, as it is a concept that focuses on transforming cities into considering certain key sectors of the economy and improving these, thus Waste management and Smart Public Transport system.

1.7 Organization Of The Study

This study consists of six chapters.

The first chapter introduces the study and outlines its focus. It discusses the background of the study, problem statement, research objectives, research questions, justification of the study, the relevance of studying Accra, and the organization of the study.

Chapter two is a review of literature on the conceptual building blocks, such as the quintuple helix of innovation, the concepts of smart cities and climate-neutral cities. This will provide relevant data from secondary sources to answer the study's research objectives (questions) which center on the approach towards building Accra as a sustainable, smart & climate-neutral city using the quintuple helix of approach.

Chapter three discusses Ghana, and uses Accra specifically as a case study. Here, there is a presentation of relevant data from secondary sources from the industry, the government, research & academia, NGOs & Civil Society Organizations and citizens, and the progress of Accra in adopting the theory and sustainable smart cities. It will further discuss on two existing smart city projects in Ga Mashie, a suburb of Accra by presenting an overview of these projects and analyzing them as smart projects.

The fourth chapter focuses on the research methodology and design. It discusses the research design, instrumentation, data analysis, ethical considerations, and limitation of the study. The chapter discusses different methods such as the sampling method and data collection method used in capturing, recording, transcribing, and analyzing the collected data.

Chapter five focuses on the findings from the interviews of the respondents.

The sixth chapter concentrates on discussion, implications, and recommendations on the data gathered and analyzed, drawing conclusions about future research agenda and a possible experiment in Accra.

CHAPTER TWO

LITERATURE REVIEW

2.1 Clarification of Terms

Some of the terms have been used interchangeably in this study and these shall be clarified because though they may be distinct, they have interrelated concepts and so have been used interchangeably.

The environment is described by “The World Atlas” as the immediate natural, social, or manufactured surroundings of living and non-living entities. These are referred to as an environment that impacts and shapes a person's mind and conduct[4]. The natural environment is also seen as territories largely untouched by anthropogenic activities, including those designed and preserved by humans for amusement and restoration in urban settings, that further encapsulates a range of environmental conditions, from the sparse dunes and grasslands landscape to lush landscapes rich in foliage, shrubbery, water bodies, and differing degrees of non-human animal life, encompassing a variety of environmental conditions, from the bare-boned desert and savannah-like terrain to lush landscapes rich in trees, shrubbery, bodies. Natural habitats encompass both green and blue spaces, including a wide range of topographies, features, and amenities that are not confined to a single quality or kind (J. Africa et al., 2014). The ecosystem is described as a place with a distinct and recognized landscape types, such as forest, grassland, desert, wetland, or a coastal area, which is referred to as an "ecosystem." The ecosystem's character is determined by its geographical features, which include hills, mountains, plains, rivers, lakes, coastal areas, and islands, including climate variables such as the quantity of sunshine, temperature, and rainfall in the location also influence it (Bharucha, 2005).

Transdisciplinary involves bringing together scientists from several disciplines, as well as non-scientists and other stakeholders, to look at the dynamics of systems holistically, transcending (thus "trans") disciplinary boundaries through role release and role extension (Choi & Pak, 2006) while Interdisciplinary contributions entail the collaboration and cooperation of

[4] https://www.worldatlas.com/articles/what-are-the-differences-between-ecosystem-and-environment.html

scientists from at least two disciplines who use their respective expertise to tackle common problems and produce shared outcomes (Lawrence, 2010).

2.2 Introduction

This section of the study presents the conceptual and theoretical framework of the main themes, the five-fold helix of innovation approach, known as the Polycentric Approach to Commons Governance by Elinor Ostrom (S. Foster & Iaione, 2017) towards attaining smart cities, and sustainability through various secondary sources.

This chapter is further divided into three sections which commence with a historical background of the previous helices before the current helix, the Quintuple Helix and its conceptualization and its differentiation from the earlier helices, followed by a section presenting the benefits (potential and existing benefits) and challenges of the Quintuple Helix through to looking at a city's preparedness for the innovation approach in question. The last section deals with the study's theoretical framework, which contributes to understanding and answering the research questions posed regarding the innovative approach to building Accra, the capital of Ghana, as a sustainable, smart & climate-neutral city and other African projects that are currently ongoing to address climate-neutrality.

SECTION I

2.2 Historical Background Of The Quintuple Helix Of Innovation Theory

Forster & Iaione define a polycentric system as a system in which governmental entities both compete and cooperate, interact and learn from one another, and duties at different governmental levels are adapted to match the magnitude of the public services they deliver (S. R. Foster & Laione, 2016). A general definition for the helix model of innovation does not exist but the concept of a polycentric system defines it. Traditionally, the innovation helices are used as standardized tools to teach policymakers and decision-makers a transdisciplinary approach that incorporates all possible synergies from academia, government, and society (citizens). Both cases lead the applications along with neighbouring fields (Taratori et al., 2021). The first helix, the triple helix of innovation, comprising the role of universities, industry and government, was introduced by Etzkowitz and Leydesdorff (1995). The quadruple helix was introduced by adding a fourth helix, defined as "the media- and culture-based public and civil society", by Carayannis and Campbell (2009) after some scholars criticized the triple

helix. It did not take long for criticism of the quadruple helix to emerge, leading to the introduction of the quintuple helix of innovation by adding citizenship.
In the next part, the origins of the revolutionary transition from the triple helix of innovation to the quintuple helix of innovation will be derived from this broader view of the helix approach to innovation.

2.2.1 The Triple Helix of Innovation 1.0

The triple helix (TH) model originally derives from an analysis of the renewal of the Boston economy, through a collaboration of university, industry, and government in the creation of businesses from academic research in the 1930s (Etzkowitz, 2012). Henry Etzkowitz and Loet Leydesdorff posits the "triple helix" model of knowledge, highlighting three "helixes" that interlock to produce a national innovation system: Academia/universities, industry, and state/government. Etzkowitz and Leydesdorff discuss "university-industry-government relationships" and networks, focusing on "trilateral networks and hybrid organizations" where these helices intersect (Carayannis & Campbell, 2011). The triple helix model of innovation is traced back to 1967 when Julius, director of the Dutch Central Organisation for Applied Scientific Research, first proposed the concept of a 'triangle' (Razak & White, 2015). In 1996, Leydesdorff & Etzkowitz met in Amsterdam, discussing to finalize how the three elements-universities, industries, and government can create a positive overlap amongst themselves and benefit the world of policy (Leydesdorff, 2012a).
The triple helix of innovation has gone through several transitions with different starting points such as the statist model, where the government controls universities and industry, e.g. in the Soviet Union, (France has used this before) and Latin American countries years ago. The second is the laissez-faire model, where industry, universities, and government are treated as separate and distinct entities, and where communication is to take place, it is peripheral. An example of this model is in the USA (Cai, 2014). Jorge Sabato, an Argentinian physicist, advises a top-down approach to development, where the government manages the affairs of industry and research institutes in all matters. The final model is the hybrid model of the Triple Helix which is characterized by elements of both the statist and laissez-faire model.

The origin of the TH cannot be presented without mentioning Knowledge-based Production Systems featuring Mode 1 and 2. Mode 1 is characterized by a separation between science and society. Science is about an autonomous university, self-defined and self-perpetuating

scientific disciplines and fields, and the determination by scientific peers of what counts as science and truth and what does not, which is why there is supposedly no interaction between science and industry (Shinn, 2002). Mode 2 is the direct opposite of Mode 1. In contrast to Mode 1, Mode 2, which was coined by Micheal Gibbons and other scholars in 1994 goes beyond traditional knowledge production and is more heterogeneous and distributed across networks that are not tied to traditional research institutions. It is transdisciplinary, contextual and uses practice-based problem solving enabled by different types of networks, and focuses on the integration of academic and other relevant actors that have been ignored in the technological and scientific field (Rosenlund et al., 2017).

To mention just a few of the criticisms of this theory by other scholars: One is that it pays little attention to national contexts and other social circumstances (Cai, 2014). Another challenge of TH is the collaboration of universities with other institutions under this model, which in turn raises the question of how these problems may affect the interactive process between these institutions. Again, this raises how universities, that are not interested in an entrepreneurial role, will deal with the model (Razak & White, 2015).

Figure 1: The Triple Helix Laissez-Faire Model

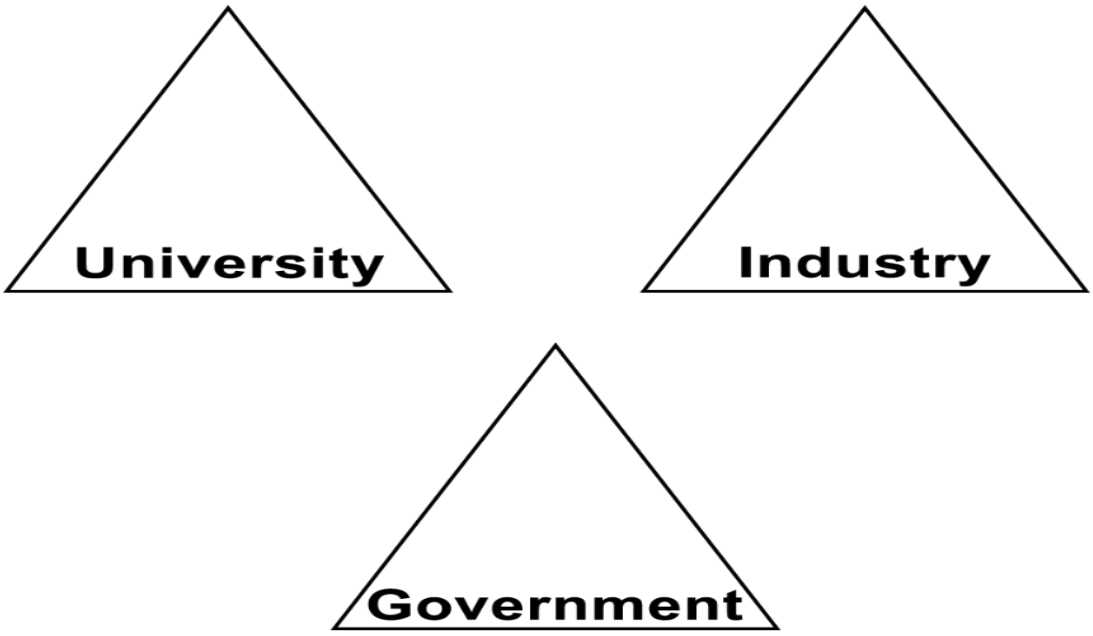


Figure 2: The Triple Helix Statist Model

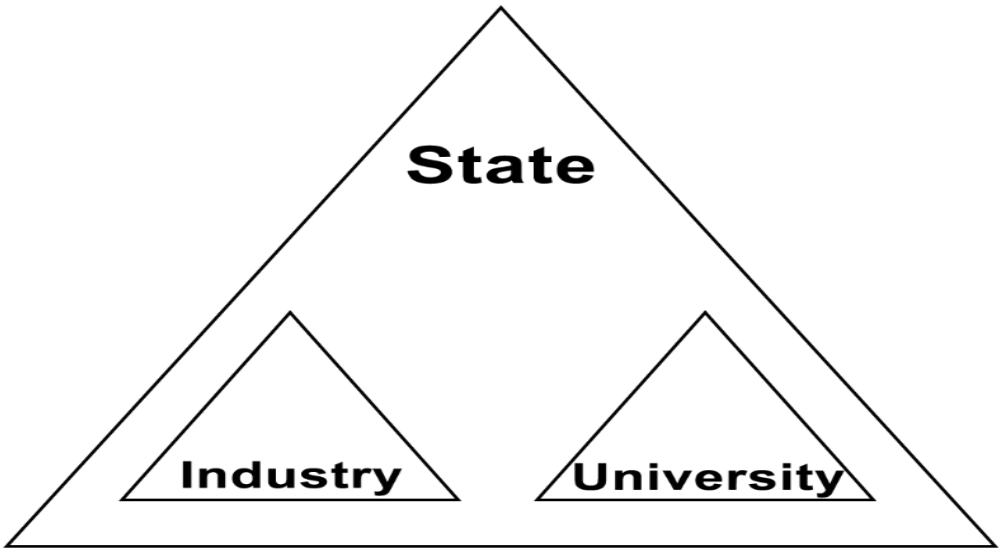
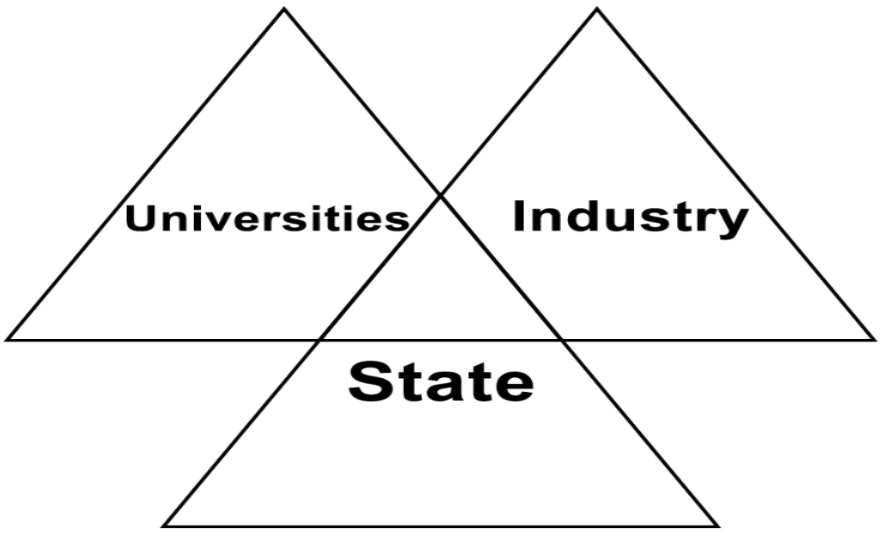


Figure 3: Trilateral Hybrid Model



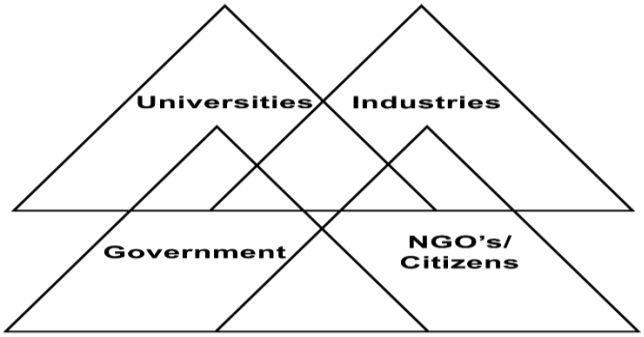
Source: Constructed from various secondary sources

2.2.2 The Quadruple Helix of Innovation 2.0

The quadruple helix (QH) is an extension of the triple helix of innovation and emphasizes academia/university, industry, state/government, and adds the fourth helix, which is recognized as twofold, i.e. the "media and culture-based public" and civil society. It emphasizes that a broader understanding of knowledge generation and application requires public participation in sophisticated innovation systems. As the public consumes and applies information, they are considered part of the innovation system. In a developed knowledge society and knowledge economy, knowledge flows into all sectors of society (Carayannis & Campbell, 2011). This helix dates as far back to the early 1990s (Leydesdorff, 2012a) and considers both science universities (or other higher education institutions in the field of sciences) and art universities (or other higher education institutions in the field of arts) when it comes to the contribution of the arts and arts universities to knowledge and innovation, created and generated in inter-and transdisciplinary frameworks and networks, possibly linking the spheres of sciences and those of the arts (Carayannis et al., 2021). Indeed, there is a school of knowledge as the public becomes increasingly aware of responsible innovation and the undeniable role of civil society in the advancement of science and technology in public policy, the QH model is timely and appropriate for dealing with new societal features as the QH model expresses the “knowledge society” and” knowledge democracy” with a sturdy focus on the people (Cai & Lattu, 2021). The QH mentions Mode 3 with the central point being the innovation ecosystem and further stresses collaboration, co-creation, and co-specialization (Kitsios et al., 2021).

The scholars' criticism indirectly states that the QH is incomplete in terms of an analytical and explanatory sphere. The natural environment is not considered, and innovation is also driven by this natural environment, so the failure to take this into account makes the QH imperfect to some extent (Carayannis & Campbell, 2010).

Figure 4 The Quadruple Helix of Innovation Model



Source: Constructed from various secondary sources

2.3 The Quintuple Helix Of Innovation

The quintuple helix (QH) of innovation consists of five actors considered as a whole, as the fifth helix, "the natural environment of society", has been added. This model is both theoretically and practically suitable for promoting societal understanding of the relationship between knowledge and innovation to support sustainable development (Carayannis et al., 2012a).

In 2010, Carayannis and Campbell created the Fivefold Helix, composing of political, educational, economic, environmental, and social systems. Each helix represents a knowledge subsystem that is spirally connected to the other systems, which in turn have a national, regional, and global reach (Barcellos-Paula et al., 2021). This helix aims to enable a place-based and triply profitable pioneering process of discovery followed by intensive experimentation and high quality and quantity of sustainable and social innovation (Carayannis et al., 2018). The utmost difference between the previous helices and the QH is its ability to provide a clear development strategy and serve as a framework for transdisciplinary, cross-cutting analysis of sustainable development (Limoges et al., 1994).

During the wave of sustainable development, worldwide society then saw the need to begin building instruments and indicators to assess sustainability. The QH is seen as one of the emerging tools (Chen, 2015). According to Konig et al., (2020) there is a clear link between the helices and the SDGs, and other researchers concur. They go on to say that Carayannis and Campbell's idea to formulate the QH is the most impactful sequel to the initial formulation when it comes to sustainability, even Leydessdorff and Etzkowitz (Konig et al., 2020)(Leydesdorff, 2012b).

While many conceptions have been instituted, the QH model cannot be conceived without the idea of a circular economy (CE). This is because, the model actualizes the environment and sustainability and, therefore, plays a part in the attainment of a circular society (Arsova et al., 2021). According to Maranesi & De Giovanni, (2020) CE is “an economic system that is based on business models that replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes; thus, it applies at the micro-level (products, companies, consumers), meso level (eco-industrial parks), and macro-level (city, region, nation and beyond), to accomplish sustainable development by creating environmental quality, economic prosperity, and social equity, and

benefits for both the current and the future generations"(Maranesi & De Giovanni, 2020). Romero et al., (2020) also posit that eco-innovation in the CE model and effective participation of multiple stakeholders in the QH model will help accomplish climate action goals, all while remaining sustainable (Durán-Romero et al., 2020a)

2.3.1 The Framework of the Quintuple Helix of Innovation

The State/ Government: The political system is represented by this helix, which plays an important function. This is because the state oversees formulating "will" or policies for the present and future and defining, regulating, and administering the general state circumstances. "Political and legal capital" exists in this helix (Carayannis et al., 2012a). Government sparks innovation in diverse ways, such as direct government funding for product creation, and R&D in private enterprises is a popular tool used to stimulate innovation in other countries; ii) government procurement is used to boost demand for innovative technologies while lowering market risk and uncertainty for businesses thus regulating and correcting market failure through regulatory policies (Mottur et al., 1978) and iii) Compensation for technical and financial risk for enterprises, subsidies, fiscal incentives, and a responsibility to impart knowledge through allocating funds to research organizations and universities are all examples of ways to encourage business investment (Harradence, 2009).

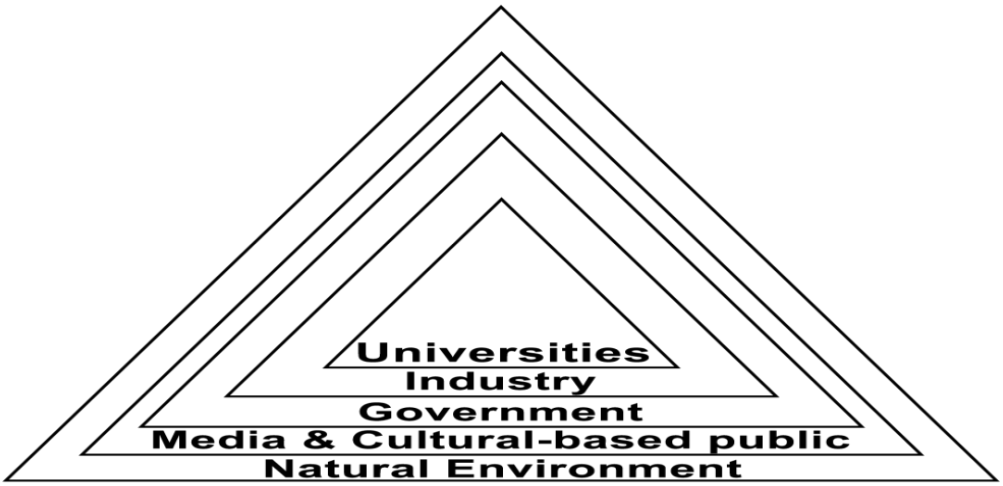
Universities/ Academia/ Research Institutions: This is defined in terms of the educational system, which oversees knowledge production and transfer (Carayannis et al., 2012a). According to Etzkowitz (2003), knowledge-producing institutions have improved their core competencies to recombine old ideas and refine and develop new ones and put them into practice. The metamorphosis of academia into a source of innovation is occurring simultaneously as the shift of invention from an internal process within individual enterprises to a process that occurs between businesses and knowledge-producing institutions. The university has taken on a new function in society as knowledge development, diffusion, and application have become more intimately involved in industrial production and governance (Etzkowitz, 2003). This is where the entrepreneurial university, also known as the third-mission institution, emerges (Palincas, 2020) and it liaises with industry and government, and it is no longer an ivory tower cut off from the rest of society (Colapinto & Porlezza, 2012).

Industry: This defines the economic system and comprises industry/industries, firms, services, and banks as the second subsystem. This helix focuses and concentrates on a state's economic capital (for example, entrepreneurship, machines, products, technology, money, and others (Carayannis et al., 2012b). Creative industries, cultural institutions, content and application production, government, and other businesses are all represented through cross-sectoral linkages and interrelations in innovation systems. Companies turn research and innovation into products and services (Mineiro et al., 2021), as well as a source of economic growth (Siegel et al., 2003)

NGO's/Citizens: Also known as the media-based and culture-based public system, it is defined by the assimilation and combination of two types of "capital," namely, the culture-based public, which includes traditions, values, etc, and "social capital," which also addresses the media-based public through communication channels such as television, internet, and newspapers, as well as an embedding of the "capital of information," which includes social media platforms such as Twitter and WhatsApp (Carayannis et al., 2012b). It also includes labor unions, citizens, and others with more growth-oriented attitudes, such as consumers and users, who enable democracy through inspiring user-driven innovation (Grundel & Dahlström, 2016).

The Environment: The natural environment, as the fifth subsystem, is critical for long-term growth and provides individuals with a form of "natural capital"- resources, plants, a variety of animals, and others as drivers for new knowledge and innovations in response to environmental challenges. The ecosystem added as the fifth helix enables the quintuple helix innovation system to be problem-oriented facilitating socio-ecological transformation, or the transition of society to a bioeconomy or circular economy, and thus to sustainability (Carayannis et al., 2012b); Grundel & Dahlström, 2016).

Figure 5 The Quintuple Helix of Innovation Model



2.4 Differences Between The Previous Helices Of Innovation And The Quintuple Helix Of Innovation

The world has shifted from the initial triadic thesis to a more integrated and internationally orientated perspective, from the triple helix of innovation to the quintuple helix of the invention. It is seen as a society in which everyone is participating in innovation somehow, even if it is in the tiniest of ways, such as policy decisions, knowledge production, and trading, to name a few examples. Even though the helices are comparable, the quintuple helix has a unique property and plays a unique purpose.

The quintuple helix, emphasizes the natural environment/ecosystem, which the other helices fails to do. The natural environment is defined as the whole of natural resources, plants, and animal diversity that contribute "natural capital" to the other four helices (Konig et al., 2020). The natural environment should not be treated as a source of inspiration for knowledge manufacturing and creativity, but as one that is vital. The environmental element acts as the backdrop for humanity's preservation, survival, and vitality. Nature, therefore becomes an equally significant and integral component of knowledge production and innovation, with ecologically based information and processes functioning as the natural environment's "output." As a result of this feature, the concept of sustainability must be highly valued. The previous helices did not incorporate this, but the Triple Helix founders enjoyed broadening the notion over time.

Another significant distinction between the present and prior helices is sustainability or the achievement of the aim of sustainable development. Almost every country in the world aspires to achieve the objective of sustainable development, working tirelessly to meet the set targets by 2030. The triple helix emphasizes the connection between the university, business, and government, whereas the quadruple helix emphasizes the connection between the university, business, government, and citizens/NGO/CSO. According to a critical study of these two helices, public and social organizations have a role in knowledge acquisition, entrepreneurship, and innovation diffusion. The SDG concept does not present itself in this context, but rather in the socio-ecological perspective of society's natural environment which is found in the QH model. Every player in this scene is concerned with the well-being of current and future generations, and the interaction, co-development, and co-evolution of society and nature are emphasized (Carayannis et al., 2012a).

Furthermore, it cannot be denied that triple and quadruple helices have played a significant role in the past in the innovation sectors of certain countries, such as Japan and the EU. On the other hand, the QH model is marked by democracy, ecology, transdisciplinarity, and a thorough contextualization of the prior helices, allowing for knowledge and competitive advantages. As a result, the QH model is ideal for all aspects of the economy, from health to politics, and can be employed in both emerging and developed countries. The QH model ignores limitations in favor of a cooperative system that improves and builds on previous innovations.
Overall, the prior helices are deemed insufficient. As the world progresses into the digital age, much attention should be paid to the ecosystem. The only way to do so is through the QH model, which has proven successful in the current innovation paradigm.

2.5 Innovation Helices In Africa

The historical trajectory of innovation has always been associated with the European Union, North America, and lately, the Asian continent as they transition from the initial triadic thesis to a more integrated, internationally orientated perspective (Limoges et al., 1994). The East has a more conservative attitude to learning and educational enlightenment, and the Western economy has witnessed greater growth due to capitalism. With the opening of borders and sea coastlines, visitors from across Asia plunge into a variety of trade and dialectical upheavals,

trade, and commerce have been an intrinsic part of academic capitalism for quite some time. It is critical to note that the term "academic capitalism" is a relatively recent subject of study in continents such as Africa (Sassen & Kourtit, 2021). Not to mention the fact that most African countries have had governments concerned with and interested in the economy's developmental stability in the early post-colonial era, and that Statesmen did strive in any way possible to assist the continent's transition from an agrarian to an industrialized economy (Coker-Kolo & Darley, 2013). Africans have been characterized as innovative and good with adaptation before colonial times according to Erik Green, who writes on Production Systems in Africa, because of the low population density and other factors, a flexible production system existed, and institutional regulation was favorable because the family system was in use (Green, 2013). But because of colonization and slavery, most of these societies have been destroyed[5] (Agbontaen-Eghafona, 2019). Although the quadruple helix model has been prescribed as an elixir of life to garner innovation on the African continent over the last decade (Martins, 2017), and although other developed continents are applying it - most having transitioned to the Quintuple Helix of Innovation, elevating development to the highest peak - the African continent has and is currently still applying the Triple Helix of Innovation model. As things stand, it will be noteworthy to see if some African countries bypass the Quadruple Helix model and instead adapt to the Quintuple Helix model directly to speed up growth.

2.5.1 Challenges of the Helix Approach in Africa

Until now, the African continent has only used the TH and QH model,(Mêgnigbêto, 2019) (Doh, 2018) hence attaining independence from colonial cruelty has been difficult. Most African states have yet to fully recover from the colonial era to develop a stable foundation for comprehending innovation and using the concepts that go with it. A few limitations are noted; Institutional System Disparities: So far, the contrast in institutional arrangements between Africa and the Western world has been captured. While the helix model has benefited them, there is little question that it will not work and will not be used in the African system. The family and kingship systems exist in Africa, and in some regions of the continent, they are more powerful than democratic governments. According to a Ghanaian cliché, the government is merely a ceremonial administrative body, with the Kingship system possessing and

[5] http://www.pass.va/content/scienzesociali/en/events/2019-23/family_ecology/agbontaen-eghafona.html

exercising authority for and on behalf of the people more. Ghana, for example, had rulers both before and after independence, and the people listened to and worked with the Kings or Chiefs more. It is still happening, and it will be impossible to put the helix models into practice without involving or including traditional authorities because of their prominent roles.

The Dilemma of Varying General Indicators of Development: General indicators as defined by the OECD/DAC[6] refer to a "quantitative or qualitative factor or variable that provides a simple and reliable means to measure achievement, to reflect changes connected to an intervention, or to help assess the performance of a development actor" (OECD, 2013). USAID[7] also describes an indicator as "a variable, which purpose it is to measure the change in a phenomenon or process" (Mdf, 2005). The World Bank[8] and the OECD have compiled a list of broad indicators that have been organized into categories ranging from social to economic indicators. These indicators span from agricultural to population indicators. As the definition of an indicator reveals, it measures a community's, country, or continent's achievement using specific methods, and this differs from community to community, state to state, and even continent to continent. As a result, implementing a theory like the helix models of innovation may be ineffective because what works for one party may not work for the other due to variances in these indicators.

The government's obligation to "push" the other actors forward: As is the case with the statist model, the government is regarded as the leader and is given complete authority. As a result, it has a responsibility to bring the other bodies along by collaborating and cooperating (S. R. Foster & Laione, 2016). This is frequently a difficult task because the state has other lesser agencies to manage, regulate, check, and maintain balance in the performance of their responsibilities. This is one of the reasons why the government has delegated some of its authority to both universities, industry, and other regulatory agencies through decentralization. It is tough to push them forward when it struggles to do so itself, therefore it is up to all the actors involved to climb higher on their own, and to seek support or be pushed up in times of adversity.

[6] https://www.oecd.org/dac/peer-reviews/Development-Results-Note.pdf
[7] https://www.sportanddev.org/sites/default/files/downloads/indicators.pdf
[8] https://data.worldbank.org/indicator

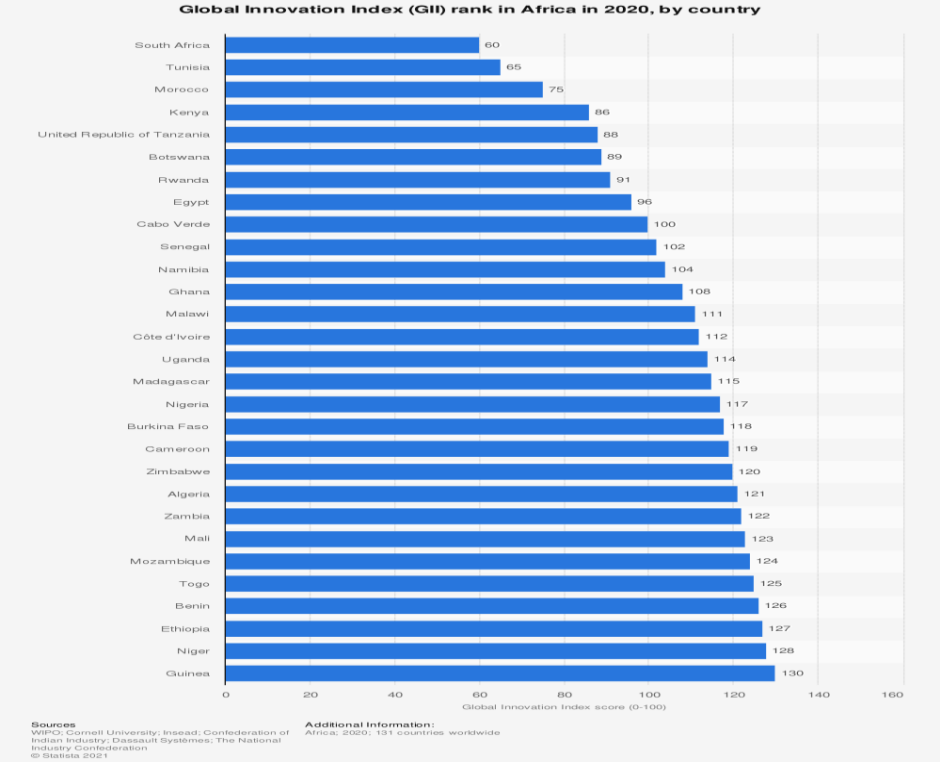
2.5.2 Africa's Progress

Africa has made significant progress in terms of innovation during the late 1990s and appears to be catching up with other developed continents. The African Academy of Sciences believes that using the QH will help Africa advance in terms of innovation and development. Some countries within the continent are utilizing the TH. Others have also begun with the QH, but new evidence suggests that each of the helix's components of the QH has only developed minimally in Africa (Okonofua et al., 2020). As a result, the continent's poor research data and minimal human development indices contribute to the continent's slow progress in certain areas of innovation and growth. Thus, there is a pressing need to expand research, strategies, and policies for Africa to benefit from the Quintuple Helix of Innovation model.

The Quintuple Helix model has yet to gain traction in Africa. Still, the African Academy of Sciences believes that the use of the quadruple helix has been beneficial to continents such as Europe and thus can be the vehicle to promote Africa's evolution in scientific innovation and development. Other studies have shown that the Quintuple Helix has done more for other developed continents since its conception, as such the Quintuple Helix is the current standard. Africa has been steadily improving its digital maturity and is the primary driver of technological innovation as a continent. The use of the internet and mobile phones has increased tremendously, as has STEM (science, technology, engineering, and mathematics) education. Despite possessing an 18 percent global population, Africa has scored poorly in several areas, accounting for only 0.3 percent of global R&D spending and 0.5 percent of patent filings, according to the "Igniting Innovation Based-Growth in Africa" report (Maher et al., 2021). According to trade data, Africa is a low-tech, low-value-add continent, producing 0.4 percent of global high-tech exports and 0.8 percent of middle-technology exports such as industrial machinery, vehicles, and chemicals[9]. Notwithstanding this, the continent has made strides and, thanks to some countries in Northern and Sub-Saharan Africa (WIPO, 2021), rates highly in certain areas on the Global Innovation Index in 2021[10].

[9] https://www.bcg.com/publications/2021/innovation-in-africa
[10] https://www.oepm.es/export/sites/oepm/comun/documentos_relacionados/Noticias/2021/2021_09_21_GII_global_Innovation_Index_2021.pdf

Figure 6 shows the global innovation ranking in Africa 2020 country by country



Source: Referenced from Statista-Global Innovation Index 2020

2.6 Opportunities Of The Quintuple Helix Of Innovation

According to the Global Innovation Index 2020, the continent scores well on some metrics and poorly on others. As a result, it is the continent's responsibility to rethink and implement policies. To this end, the African Union Agenda 2063 has been established with plans and policies that take Science, Technology, and Innovation (STI) into account to expedite Africa's transition to an innovation-led, knowledge-based economy with attainable goals (African Union Commission, 2014). Physical, digital, and biological technologies are used to attain these goals using the Quintuple Helix of Innovation model as a governance tool.

2.6.1 Opportunities- (Potential and already existing)

Economic Development: The QH has benefitted most European countries, and the EU values it since it ensures collaboration among many stakeholders in order to encourage and warrant research, advancement, and innovation with the ultimate goal of boosting growth and development. As a result, innovations in products and services various companies or countries

offer are tailored to fulfill the demands of inhabitants, implying socioeconomic growth in a certain area (Franc & Karadžija, 2019).

Promote Sustainability: Another possibility the Quintuple Helix provides, in this case, is the promotion of sustainability, as Arsova and his colleagues predicted in 2020. (Arsova et al., 2021). Because the QH is the only Helix Model that includes the Natural Environment or Ecosystem, the concept of sustainability can only be envisioned if it is used. The environment contains all four helices: government, industry, universities, NGOs, and citizens. SDG 9 emphasizes the importance of industry, innovation, and infrastructure in providing additional opportunities in their own right.

Boost innovation through the introduction of new technologies, businesses, and types of interactions (Ranga & Etzkowitz, 2013): The TH provides an opportunity to improve innovation by ensuring that innovations are well-structured, systematic, and go beyond the individual domains' technology and competencies. This will be an opportunity to establish and disseminate these new technologies, promote businesses, and allow networking and links between the institutional sectors of academia, industry, and government to be constantly retrofitted in a perpetual transformation through this creative process, which will also help to provide immediate solutions to societal issues in Africa.

Planning & development policy guidance (Shinn, 2002): The QH also allows Africa to have the essential information, values, and attitudes to plan, create, and implement policies, but through an efficient and standardized approach that is tailored to the African situation and context. This is because, in the case of policies, indices such as geographic locations and economic position, to name a few, could influence the process. As a result, the QH provided advice to several developed countries with the help of non-governmental organizations, civil society organizations, and citizens who participated in the innovation process.

Skills Development: In addition, the QH will allow for skill development and enhancement in light of SDG 9 (industries, innovation and infrastructure), often known as the 3I's[11]. With a

[11] https://www.un.org/sustainabledevelopment/infrastructure-industrialization/

focus on the 3I's, the government, colleges, companies, and non-governmental organizations (NGOs) will train individuals and the public through various mediums to refine their abilities in all sectors to create a sustainable environment. For example, technological universities will improve the public's digital, technological, and scientific skills; the government will train citizens to be skilled in technology and the ability to deliver public goods and services; businesses will educate workers on how to use new tech to produce goods and services, and non-governmental organizations (NGOs) will use technology to raise awareness of protecting the environment.

Local Adaptation of Innovation Model

The innovation helix model may or may not work for certain cities; nevertheless, a portion of the model can be taken to develop an innovative model that is appropriate for the city or country in question. This presents itself as an opportunity.

2.6.2 Cities Preparedness for the Quintuple Helix of Innovation Approach

The QH model of innovation necessitates that the city in question be fully prepared to change when a variety of circumstances come into play, and this varies from city to city. Considering aspects like social institutions, level of invention, and others, the innovation model employed in Antwerp or London, for example, cannot be utilized in Accra or Johannesburg. Aspects such as:

Existing human capital**:** Human and social capital both play vital roles in attaining the goal of establishing an intelligent city, and innovation is one of the ways of knowledge generation (Dakhli & De Clercq, 2004). The concept is rooted in economic science development and a consensus for the definition does not exist yet (Alika & Aibieyi, 2014) but human capital can be broadly defined as the stock of knowledge, skills, and other personal attributes embedded in people that helps them to be productive, according to the OECD in 2001[12]. Marimuthu, 2009 describes human capital as the processes of training, education, and other professional activities to improve an individual's knowledge, skills, abilities, values, and social assets to improve their

[12]https://www.oecd.org/economy/human-capital/#:~:text=Human%20capital%20can%20be%20broadly,helps%20them%20to%20be%20productive

satisfaction and performance (Marimuthu et al., 2009). The advantages of human capital include income, better health, and the presence of individuals with high human capital can have broader spillover effects for communities by a few studies (Keeley, 2007) and an instrument used to sustain productivity (Marimuthu et al., 2009). The existence of human capital in public agencies, the private sector, universities, and NGOs is a crucial component for a city to apply the QH model.

Existence of social capital**:** When human capital is stated, social capital must be included in the equation because the two are related. As the term indicates, social capital refers to a collection of elements that share common characteristics, making it a component of social systems that facilitates specific behaviors from actors. The notion likewise permits the use of resources and how their combination with other resources achieves diverse results for the people involved. The absence of social capital in the family has the potential to result in a failing human capital, causing problems for the family, and so has the potential to distort or disrupt the family system, which is an important part of society (Coleman, 1988). The presence of social capital is an indicator of a city's readiness for innovation.

Existing organizational functions to support innovation and entrepreneurship: Organizational innovation is known as an organization's ability to consistently transform ideas and knowledge into commodities, services, or processes for the satisfaction of its consumers. This is one of the complex processes that managers must address, and some theories have emphasized organizational structure, adaptability, and capability as the foundation of innovation management while other models have emphasized organizational climate, participative management, and incentives for innovation as the core requirements for managers to organize and lead organizational innovation. In all these, managers can support innovation and entrepreneurship in organizations by i) ensuring that leading innovators view innovation capability as more than just research and development, and every aspect of the business should be redesigned to stimulate and reward innovation; ii) successful managers also regard innovation as a source of competitive advantage and a means of generating new knowledge (Hadi Razavi & Attarnezhad, 2013).

The possibility of the promotion of local innovation ecosystems and regional forums for innovation: The spread of ideas and solutions is spurred by the advancement of ICT

technologies and their increasing availability and affordability. This will result in a paradigm shift, with grassroots, bottom-up, spontaneous movements and communities of revolution forming new ecosystems with the potential to replace current ones, all while maintaining a firm footing at the local level. These new ecosystems will be built around a defined set of values: shared intent, common purpose, collaboration, transparency, and openness. The new actors must be aware of hybridization where it is relevant, integrating social goals, entrepreneurial thinking, and financial motivation (Sgaragli, 2014). To promote community engagement and ownership of community-led projects, it is critical that the community can relate to technology breakthroughs and concepts. This is considered part of a city's readiness to use the QH model of innovation.

Formalization of partnerships and a strong effort to engage the Private sector: The Public-Private-People- Partnership (5P) is a partnership in which all parties interact and perform their respective responsibilities to encourage innovation. This also is a look at the five principles of design suggested by Forster & Iaione in the 2016 article they authored.

Proactive strategies with Universities: Because it performs the roles of knowledge production, transmission, and distribution, the university is considered one of the most important components of the innovation model. The other actors, if not all, then the majority, come from universities and must do everything to establish firm strategies that can transform universities/research institutions from mere institutions to effective knowledge production, transfer, and distribution institutions with purposeful innovative intent. Moreover, they must do it with long-term forethought and vision, demonstrating a city's readiness to grow technologically.

SECTION II

2.7 The Quintuple Helix And Smart Cities

The Quintuple Helix is a model that captures and focuses on the sum of a state's (nation-state) social (societal) connections and academic exchanges to promote and depict a knowledge, know-how, and innovation cooperation system for more sustainable development (Carayannis & Campbell, 2010). The city is a representation of a distinct natural setting that houses an innovative and smart structure known as "intelligent communities," in which relationships and

collaborations improve social and technological reality by an approach that includes engagements among the stakeholders (Taratori et al., 2021). Smart Cities have become the talk of the global world in the 21st century[13] and scholars have brought up numerous definitions for them. For this study, A.D Guerrero's definition of a smart city is more appropriate; he defines it as a purposed geographical space with the capacity to handle its resources (both natural, materials, human, buildings, and infrastructural facilities), as well as refuse produced by routines, and it should have an element of sustainability and environmental safety (Guerrero-Pérez et al., 2013). The phrase "smart cities" is one of many; others have coined terms such as "intelligent cities," "eco-cities," "sustainable cities," "digital cities," and others, but the notion is transparent, purposeful, and tries to attain the same goal- one that enriches the world for living beings by making it more comfortable and delightful without destroying the natural environment.

2.7.1 Conceptualizing/ Characteristics of Smart Cities

To begin with, a city is a location or area where people live and work (Al-Nasrawi et al., 2016) primarily government, transportation, and commerce centers (Jacobs, 2012) thus there are two ways to define a smart city: the actual definition and the definition based on certain criteria identified through evaluation, both of which will be conceptualized (EC, 2007). While there have been many different interpretations of the term "smart cities," A.D Guerrera's definition is the most comprehensive and claims that it is a purposed geographical space with the capacity to handle its resources (both natural, materials, human, buildings, and infrastructural facilities), as well as refuse produced by routines, and it should have an element of sustainability and environmental safety. Currently, the concept of "smart cities" has evolved into "sustainable smart cities," and these phrases may be used interchangeably in this study because the study encompasses both. UNECE and ITU together with a group of experts discussed, and through a multi-actor approach, came up with a joint definition for the term “sustainable smart cities”[14]. According to that definition, a smart sustainable city is an innovative city that uses ICTs and other means to improve quality of life, the efficiency of urban operation and services, and

[13] https://opencanada.org/are-smart-cities-a-bright-idea-for-the-global-south/
[14] https://unece.org/housing/sustainable-smart-cities

competitiveness, while ensuring that it meets the needs of present and future generations concerning economic, social, environmental as well as cultural aspects (Housing, 2020).

Per the "Digital Agenda for Europe," a city must meet a criterion and possess certain characteristics or qualities following review to be classified as smart. As a result, the second definition is revealed, with six qualities linked with it based on various works of literature and a round-table discussion. They are smart economy, smart people, smart governance, smart mobility, smart environment, smart governance (Giffinger, 2010) and are briefly discussed below;

Smart Economy: Given that urban areas have significant economic competitiveness features, the smart economy has become one of the key contributors and a survey instrument for smart implementation. When the term "smart economy" is used, it relates to the 4th Industrial Revolution and the concepts of digitalization and globalization (Yudono et al., 2019)-the smart economy's goal. It is an ecosystem that enables community business activities that are integrated with progressive and flexible industry sectors to technological advances in this century and increasing community financial knowledge through a range of programs such as the cashless society (Bahari et al., 2021). Giffinger & Gudrun further classify Smart Economy into entrepreneurship, productivity, employment, global competitiveness, the ethos of innovation, and economic image/trademark , etc. Giffinger categorizes the smart economy into six categories with 23 assessment indicators (Giffinger, 2010).

Smart People: This is the second characteristic of a smart city, and it strives to change the way citizens connect with the public and commercial sectors as individuals or businesses, whether through information or service provision. It also focuses on increasing social and digital inclusion/equality through educational opportunities, in all forms and considers it a necessary precondition for more effective information and service delivery based on new technologies. Talent development is seen as an important aspect of economic development. It further looks at solutions to assist in the construction of an accessible and inclusive environment to boost a city's or community's economy and innovation[15]. People have a crucial role as the central element in an urban agglomeration and development of a smart city, therefore the "people

[15] https://hub.beesmart.city/en/smart-city-indicators

component" cannot be singled out (Lara et al., 2016). According to Giffinger and Gudrun, it emphasizes human and social capital and exposes seven aspects, including the level of qualification, an affinity for lifelong learning, and social capital. Diverse social and ethnic groups, adaptability, innovation, cosmopolitanism, and civic engagement (Giffinger, 2010)

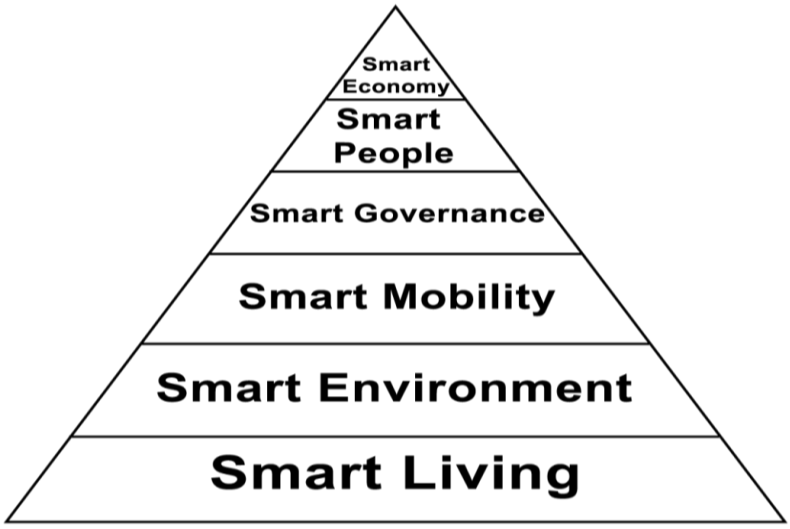
Smart Governance: UN-Habitat explains Governance as how individuals and other interest groups articulate their interests through formal or informal channels, negotiate their disputes, and exercise their legal rights and obligations through complex systems, processes, and institutions. It goes on to define good urban governance as the management of an urban entity through the exercise of political, economic, social, and administrative authority, thus a total of all the different ways that individuals and institutions, both public and private, plan and administer the city's common affairs (Jackohango, 2010). Smart Governance is the kind of governance wherein decision-making and public services and various stakeholders are involved. ICT-mediated governance, also known as e-government, is critical for bringing smart city projects to residents and maintaining transparency in the decision-making and implementation phases (Albino et al., 2015). Perriera, 2018 states that collaboration, citizen participation, and data-based evidence characterize Smart Governance (Pereira et al., 2018). Integration, innovation, information sharing, evidence-based, citizen-centricity, sustainability, creativity, effectiveness, efficiency, equality, entrepreneurialism, citizen engagement, openness, resiliency, and technology savvy are among the multiple dimensions of smartness that contribute to understanding the development of smart governments (Gil-Garcia et al., 2016).

Smart Environment: Is derived from the term "environment," which refers to the environment in which living organisms exist, and the inclusion of "smart" is linked to creativity, innovation, human capital, scientific concepts, and collaboration, as well as digitalization (Caragliu et al., 2009). Therefore “smart environment” relates to natural living conditions in the city (for example, green spaces), natural resources management (for example, resource reuse and replacement), and environmental protection. Effective waste management, the utilization of renewable energy sources, and green urban design are examples of smart environment solutions (Kozlowski & Suwar, 2021). The concept of circular economy is introduced here.

Smart Living: When it comes to SC, quality of life is a fundamental component that cannot be ignored, and thus should not be treated as a minor element (Al-Nasrawi et al., 2016). The

European Commission describes Smart Living as a movement that encompasses technological breakthroughs that allow individuals to benefit from new ways of life entailing unique and cutting-edge solutions aimed at making life more efficient, controllable, cost-effective, productive, integrated, and long-term (European Commission, 2014) with an important aspect of stimulating tourism coupled with ICT support, social initiatives are used to create new or improve the existing lifestyles as well as safety and health of inhabitants (Albino et al., 2015) and information about entertainment events, spending free time and the nightlife, safe, pleasant and calm communities to tourists[16].

Figure 7 Characteristics of a Smart City

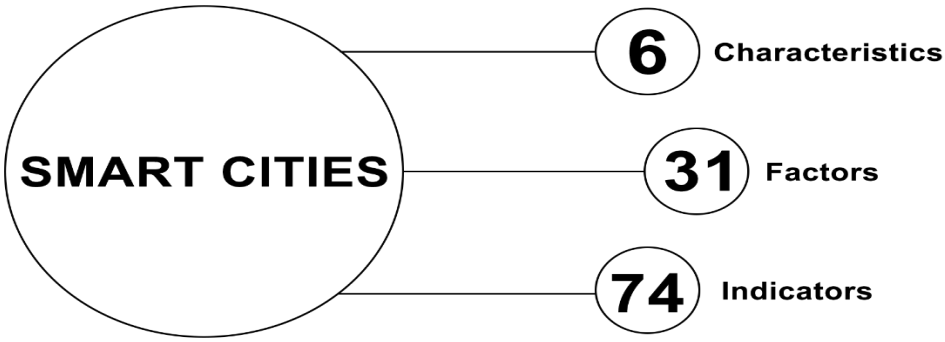


Source: Constructed from Giffinger & Gudrun, 2010.

Giffinger and Gudrun further explain that the characteristics are not the only thing that goes into making a city smart, but that they also have elements and indicators inherent in them. A collection of connected indications has scientifically determined every smart characteristic factor; hence these factors have been identified, counting as 31. For incorporating and collecting the relevant components, 74 indicators have been defined and employed (Giffinger, 2010).

[16] https://aptika.kominfo.go.id/2020/10/mengenal-lebih-dekat-konsep-smart-city-dalam-pembangunan-kota/

Figure 8 Description of Characteristics, Factors & Indicators



Source: Constructed from Giffinger & Gudrun 2010 and other secondary sources.

2.7.3 Debates on Smart Cities

Several debates on smart cities have erupted over the years as the concept has grown in popularity in the twenty-first century. Still, the Urban and Economic Development (URBED) organization, which was founded in 1976, has always shown a keen interest in how towns and cities can realize their full potential (Falk & Simmons, 2020). Despite its ancient towns and legacy infrastructure systems, Europe has led the way in the adoption of smart cities with a sustainable, environmentally friendly agenda and a focus on public transit and infrastructure efforts, according to a 2018 McKinsey report. Similarly, the Asian continent has experienced a surge in smart city development in recent years[17]. Some pessimists state that the key obstacles that are profound variables such as context, relevance, and value from an African perspective are not taken into account and thus not ingrained in the modern definition, growth, and practice of smart cities, insinuating that the African continent will continue to lag in case of smart city achievements if headway is assessed on encroachment definition (Achieng et al., 2021). Some have also suggested that the rise of smart cities may exacerbate inequality.

In the literature on smart cities, there is diverse school of thought or theories posited by various scholars and four of them will be conceptualized.

[17] https://www.rbcwealthmanagement.com/en-us/insights/how-are-smart-cities-meeting-the-challenges-of-urbanization-in-the-21st-century

City as a Commons: The intention of the city as a commons is to alter the city's democratic and economic functioning shifting it to establish a city that better serves the needs of all of its people, but also to recognise the trend of huge urbanization and the fact that cities are increasingly becoming the focal point of political life. It focuses on urban collaborative governance which is a system that redistributes decision-making power and influences a more involved population, not just the State authorities. The facilitator state establishes the environment for residents to form collaborative connections with one another and collaborate with public authorities to protect common resources, including the city itself as a resource (S. R. Foster & Laione, 2016).This is more aligned to the quintuple helix of innovation that is the focal point of the study and is recognised by Lab.Gov as the urban commons and the public, private, knowledge, social sectors[18], therefore upholds the concept of the study.

Smart Machines & Information Organizations: The assumption made is that a "smart city" employs information and communication technology (ICTs) for automation and intelligent functions, as well as reorganizing its procedures, structure, and governance to make use of these technologies (Ching, 2013).

Automation has been viewed as a significant method of increasing efficiency (Kallinikos, 2010) and as some theorists have already proposed, city functions can be taken over by "smart machines," which can be made smart via the application of advanced analytical sensors and computing algorithms and are expected to perform more accurately and reliably than humans, assuming humans can perform such functions at all. Of course, making these types of operations allows city officials to "leverage information" across ministries, "predict problems and reduce the impact of disruption," and "organize resources to respond to crises quickly and efficiently". Other experts then state that these intelligent robots cannot accomplish everything by themselves and that they require human assistance in delivering their services (Kim et al., 2021). As much as "smart machines" authored by Professor Zuboff are known for information extraction from automated processes and "generate information about the underlying productive and administrative processes through which an organization accomplishes its work, the human element is the baseline that covers up the inefficiencies produced by the machine. Therefore, good governance and a public administration system are obtained because of smart machines with information organizations and human efforts.

[18] https://labgov.city/commonspress/the-co-city-cycle/

Learning & Adaptations: The assumption made is that through learning channels, as well as measuring, monitoring, and feedback mechanisms, the "smart city" learns, recalibrates, and adjusts itself. Smart cities can discover and re-learn how to analyze and evaluate their performance using indicators established by the city's goals (Ching, 2013). Boyd Cohen, a theorist, offers the Smart Cities Wheel, which sheds further light on the features of a smart city as a popular framework among people, government officials, the commercial sector, and other players, with ICT serving as the ultimate optimizing instrument for growing smartness (Peek & Troxler, 2014).

Systems Theory on Smart city: Smart cities are cities with complex systems, and they can be built on a systems theory under this idea. The systems theory views cities as an environment-; it is vast and may be separated into subsystems, one of which is the cyber-physical system (CPS). This demonstrates smart cities as cyber-physical systems. Firstly, the CPS is defined by Radkahisan and Helen as a term used to describe a new generation of systems that have integrated computational and physical capabilities and can interact with people in various ways. They explain that the capacity to interact with the physical environment and enhance its capabilities through computing, communication, and control is a critical enabler for future technological advancements (Baheti & Gill, 2011). CPS is the world where the virtual and physical world is linked and the point where these two systems meet is called the interface. The interface is utilized for interactions and exchanging information is critical to smart cities, the use of interfaces allows for the creation of a modular system that can be readily updated or expanded and this is how smart cities are then conceptualized as CPS. (Lom & Pribyl, 2021). CPS has numerous benefits and Jay, Behrad, and Haung-An mention three of them which are that; i) CPS give the extra self-comparison capabilities to collect knowledge from components and machine-level information ii)it also helps to record time machine to record and synthesize future steps to enable self-awareness and self-prediction and iii) allows the factory to be self-configurable and maintainable (Lee et al., 2015).CPS is beneficial to the industrial world within cities.

2.7.4 Factors that influence the building of Smart cities (The Design Principles)

In both advanced and emerging economies, there is a steady migration of people into cities, resulting in high resource consumption and disadvantages ranging from pollution to an increase in social vices. Some authors have termed it as "factors", others call them the" driving force", while some also call it "enablers". Because the study is still ongoing, these terms may be used interchangeably, however only a handful of the components are addressed as key factors gathered from previous studies. Forster & Iaione call it the design principles and they are elucidated below;

Collective Action/ Collective governance : This is also termed Principle 1 by Forster & Iaione as the presence of a multistakeholder governance scheme in which the community emerges as an actor and partners (through sharing, collaboration, cooperation, and coordination) with four other possible categories of urban actors in a loosely coupled system (S. Foster & Iaione, 2017).

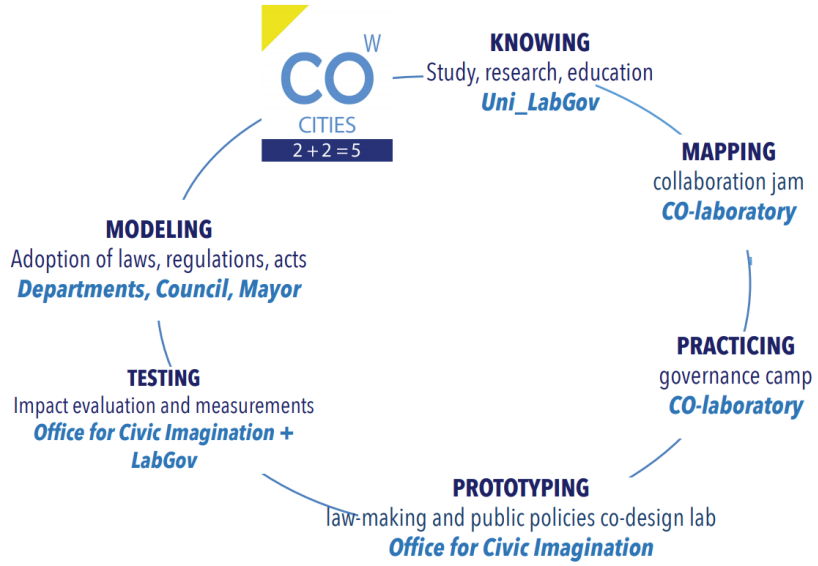
An enabling State or Principle 2 expresses the involvement of the state (typically local government) in enabling the construction of urban commons and supporting collective governance systems for their administration and long-term viability; and in addition to doing what it does best, government should assist individuals, families, and communities in doing what they do best. This is seen in three key dimensions; thus, seeing and engaging in people's lives on the round, Involving governments and public agencies are considering how they might support people who require assistance to maintain as much control over their lives as possible and to progress in small steps (Elvidge, 2012).

Social and Economic Pooling/Principle 3 refers to the presence of specialised institutions (e.g., civic, financial, social, economic, etc.) that are accessible, socially inclusive, and controlled or operated local communities functioning within quasi economic structures (e.g. cooperative, social and solidarity, circular, cultural, or collaborative economies, etc.) that pool resources and stakeholders, resulting in the creation of new opportunities (e.g. jobs, skills, education, etc.) and services (e.g. housing, care, etc.).The variable highlights social elements that drive smart city development. To begin, these considerations analyse the smart city's social component, describing its four key aims as follows: a) development of human capital, which includes building intellectual capital and creating knowledge, as well as enhancing the position of the resident (aware, educated, and participating); b) social capital development, which involves long-term social progress and information literacy; (S. Foster & Iaione, 2017) c)

changes in behavior, such as a sense of cause and value, as well as a sense that all residents are co-owners and accountable for their city; d) implementing technology that reacts to users' needs, talents, and interests while respecting their diversity and individuality is the social dimension (Radziejowska & Sobotka, 2021). Batt & Pitroda identifies poverty, demographic changes, recreational and cultural facilities, smart people, safety, security, social cohesion, and immigration friendly environment as social elements (Patel et al., 2017).

Experimentalism or Principle 4 is an adaptive, place-based, and iterative method to designing legal and policy changes that support the urban commons with an intention to position it with the concept of sharing and sustainability (S. Foster & Iaione, 2017). This is why LabGov.city has gone ahead to conduct some experiments in both Italian cities and others and this experiment led to an approach being introduced called the Co-City Cycle-this is a policy cycle in which interested cities or single actors work together to test a commons-based strategy to any urban challenge and apply it to a variety of urban assets and services[19].

Figure 9 Phases of the Co-City Cycle



Tech-Justice/ Technology/ Principle 5: As an enabler of cooperation and co-creation of urban commons, Tech Justice emphasizes access, participation, co-management, and/or co-ownership of technical and digital urban infrastructure and data.Technology is one of the major

[19] https://labgov.city/commonspress/the-co-city-cycle/

drivers when building a smart city and ITU's definition for a smart city states it as "an innovative city that uses information and communication technologies *ICTs) and other means to improve the quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, and environmental aspects. The term highlights the various components that go into creating a smart city, but technology considerations influence how smart cities develop and the smart city ecosystem is a complicated one that encompasses a wide range of technological fields (Lea, 2017). Cities use technology to enable collaboration and sustainability, as well as to pool consumers of urban assets, share infrastructure, and manage open data (S. R. Foster & Laione, 2016). Frost and Sullivan also adds five key technological groupings which consists of IT Players, Telecom, Governance, Energy & Infrastructure, and Building & Automation. This being stated, smart cities' IT infrastructure, which includes other online transaction modes, Internet of Things (IoT) and GPS-enabled networks for mobility purposes, Automated and Simplified Network Management for accuracy and consistency of deployed configuration [20], cybersecurity, data connectivity, digital modelling, AI, to name a few, have impacted all operational procedures, effectively serving as a backbone, with blockchain technologies also satisfying as a secure and smart way of transactions (Dipak, 2021). Citizens may participate directly in all stages of service production, including design, growth, and evolution, thanks to the usage of ICTs in cities creating and enhancing a more horizontal relationship between citizens and authorities (Choque et al., 2019). The presence of technology in smart cities cannot be understated.

Iaione and Forster further state that institutional, financial and legal mechanisms are tools that are employed to construct, govern, and sustain a variety of shared urban resources consistent with the principles design principles.

Institutional mechanisms: Policy innovation labs, collaboratories and urban living labs, and collaborative housing are examples of institutional tools that are used to govern the affairs of a community or city while ensuring resource preservation and sustainable resource management.

[20] https://ipfabric.io/the-road-to-the-self-driving-network/?utm_source=google&utm_medium=PPC&utm_campaign=Website+target+search+-+europe&gclid=CjwKCAjwi6WSBhA-EiwA6Niok_JR4E-p3BLGhz_wZi4tCsWE--78JVhmDZO8Vbfoc6w-iptZ_oG--xoCNM8QAvD_BwE

Legal Tools: These are a variety of legislative instruments that can be used to implement an urban co-governance plan and complement the institutional processes mentioned above. Urban civic uses, public-community pacts, land trusts, and others are among them.
Financial Tools : Tools for bringing together or pooling resources in a variety of ways to fund social projects that benefit the community or city. Crowdfunding and civic funding, solidarity funding, and social project funding, such as bonds, are among them (S. Foster & Iaione, 2017).

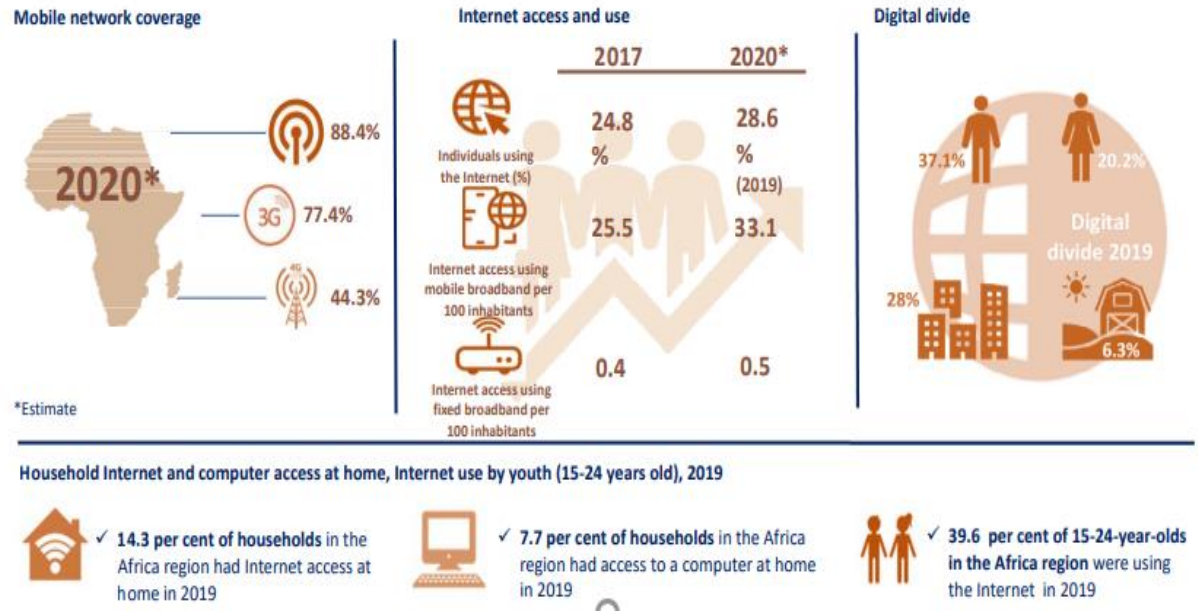
2.7.5 Introduction of Smart Cities in Africa

Africa is the world's second-largest continent after Asia, and the concept of smart cities has been brought to the continent, with Kigali, Rwanda's capital, being the first (Paquete, 2016). Across the midst of the continued rapid growth of sustainable smart cities in other continents such as Europe, Asia, and America, some writers have anticipated a lag in the African continent's progress and technology trend, while others are hopeful with the UN stating that megacities will arise from developing continents such as Africa and parts of Asia (LaGory, 2014). Smart Cities are a trend now, the future of Africa is being explored, and the governance model of innovation is being researched to help with the transition to smartness and sustainability and this is timely. Using the Global Innovation Index 2021 as a guide, several nations and regions on the continent have scored highly in particular areas (*GII 2021 at a Glance*, 2021). When it comes to smart cities, the population measure is critical, and according to the Global Population Growth and Sustainable Development report, Sub-Saharan Africa and Central and Southern Asia are expected to account for three-quarters of the projected increase in world population over the next three decades. Sub-Saharan Africa is expected to account for the majority of the global increase until the end of the century, adding between 23 and 38 million people per year between 2020 and 2100 (Fern, n.d.).
Despite the closeness that the so far remarkable efforts in Nairobi, Kigali, and Cape Town provide, the notion of a smart city is encapsulated by its definition, which no African city appears to have formed or conceptualized in their own value, context, or significance. Instead, efforts are founded on and directed by the concept's meaning in the Western world (Achieng et al., 2021).

In most African nations, the usage of smart technologies such as the internet, smartphones, and other similar devices is undisputed, and these are utilized by the majority of citizens, both young and old, for a variety of reasons. From health to sewage management, a certain amount

of smartness may be found in several areas of the African economy. The problem is that it cannot be characterized well enough to be evaluated as a specific trait of intelligence. Despite the fact that Africa is one of the world's fastest-growing continents in terms of population, there have been expectations that opinions have shifted, and Africa is rising, in reality, it has come a long way[21] (Huet, 2015).

Figure 10 Statistics of the African Region using Mobile Network Coverage and Internet Use & Access



Source: ITU WTI Database and World Bank data (for gross national income (GNI) data.

SECTION III

2.8 Debate On The Quintuple Helix And Sustainable/Climate-Neutral Smart Cities In Africa

The performance of smart city initiatives has become a priority for both researchers and government as their prominence has surged. Scholars like Krassimira have studied and noticed that the QH model of innovation, which is the typical model of the TH model, provides a chance to monitor and analyze how successful and efficient smart city initiatives are from the four players' perspectives- in so saying, the QH model is more appropriate for creating smart cities (Paskaleva et al., 2021). Other scholars have also stated that due to the fifth helix which is the

[21] https://www.bearingpoint.com/files/smart-cities-the-key-to-africas-third-revolution.pdf

natural environment/ ecosystem, from a more "technological standpoint," the city represents a unique ecosystem for the housing of innovative and' smart' systems that are deemed as "intelligent communities," in which interactions and collaborative effort enhance cultural and scientific authenticity by a built reliable distribution network touchpoints amongst concerned parties, therefore the Quintuple Helix is suitable for building smart cities (Appio et al., 2019).

The concept of Smart Cities, which is based on urban innovation, resourceful legislation, and information and communication technology, has garnered considerable attention from the political elite, borough and constitutional governments worldwide as a tool to alleviate contorted and depraved challenges in the knowledge economy's increased urbanization (Praharaj et al., 2018). A multi-level policy approach to smart cities creation is the smart specialisation mechanism. In a global economy in change, the new growth plan with a focus on the climate objective may be seen as a smart specialisation approach, claiming world leadership in clean technology, and exporting successful solutions. However, global value chain reorganization for sustainability will necessitate a separation of material and immaterial manufacturing (Larosse et al., 2020). This concept of smart specialisation comes as a nexus of change for climate neutrality and sustainability, and the QHM framework provides a method for recognizing and exchanging information gained in each helix, which leads to eco-innovations based on the CE model that are suited for climate change objectives (Durán-Romero et al., 2020b).

The concern is whether African cities can achieve smartness, sustainability, or climate neutrality, especially now that these notions have gained traction. Another prediction made by academics is how these African cities would achieve sustainability through innovation and governance processes, because many elements go into achieving a specific level of smartness, and as it is always assumed, Africa's indices are not particularly impressive especially in the contexts of population, innovation, industrialism, etc. On the other hand, others admire the efforts that some cities on the continent are doing, especially in sectors such as energy, formalising the informal sector, just to name a few.

2.8.1 Theoretical Framework

The research applies numerous theoretical frameworks, but it will focus on the most important and interconnected ones, such as the Backcasting, as well as knowledge-based theory, institutional spheres and social networks theories, evolutionary and co-evolutionary theories.

The role of agglomeration in the emergence of industrial modernity is the transition from an agrarian to an industrial civilization (Fields, 1999). This transformation has been identified over time as being regulated by a peculiar process that varies across demography, geography, planning, and so on, yet the concept of innovation transcends all of them. Through the various phases of the innovation models, the TH model is specified as the most acceptable preconditions and techniques for fostering innovation and entrepreneurship, and it is widely applicable as a paradigm for knowledge-based development (Cai & Etzkowitz, 2020). The QH model also emphasizes the importance of the knowledge economy progressing in lockstep with the knowledge society (Carayannis et al., 2012b). However, in the Quintuple Helix model, a change of events is viewed as merely the expansion and insertion of a new helix, the natural environment, which explains why the previous four helices are all imbedded in the fifth thereby strengthening the helix model.

Joshi, 2016 proposes that setting a smart city vision and efficiently advancing toward it with a systems-based strategy is critical for maximizing resource efficiency and security while maintaining socially inclusive growth (Joshi et al., 2016). Certain scholars have also previously linked helix models of innovation to stakeholder theory, using it as a theoretical lens to probe the contextual nature of a region and its component university models, with a focus on normatively grounded strategies as reflected by various stakeholder clusters and their viewpoints, frictions, and synergies (Etzkowitz et al., 2005). McAdams also points out that stakeholders differ depending on the region and university (McAdam et al., 2016). Mendizabal, 2021 also develops a framework based on a combination of Stakeholder Dialogues (SDS), vulnerability assessments, and backcasting exercises to better understand what causes cities to transform to adaptive and sustainable cities (Mendizabal et al., 2021) and Simon holds that backcasting is relevant as it is a strategic problem-solving framework, in the quest for the answer to how to reach specified outcomes in the future (Bibri, 2018a). Mora's middle-range theory of sustainable smart city transitions is a realistic theory that combines different smart-city-related concepts in a model that attempts to disclose the causative factors in a sustainable smart city transition and is ideal for this research. However, this study aims to understand if the transition has occurred and, if not, what can be done to make it happen quickly through an innovation model (Mora et al., 2021) and through the innovation helix model, backcasting theory will help to comprehend urbanization, sustainability diffusion, and the rise of ICT, which are the three most important global trends at play (Bibri, 2018b).

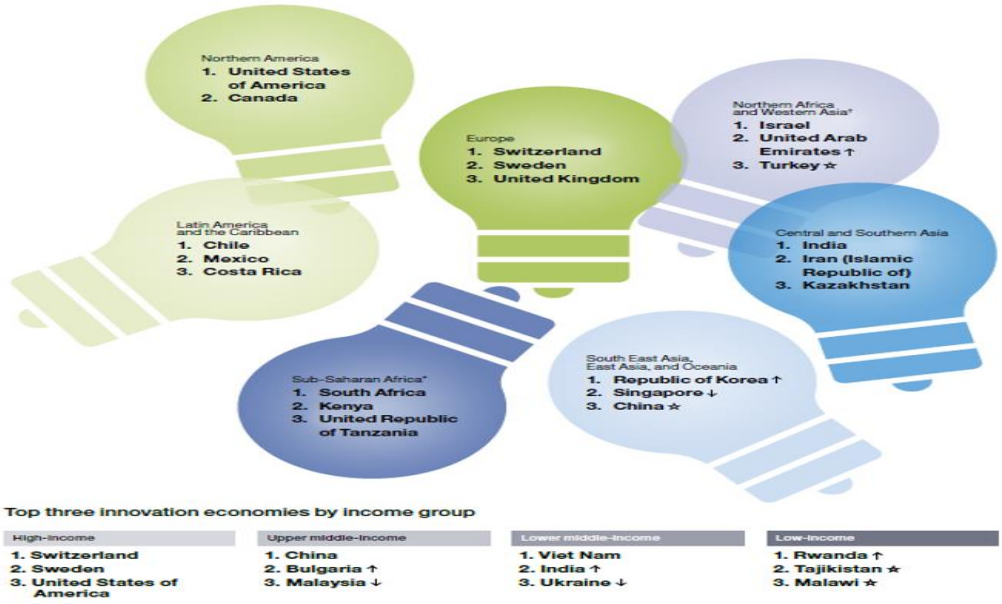
According to the theory of evolution and co-evolution, the helices models have evolved over time, starting with the knowledge-based production theory (which considers tacit, explicit, and cultural knowledge) and progressing to the triple helix model of innovation, the quadruple helix model of innovation, and finally the quintuple helix model of innovation. Rowan, 1977 describes the model of innovation with "institutionalization and how it involves the processes by which social processes, obligations, or actualities come to take on a rule like status in social thought and action" (Meyer & Rowan, BrianAcland, 1977). It acknowledges the social network theory which looks at the relationship and interaction amongst the various actors involved in the innovation helices model to stimulate innovation and co-evolving actors (Ivanova, 2014). This helps to shape the relationships in an institution.

Knowledge-based theory is significant to the helices models because the helical models emanate from knowledge-based theory. Loet Leydesdorff identifies that 'Mode 1' research is discipline-structured, whereas 'Mode 2' research is primarily legitimated and organized with reference to application contexts (Leydesdorff, n.d.). Carayannis explains that "Mode 3" is an expansion of Mode 1 and 2, thus it connects systems theory and knowledge, and a knowledge systems viewpoint is emphasized (Carayannis et al., 2015). The Knowledge-based theory includes tacit knowledge, proposed by author, Polanyi and is the form of knowledge that can be found in people's heads. As a result, it is difficult to transfer without a common paradigm and a set of specialized competencies shared by the transmitter and receiver. In contrast, explicit knowledge takes the form of codes, it is duplicated and communicated among a variety of users, and it must be comprehended through communication systems or channels such as publications, manuals, and so on (Arrazola, 2015).

Cultural knowledge comes to play when the way of life at a particular time is known, and perhaps shared or communicated. In terms of the frameworks stated above, Africa, which is now employing the TH model as a form of urbanization, will undoubtedly get there, but time may be a constraint. Combining stakeholder theory with backcasting theory, coupled with the institutional and social network theory and knowledge-based theory will be useful for identifying the present roles of stakeholders in the transition to a smart city by identifying characteristics and acquiring a suitable innovation model for African cities.

2.8.2 Smart Cities Adoption Compared- High-Income Countries Vs. Low-Income Countries
Due to the varying variables, it is necessary to examine the adoption of smart cities in both advanced and less advanced countries to decide which model will be suitable for each country or continent.

Figure 11 Top three innovation economies by region

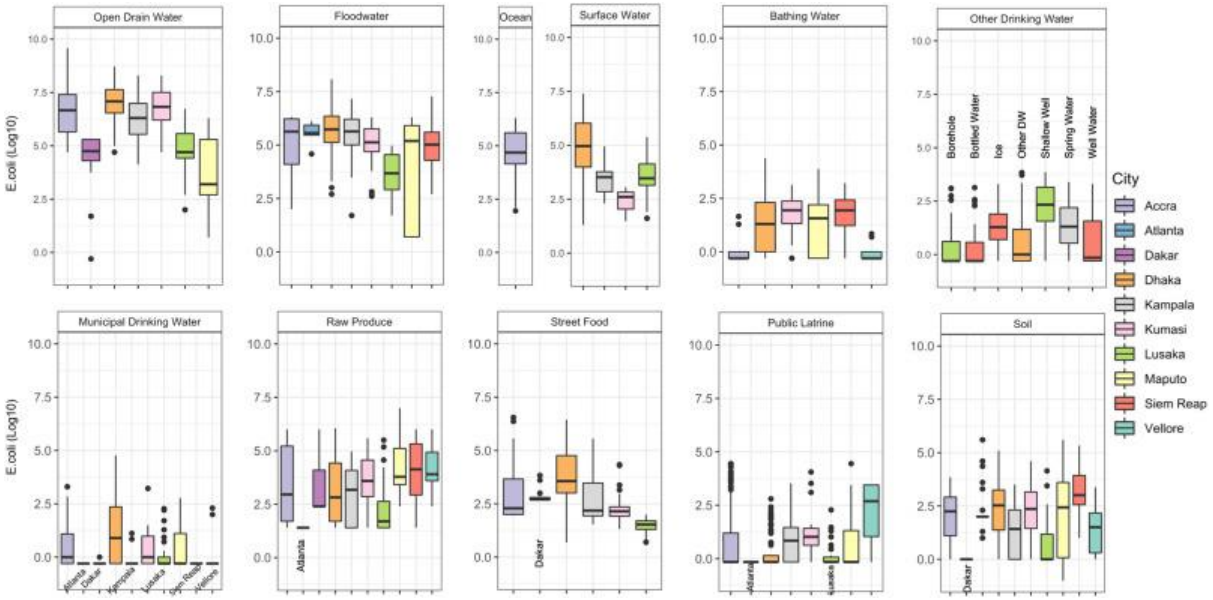


Source: Referenced from Global Innovation Index Database, WIPO, 2021

According to a set of metrics utilized in the investigation, the image above depicts the numerous locations that are extremely inventive. The top-down arrows represent changes in position within the top three since 2020, while the star represents a new arrival. The top three nations in Northern Africa and Western Asia are identified with the exception of island economies. Israel, Cyprus, the United Arab Emirates, and Turkey are the top four economies in the area in terms of total GDP. Mauritius, South Africa, Kenya, Cabo Verde, and Tanzania are the top three economies in Sub-Saharan Africa, excluding island economies.

2.8.3 Smart Cities Comparison of cities in low-income, middle-income countries and a high-income country (Waste Management)

Figure 12 Smart Cities Comparison of cities in low-income, middle-income countries and a high-income country (Waste Management)



Source: Reference from (Y. Wang et al., 2022)

Ten cities, two from Ghana, one from Zambia, Senegal, Bangladesh, Uganda, Mozambique, India, Cambodia, and the United States, are classified as low-, middle-, and high-income. The notion of a smart city, the smart environment characteristic, testing focused on environmental contamination of water and its consumption, and the findings visually, following data collection and observation, are shown in the picture above. Poor faecal sludge management and insufficient sanitation in urban areas result in widespread faecal contamination in the residential environment in many LLMICs, according to the report. However, the amount of fecal contamination in different compartments (environmental reservoirs) in many cities, as well as the ways in which people encounter those environmental compartments, are not well understood. Environmental samples and behavior questionnaires were gathered for each research zone and used to determine exposure to fecal contamination in the environment via various pathways. In all the cities analyzed, the food (rawproduce and street food) channels were the most prevalent, but open drains, flood water, and municipal drinking water all contributed considerably to faecal exposure in certain neighbourhoods within each city. A better understanding of the impact of poor faecal sludge management on urban residents in LLMIC can be developed and used to guide city, country, and region-specific investments and interventions by local and national governments, non-governmental organizations, and development banks by combining the findings from studies conducted in a variety of countries and regions around the world.

Table 1Definition of Institutions

Institution	Definition
UNECE & ITU	A smart sustainable city is an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects.
OECD	The concept of smart cities is around the contribution of digital innovation to better lives for all people; measure how smart cities perform and ultimately deliver well-being outcomes for citizens; and guide local and national governments in their efforts to reshape city governance, business models and stakeholder engagement.
EU	A smart city is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business [22].
IBM	A smart city is one that uses technology to transform its core systems and optimize the return from largely finite resources.
California Institute for Smart Communities	A community in which government, business, and citizens see the promise of information technology and make a conscious decision to use it to improve life and work significantly and positively in their region.
AU	A city is defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement.

2.9.4 Climate Neutrality In African Cities

Climate neutrality is a current concept and just as cities are striving to attain smartness, they are also treading the road of climate neutrality in conformity to the IPCC (Paris Agreement).There are many projects on-going in African cities that aim to achieve climate

[22] https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en#:~:text=A%20smart%20city%20is%20a,resource%20use%20and%20less%20emissions.

neutrality in different fields. They employ technologies such as robotics, artificial intelligence and renewable energies. Below are a series of example that discuss some of them.

Technology-Intensive Projects in African Countries in The Field of Robotics, Artificial Intelligence & Renewable Energy Technologies

Kenya – Flying Labs

Flying labs is a federated and decentralized network, co-created and facilitated by "WeRobotics", a non-profit organization, to support and facilitate knowledge exchanges between labs, disseminating the results of their research and enabling technology transfer from the labs to industry. In 2018, Kenya Flying Labs (KFL) was established to leverage the East Africa drone-industry ecosystem, with tremendous progress recorded in using and promoting Unmanned Aerial Vehicles (UAVs) by Tanzania Flying Labs (TFL) ZipLine in Rwanda. Kenya has been integrated in the last years within this vibrant network of knowledge and know-how, making major achievements in sustainable robotics to preserve and protect natural resources and the African ecosystem. KFL has invested a lot to integrate, support and promote the use of drones powered with solar energy for humanitarian projects and to preserve the Kenyan forests. In this regard, the major projects carried out by KFL are the mapping of forests to help improve forestry across the country, building capacity to fight illegal activities inside forests. UAVs have been employed also for light cargo deliveries of medical supplies during environmental and humanitarian emergencies thanks to appropriate licences acquired from the Kenyan Civil Aviation Authority. KFL has been deeply cooperating with the Kenyan Red Cross to experiment with new models of governance and organisation to develop new technical solutions to address pressing environmental challenges such as climate changes and natural disasters. One main strength of the KFL governance model is its focus on impacts and on how great results can be achieved with few resources including all the relevant actors ready to be engaged [23].

Rwanda – A cashless society

Rwanda has been one of the leading African countries to achieve tangible results in terms of socio-economic development, political stability, digital and ecological transition. The National

[23] https://flyinglabs.org/kenya/

Bank of Rwanda has undertaken a major leap towards the sustainable and digital goals of Rwanda through the adoption of the Rwanda Payment System Strategy 2018-2024. The strategy aims to digitalize the economy by becoming a cashless society by 2024 through a world-class payment system, thus boosting the efficiency and flexibility of payment transactions and making them more sustainable and resilient. The strategy is framed in a broader societal commitment to accelerate the sustainable economic growth by creating an interoperable payment landscape as an enabling environment for product and service innovation, thus providing affordable payment services to many African cities. The strategy also includes a comprehensive program to boost the Rwanda cybersecurity capacities assuring security, reliability, and resiliency of e-payment systems. The strategy will be developed by embracing an open innovation approach thanks to the development of tailor-made Open Application Programming Interfaces (APIs). These tools will enable innovation and collaboration between banks and third parties in a context of free flow of information, technical know-how and best practices. Major opportunities will be disclosed to Rwanda and the Sub-Saharan region by implementing mobile wallet (mWallet) payments to meet the demands of end-users and as such the sector is projected to have an accelerated growth by 141% in volume, 161% in value and 187% in revenues between 2013 and 2023 in Sub-Saharan Africa [24].

South Africa- Solar for Energy

South Africa decided to be one of the gamechangers by making use of a future energy mix and the growing need for power considering the global warming- drought, severe storms, wild temperature swings and the energy plans to address energy demands that increase daily. There is a predicted mix with the source of energy since the Department of Energy has planned for what South Africa's energy generation portfolio will look like by the year 2050. The idea is to use natural energies such as wind, gas, nuclear, coal and most importantly solar since it is cheaper than coal in many countries worldwide. Solar power which holds the most potential in South Africa due to the country's geographical location receives large amounts of solar energy. As a matter of fact, the energy sector in South Africa is an important component of global

[24] https://www.mfw4a.org/publication/rwanda-payment-system-strategy-towards-cashless-rwanda-2018-2024

energy regimes due to the country's innovation and advances in renewable energy. The country's contribution to greenhouse gas emissions is ranked moderate and its per capita emission rate is higher than the global average. Solar energy in South Africa is primarily based on PV and CSP. The levelized cost of solar electricity is relative to the quality and quantity of solar radiation in South Africa.

The same plant can produce up to 20% more electricity for the same capital investment in South Africa compared to countries in Europe. The furthest area in the west of the country receives the highest levels of solar radiation, ranging from 2100 kWh/m2 to more than 2300 kWh/m2. Solar power production in South Africa is anticipated to reach 8400 MW by the year 2030. South Africa has implemented a solar park in the Northern Cape region that is set to deliver 180,000 megawatts of annual solar energy to the country. It is estimated that only 3000 km^2 of land used for solar electricity is required to meet South Africa's demand. Solar energy is a low-cost source of energy compared to traditional non-renewable energy resources in South Africa. The introduction of solar power plants has stimulated the economy and created jobs within the country. South Africa's land cover receives an average of 2,500 hours of sunshine per year. Solar energy systems have a high initial cost, but typically return the investment within 5 to 8 years. The use of solar energy in South Africa is driving the use of other renewable energy sources including wind, hydroelectric, and biomass. Global reductions in renewable energy process provide an important opportunity for African cities to "leapfrog" to cleaner low carbon electricity supply. Focusing largely on the domestic, business and agriculture sectors to boost the African economy in diverse ways using these renewable energy sources available to them [25].

[25] https://www.esi-africa.com/renewable-energy/solar-energy-hybrid-system-used-to-power-bentley-park-in-south-africa/

CHAPTER THREE
THE ACCRA CASE

3.1 Introduction

This chapter focuses on the Ghanaian case, with Accra as the focal point giving a brief background study of Ghana and an in-depth background of Accra. It starts with Accra's smart city situation, then moves on to contemporary innovative project developments and its classification as a smart city. It then examines the condition of innovation in Accra before conceptualizing the Quintuple Helix of Innovation model in the Accra environment.

3.2 Background Of Ghana

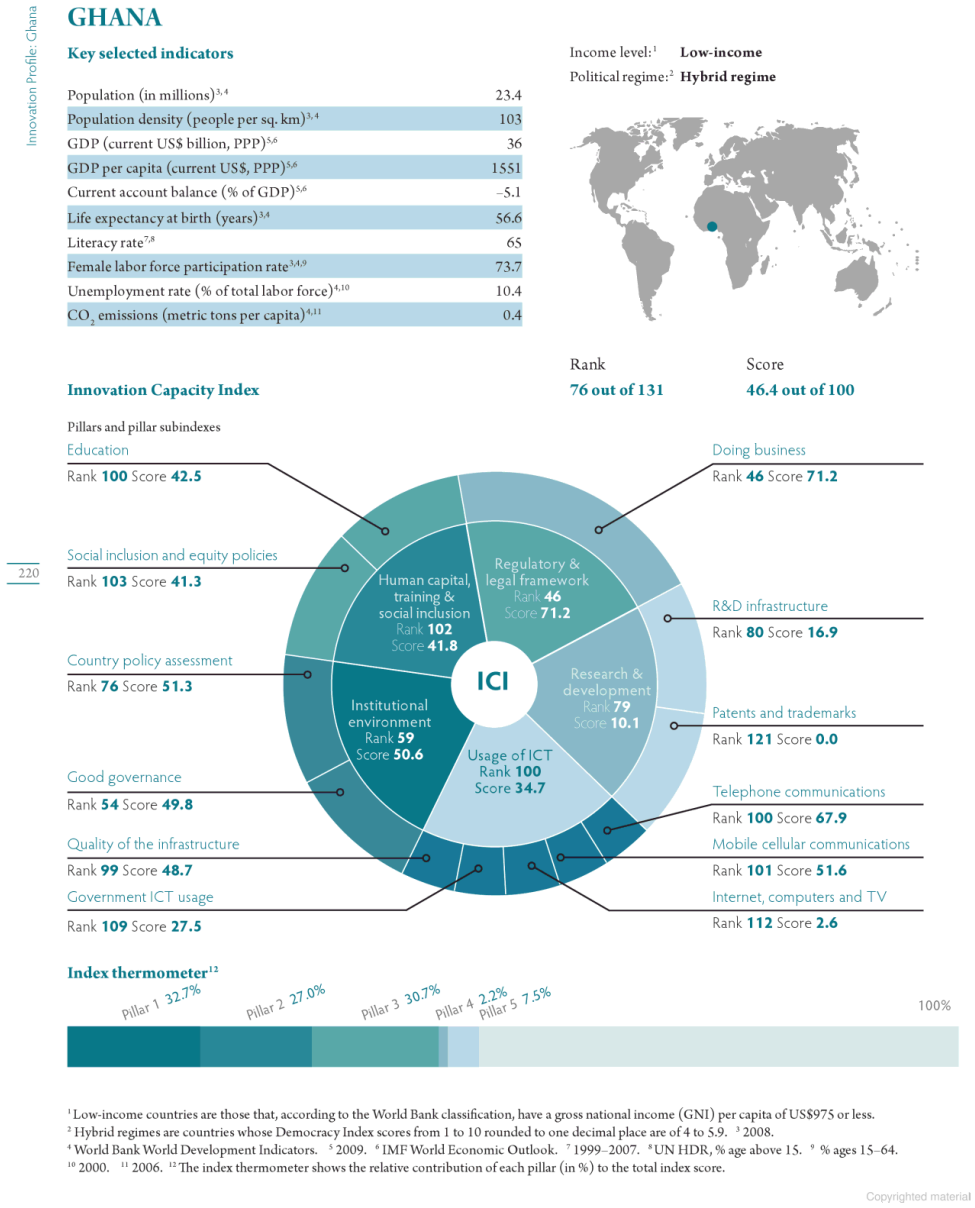
Accra is the capital of Ghana, a West African country previously known as the "Gold Coast" and bordered by Cote d'Ivoire on the West, Togo on the East, and Burkina Faso on the North[26]. Ghana is a multi-ethnic country with about 26 million people, made up of more than 100 tribes, with the Akan, Ga- Adangbe, Ewe, Guan, Mole-Dagbon, Dagomba, Hausa, and Kusasi being the nine major ones[27]. Although English is the official language, Ghana has over 50 indigenous languages spoken by diverse groups. Despite this, most of the population speaks popular local dialects like Akan, Ga, Ewe, Dagaare, and Dagbani (Sadat & Kuwornu, 2017). Ghana is a secular state per its constitution. According to national census data, Christianity is the most popular religion accounting for 68.8% of the population, followed by Islam (15.9%) and traditional religion (8.5%) (Quashigah, 2010). Ghana has sixteen regions with 216 local districts created for administrative purposes[28].

[26] https://thecommonwealth.org/our-member-countries/ghana#:~:text=Ghana%20is%20a%20West%20African,and%20Togo%2C%20to%20the%20east.
[27] https://buzzghana.com/ethnic-groups-ghana/
[28] https://www.ghanamissionun.org/map-regions-in-ghana/

Figure 13 Map of Ghana with its major cities

Reference: Sourced from an article on Research Gate- https://www.mapsofworld.com/ghana/

Figure 14 shows the position and rate of innovation in Ghana with crucial indicators.



[1] Low-income countries are those that, according to the World Bank classification, have a gross national income (GNI) per capita of US$975 or less.
[2] Hybrid regimes are countries whose Democracy Index scores from 1 to 10 rounded to one decimal place are of 4 to 5.9. [3] 2008.
[4] World Bank World Development Indicators. [5] 2009. [6] IMF World Economic Outlook. [7] 1999–2007. [8] UN HDR, % age above 15. [9] % ages 15–64.
[10] 2000. [11] 2006. [12] The index thermometer shows the relative contribution of each pillar (in %) to the total index score.

Reference: Source from A.Lopez-Claros, *The Innovation for Development Report 2009-2010*

Figure 15 Africa Innovation and Entrepreneurship Rankings

	Country Ranking					
	Ghana	Kenya	Morocco	Mauritius	Nigeria	South Africa
Global Entrepreneurship Index, 2018	93	109	65	NA	101	57
Global Innovation Index, 2018	107	78	76	75	118	48
Global Competitiveness Report: Innovation Ecosystem Component, 2018	87	66	88	50	92	46
StartupBlink Ecosystem Report, 2019	75	52	65	NA	56	51

Reference: Source from Cornell University, INSEAD, and WIPO 2018: ACS and others 2018: and StartupBlink 2019.

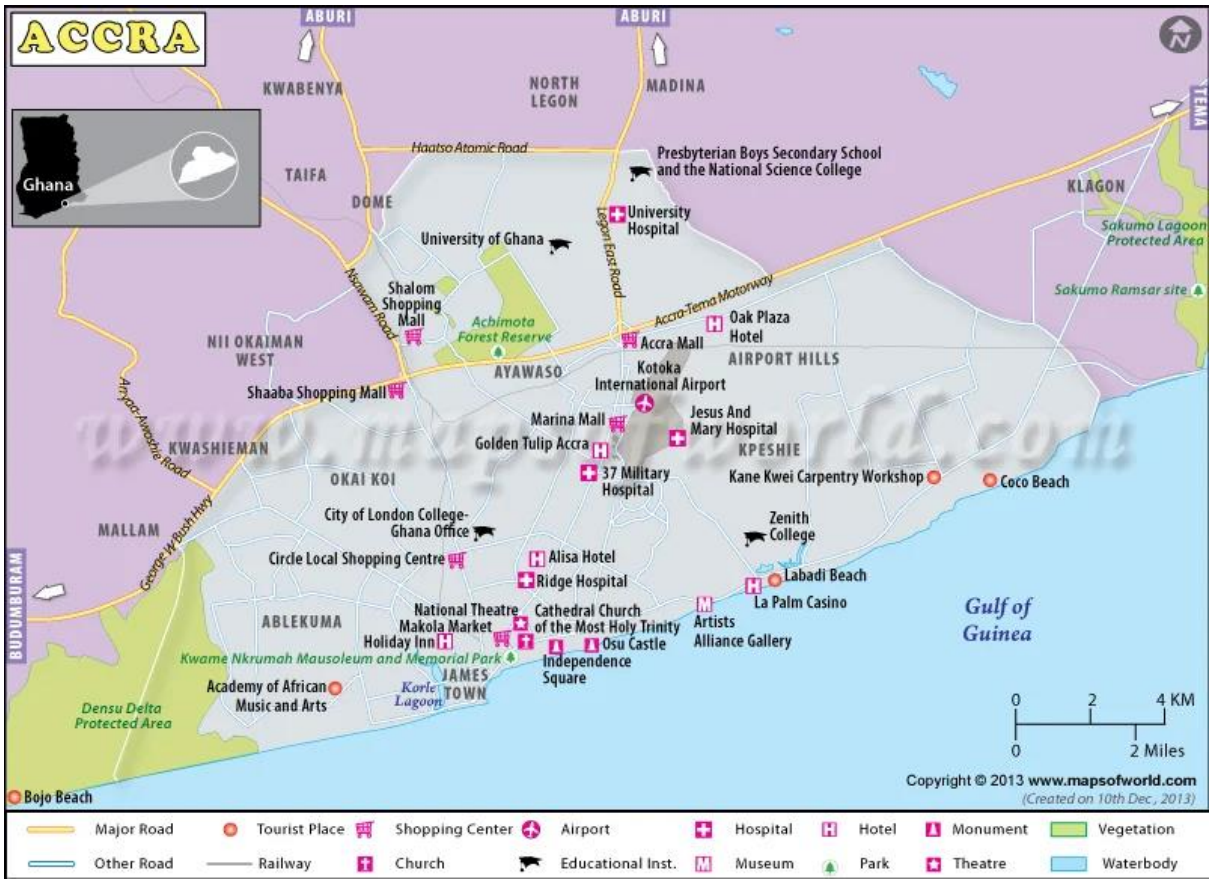
ACCRA

The mayor of Accra states in a paper *Accra Resilience Strategy* that the GAMA Authority's objective is to establish a resilient Accra, thus, "A smart, sustainable, and resilient city that anticipates and plans for shocks, rather than reacts to them. We will transform the city's ongoing stresses into opportunities: by embracing informality as an engine of growth, designing infrastructure to improve our natural and built environments, and optimizing our resources and systems for greater efficiency, accountability, and transparency."(Accra Metropolitan Assembly, 2019). Accra, one of Africa's megacities (Güneralp et al., 2018), is located in the south on the coast of the Gulf of Guinea, the largest city and capital of Ghana[29]. People from various walks of life live and work in Accra, but it is home to the ethnic group Ga Adagme, who are primarily Ga's, Dangme's, and partly Krobo's. According to the 2010 Population and Housing Census, the Accra Metropolitan Assembly (AMA) has 1,665,086 people accounting for 42 per cent of the region's total population. Males account for 48.1 per cent of the people, while females account for 51.9 per cent. The metropolis is entirely an urban centre. It has a sex ratio of 93 and a youthful population (under 15 years) of 42.6 per cent, indicating a broad base population pyramid that tapers down with a tiny number of older people (60+ years) accounting for 5.9%. The total dependency ratio is 48.5 per cent, with the child dependency ratio (42.6 per cent) being more significant than the old-age dependency ratio (5.9) (Ghana Statistical Service (GSS), 2014). The population of the capital is currently estimated to

[29] https://www.nationsonline.org/oneworld/map/google_map_Accra.htm

be around 2,605,402[30]. The Greater Accra Metropolitan Area (GAMA) consists of towns and communities within Accra and Tema. The Metropolitan Area has grown from a collection of modest coastal fishing settlements to become Ghana's most populous urban district. It is Ghana's main entry point accounting for a quarter of its GDP and attracting over 80% of all foreign direct investment. The metropolis is made up of fifteen local government districts that are inter-connected. It is not governed as an established metropolitan area with strong economic, environmental, and social ties because each section is managed as a separate administrative and planning entity (M. Ahumada et al., 2016).

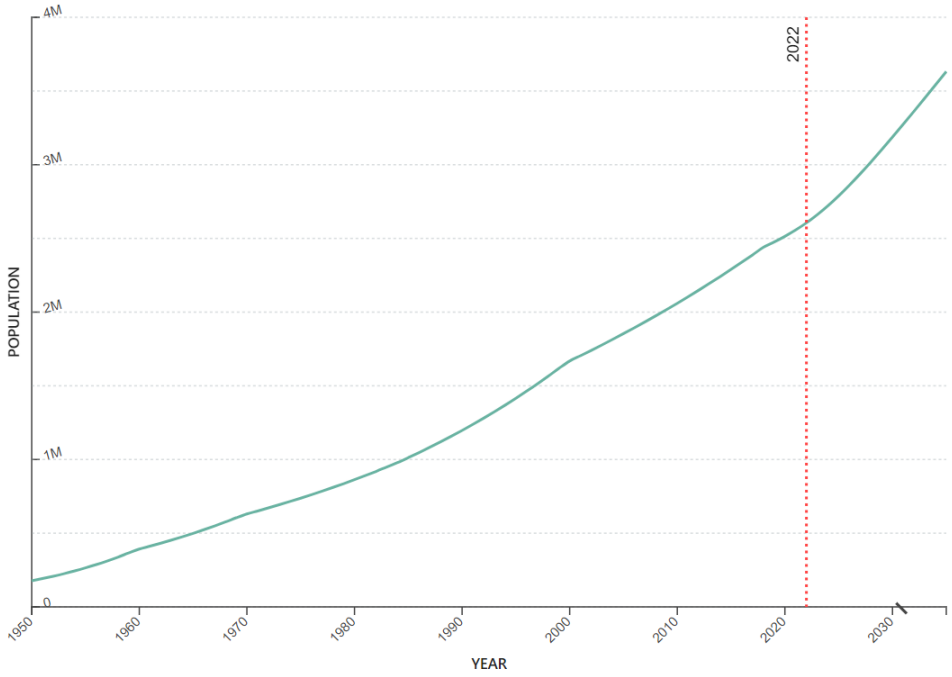
Figure 16 Map of Accra



Reference: Sourced from https://www.mapsofworld.com/ghana/accra.html

[30] https://worldpopulationreview.com/world-cities/accra-population

Figure 17 Representation of graph that shows the increasing rate of Accra's population annually and the current population



Reference: Sourced from https://worldpopulationreview.com/world-cities/accra-population

3.3 Ga Mashie Aerobic Compost Facility-Smart Waste Management in Accra

In the Accra metropolitan, solid waste management (SWM) is being provided in an unsustainable manner. Large amounts of waste are generated in Accra due to uncontrolled urbanisation, putting strain on an already overburdened solid waste management infrastructure. According to waste stream data released by the AMA's Garbage Management Department, Accra inhabitants generated about 2000 metric tons of solid waste daily in September 2007, up from 1800 metric tons in 2000 and 1200 metric tons in 1994. The EPA has also predicted that by 2025, the city's daily trash generation will have increased to almost 4000 metric tons. Under prevailing circumstances, only roughly 1200 metric tons of garbage are collected daily. Home waste collection is usually restricted to high- and middle-income regions, leaving the poor to deal with the matter on their own. In the Ashiedu Keteke sub-metro, interventions are taking place. The Ashiedu-Keteke sub-metropolis is a low-income area battling indiscriminate garbage disposal in surface drains and streams, causing unsanitary and unsightly environments in many parts of the sub-metropolis. The Great Thinkers Social Club, an NGO founded by some of the community's smartest people, chose to implement an integrated waste management

solution in Ga Mashie. In its engagement with the AMA, the organization collaborated with the Ashiedu Keteke sub-metro and community residents to successfully conduct sanitation educational forums, increase refuse skips, and prioritize sanitation management by residents, resulting in conscious efforts by both parties to address the concerns.

Description of the products or services: Assisting urban poor and low-income individuals in managing their own waste and generating cash from it. Waste Concern is also assisting low-income farmers in obtaining low-cost, sustainable organic fertilizer. Under the house-to-house rubbish pickup services, the primary clientele are residents of Ga-mashie (James Town and Ussher Town). Slum and squatter settlement dwellers, private compost marketing companies, poor farmers (compost users), waste management authorities, and other development organizations. The traditional technique taken by local governments is "end-of-the-solution", in which waste is collected from communal bins, carried by open trucks, and dumped in unclean dumping sites. Instead of viewing waste as a problem, the Great Thinkers Social Club's model of community-based approach creates a value for garbage, encouraging people to view it as a resource raw material.

Partnership: Waste refers to labor-intensive technology that is acceptable for the Ga-mashie Community and the city in terms of socioeconomics and climate. Under this concept, public, private, and community relationships are employed to benefit each partner. Rather than marketing compost directly, the Great Thinkers Club is partnering with a seasoned private fertilizer company with a nationwide network. The private sector sells two different types of compost: ground raw compost and enhanced compost (blended and enriched with necessary nutrients based on soil and crop type). Enriched compost has gained popularity since it is less expensive than chemical fertilizers and can yield more crops.

Description of the operational model**:** The city authorities and the Ga-mashie community has made land available for the community-based compost facility at no cost under this arrangement. By incorporating the urban poor in the composting plant located near the community, the Great Thinkers Social Club organizes to collect, segregate, and turn solid waste into organic compost. Community members pay a reduced charge for house-to-house garbage collection and supervise operations in their neighborhoods, while private enterprises with skills and connections sell organic compost to Ghanaian farmers.

The Ga-mashie Community oversees monitoring and contributing to the expense of the house-to-house rubbish collection system. The community has also appointed kids to help with rubbish collection and composting. The Great Thinkers Social Club works with local governments and the commercial sector to get land and logistical support for the program's implementation and recycling and compost marketing. The Great Thinkers Club offers technical assistance for the installation of composting units, community training in management, compost marketing, and service operation and maintenance.

Public Sector Involvement**:** The City Corporations, AMA, and its Public Works Department (PWD) have granted permission to use the allotted site for composting. The EPA has also issued permits after determining that all protocols are being followed to guarantee the health and safety of the facility's employees and the public.

Opportunities: The high proportion of organic matter in waste, community, and private sector willingness to pay for the service, an abundance of labor, limited resources, availability of proven technology to compost organic waste, and demand for organic fertilizer have created a unique opportunity for replication and scaling-up of this model.

People in the Ga-mashie neighborhood pay for a rubbish collection service that goes from house to house. In exchange, people enjoy a higher quality of life in their communities, and their property values rise. The urban poor, particularly women, now have a new source of income. The private sector makes money by marketing an environmentally benign product, while impoverished farmers save money by employing compost and enriched compost to grow more agricultural products.

Challenges: Land available from the government for composting facilities within the city limits. There are not enough policies in place to encourage waste recycling and composting. Compost commercialization must be systematically pushed by the government. Easy accessibility of bank financing options for entrpreneurs who want to start comparable businesses.

3.4 Smart Cities Situation

Africa is no longer left out of the smart city concept; like Kenya and South Africa are both taking steps to improve a variety of areas of their capital cities to satisfy smart town requirements per *The Smart City Journal*. Accra being the capital of Ghana is additionally one of the best places to put into effect smartness for other cities both in Ghana and beyond to

replicate. Ghana is one of the sub-Saharan African countries amid rapid urbanization and this has largely bought into the concept of the right to the city and inclusive urbanization, as reflected in national policy. Indeed, Ghana's national policies emphasize urban renewal and the upgrading of slums and other informal settlements, as well as the promotion of the urban informal economy, such as the National Urban Policy Framework (NUPF) and Action Plan, 2012; National Housing Policy (NHP), 2015; National Spatial Development Framework (NSDF), 2015-2035; and other related national-level policies (Crentsil & Owusu, 2018). It is with no doubt that Accra received the IBM Smarter Cities Challenge grant in 2014, funding that would aid in the city's social and infrastructural development. Accra is one of the four African cities picked from a total of 33 candidates. The IBM Smarter Cities Challenge, which began in 2014 and is funded by IBM, is a three-year, $50 million initiative in which IBM sends teams of experts from various disciplines to cities to help them formulate strategies for improving the quality of life for their citizens, using ICTs as a driving tool (Eduam, n.d.).[31] Ghana is also one of the first 10 countries that willingly expressed interest in the Smart Africa initiative (The World Bank Group, 2019). The Ghanaian government launched the National Urban Policy Framework and Action Plan on March 28, 2013. The Policy highlights the difficulties of urbanization as well as the efforts that will be taken to meet the goals set out to address the issues in all the cities, especially Accra as the capital. Limited data and information on urban centers; environmental deterioration; insufficient urban infrastructure and services; rising urban insecurity; and poor urban transportation planning and traffic management are just a few of the issues faced in the city (Appiah, 2019).

Apart from Kigali, Accra is one of the few African cities to have included all 17 SDGs into its development features, with around 14 of them achieved thus far (ESI Thoughtlab, 2021).

Smart Governance in Accra

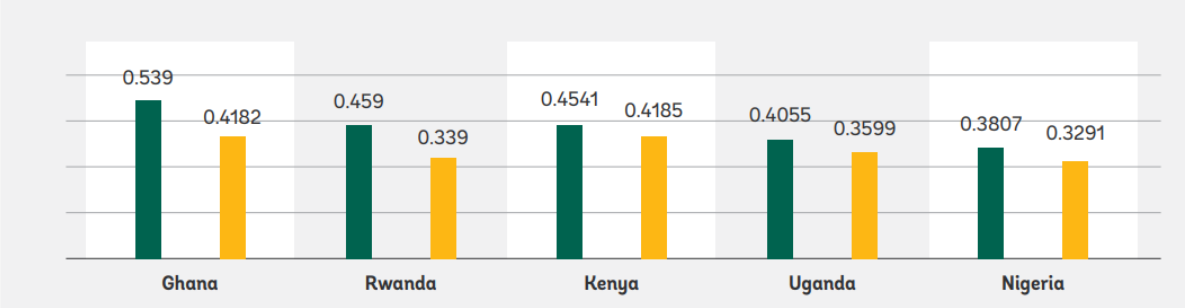
The Ghanaian government has implemented many efforts to promote e-governance throughout the country, particularly in Accra, by building an e-services platform. The Ghana Police Service-Criminal Investigation Division (GPS-CID), Ghana Passport Office, Driver, and Vehicle Licensing Authority (DVLA), National Health Insurance Scheme (NHIS), Land Registration, Retirement, and Pension Scheme, and Ghana National Service Scheme (NSS) are

[31] https://www.thesmartcityjournal.com/en/articles/smart-city-accra-ghana-gold-coast

among the government institutions that have been digitized on this platform. Furthermore, the Ghana Ports and Harbor Authority's digitization of documentation, import and export processes allows importers to follow their commodities (Appiah, 2019). Another initiative is "The Ghana Open Data Initiative" (GODI) created in 2012 by the National Information Technology Agency (NITA) to develop an open data ecosystem in Ghana to assist government e-services. The Open Data Government is important because it encourages transparency and accountability, which fosters social and economic progress. The initiative also promotes citizen involvement and inclusion by providing citizens with accurate and timely data and information. Easy access to government-held data minimizes the risk and transaction costs in the economic sector, eliminating growth hurdles (AIMS, 2017)[32]. The government's continuous investment in public sector digital platforms reflects a growing need for improved efficiency, openness, and accountability. A digital address system, e-procurement, e-immigration, e-parliament, and e-judiciary are among the digital platforms that have been established to improve governance and delivery of public services. The government has just started implementing the long-awaited digital identity program (the Ghana Card) and other national identity cards. Ghana is the only African country to move from a middle to a high E-Government Development Index (EGDI) level in the 2018 UN E-Government Index assessment and this is a great achievement (The World Bank Group, 2019) as most of the public agencies that provide these e-services are located in Accra. The Ghanaian Parliament has approved the Right to Information (RTI) Bill into law in March 2019, allowing citizens access to information though several obstacles almost restricted this (The World Bank Group, 2019). The Smart Governance trait, as modeled by Giffinger (2010), characterizes the government's provision of various e-services (Giffinger, 2010).

Figure 18 Graph that shows the level of e-governance amongst five African countries with Ghana as lead

[32] http://aims.fao.org/activity/blog/ghana-open-data-portalunleashing-power-open-data



Reference: Ghana Digital Economy Diagnostic-Stocktaking report, World Bank

Smart Economy in Accra

The tertiary sector is slightly unbalanced in Ghana's economic structure. Studies have observed that the tertiary sector contributes about 45 percent of total value-added, with the secondary sector accounting for 33 percent and the primary sector accounting for 21 percent. Furthermore, the tertiary sector employs 49% of the workforce, while the secondary sector employs 23% and the primary sector employs 28% (Systems, 2020). The World Bank Group's assistance for the African Union's Digital Transformation for Africa initiative, which aspires for every African individual, company, and government to be digitally enabled by 2030, includes the Digital Economy for Africa (DE4A) Initiative. Five concepts underpin the Digital Economy for Africa initiative: Collaborative, Transformative, Inclusive, Home-Grown, and Collaborative. According to the author of the Ghana Digital Economy Diagnostic-Stocktaking report, he states that African countries must create crucial foundational pieces of a digital economy to have a successful and inclusive digital economy. With that being said, the elements are digital infrastructure, digital platforms, digital financial services, digital entrepreneurship, and digital skills (World Bank Group, 2019). Meanwhile, Ghana's economy is driven by the services sector, with ICT accounting for around 3.6 percent of the country's GDP(IFC, 2017). GAMA is Ghana's most powerful and prominent urban region, accounting for 83 % of the total national direct investment as well as leading Ghana's economy, accounting for 25% of the country's GDP. Accra and the ICT industries have a high concentration of entrepreneurship clusters (M. Ahumada et al., 2016). Outside of Accra, the ecosystem is often underdeveloped, leaving start-ups and entrepreneurs underrepresented outside of the city, making the city the major element for driving innovation and entrepreneurship (World Bank Group, 2019).

Smart Mobility: This concept is characterized mainly by forms of transportation that apply ICT, especially public transportation. In Accra, the existence of road transport, maritime and water transport, aviation, and rail is reflected ("Ghana's Infrastructure Sector," 2018) yet the main transportation system is represented by more mini-buses, large buses, and taxis-the informal sector while Metro Mass Transit Ltd is Accra's only formal passenger transport company (IBIS Transport Consultants Ltd., 2005). A growing section of Ghana's population has been able to afford, buy and operate vehicles in recent years resulting in a rise in the number of automobiles on the road in Accra, resulting in greater traffic congestion[33]. For accessibility, both locally and inter (nationally), Accra cannot be rated highly. Locally, the average commute time is 110 minutes for a distance of 3.28 kilometers. Half of commuting workers report that terrible roads are the biggest impediment to getting to work, while a quarter says high traffic is the worst problem. More than half of those actively looking for work say that access to the workplace is their biggest obstacle (Abane et al., 2019). The rate of national accessibility is better because large buses go inter-regionally, while some minibusses do as well. The Bus Rapid Transit (BRT), a high-capacity mode of public transportation has also been inaugurated in November 2016, although it has became almost non-existent in Accra, with only a few people using it[34]. Therefore in December 2016,there was an introduction of the Quality Bus Service (QBS) to substitute the BRT and it is currently running along the Amasaman and Adenta corridors (JICA, 2021).

In terms of sustainable, innovative, and safe transport systems, the KOICA, Korea International Cooperation Agency, supported the Ministry of Transport and Greater Accra Regional Coordinating Council in preparation of "The Transportation Master Plan in Greater Accra Region in 2015-16". The Arterial Bus & BRT System, Railway Network Plan, Road Networks, Transport System Management, ITS Project, and Proposed Corridor Renovation and Improvement Project Package along the Librarian -Adenta corridor, both suburbs of Accra, are among the numerous objectives to be implemented for intelligent systems in certain parts of the city. Some of the plans are unable to be implemented due to a variety of obstacles, but

[33] https://www.copenhagenconsensus.com/publication/ghana-priorities-urban-transportation-bus
[34] https://www.theigc.org/blog/transport-job-accessibility-towards-competitive-inclusive-accra/

others are moving forward despite the obstacles—three major flyovers are being built within the city, namely the Tema, Pokuase, and Obetsebi-Lamptey Flyovers, which are funded by the Project for Improvement of Ghanaian International Corridors, Accra Urban Transport Project, and National Government Investment, respectively (JICA, 2021). Due to the state of Ghana's railway sector, the country's public transportation system is heavily reliant on roads. Approximately 95% of transportation services are provided by the informal private sector, whose activities can be dangerous, unreliable, and inconvenient at times (Abane et al., 2019). The Ministry of Railway Development's Urban Railway Investment has drafted policies to introduce an LRT/Tram system, a SkyTrain project, and an Urban Railway Project to promote convenient transportation of resources from inland regions to major ports on meticulous investigations(JICA, 2021). The availability of ICT infrastructure within the city is dense with transportation, power, information and communications technology (ICT) infrastructure, reflecting the spatial distribution of economic activity (W. Africa, 2012). The relationship between ICT and transportation infrastructure and its availability is low, and the government is taking steps to improve it through a variety of means, including digital skills acquisition programs, to name a few.

Smart Environment: The smart environment characteristic is defined by a lack of pollution of natural conditions, environmental protection, and sustainable resource management as conceptualized by Giffinger, 2010. Due to Accra's rapid urbanization, which includes the construction of an industrial city and the expansion of ports in both GAMA and Tema, as well as the city's central urban district, where people move in and out to conduct business, pollution is concentrated within the city in many forms (J. Wang et al., 2022). The most common means of transportation in Accra is via vehicular means. Most public transit vehicles or minibusses, konwn as the "tro-tro" in Accra, are imported as second-hand cars that consume fossil fuel and emit significant levels of vehicular emissions (Imoro Musah et al., 2020). Other existing pressures harm the environment, but the Government, relevant agencies, and stakeholders should be commended for the progress made thus far through the vision that was set as an environmental policy "To manage the environment to sustain society at large," and numerous efforts have been made to ensure that citizens have access to sufficient and wholesome food, clean air and water, decent housing, and other necessities of life, thus, ensuring environmental protection of all forms. Institutions such as the Ministry of Science, Technology, and Innovation, the Environmental Protection Agency (EPA), and the National Disaster

Management Organization all recognize and play important responsibilities in protecting Ghana's natural ecosystems. They are guided by fundamental ideals such as integrity, accountability, environmental justice, inclusivity, commuter pay, and others that contribute to Accra's transformation into a smart city.

Sustainable Resource Use and management is one of the strategic goals of Accra to become a sustainable and resilient city. The government's goal is to ensure that nonrenewable resources are used wisely, that current and future generations' interests and needs are considered, that all environmental impacts associated with resource exploitation are assessed, that the potential for alternative technologies with lower environmental impacts is explored, that renewable resources are used sustainably, and that investment policies do not unnecessarily transfer ownership of the country's natural resources (Hamilton & Stream, 2014). Many more policies and projects are in the works, but there is still much more that can be done.

Smart Living considers Accra people's cultural amenities, health conditions, personal safety, educational opportunities, housing equality, tourism, and social cohesion. Ghana is known for its hospitality, and Accra extends a warm welcome to guests in a variety of ways. Accra has cultural facilities such as the Centre for National Culture popularly known as the Art Centre[35] and the Nubuke Foundation[36], which house a variety of Ghanaian and African assets such as woven Kente cloth, wooden sculptures, beadworks, leather bags, earrings, and other fashion accessories, the latest in African attire fashion, and high-quality handicrafts from across the country. These are the areas where most international visitors go to get a true taste of both ancient and modern-day Ghana. Accra is one of the safest, most tranquil, and secure cities in the world. During the night, police patrols are stationed in areas deemed dangerous, but Accra is generally safer than other African cities. Kidnapping, murder, assault, and other severe crimes are at an all-time low[37]. Accra is seeing an increase in educational options, with full and partial scholarships available for students to pursue a variety of degrees. More scholarships are being offered by the government, businesses, non-governmental organizations, and individuals, allowing people to study for free or at a reduced charge. Accra's educational system includes creche/Montessori, high school, technical and vocational schools, universities,

[35] https://visitghana.com/shopping_location/centre-for-national-culture/
[36] https://artsandculture.google.com/partner/nubuke-foundation
[37] https://www.expatarrivals.com/africa/ghana/safety-ghana

chartered institutions, language schools, law schools, and business schools. Accra has a total of 67 fully authorized universities and higher education institutions[38]. Accra is home to Ghana's premier and largest university, the University of Ghana. Policies and structures exist to address urban health challenges in terms of health conditions. Accra has 28 hospitals and significant health issues are primarily communicable diseases as a result of inadequate environmental cleanliness, ignorance, and poverty (HABITAT, 2009). Malaria was formerly on the rise, but thanks to increased understanding of the natural ecosystem and healthy living, the rise, and transmission of the disease has been significantly reduced. According to the Ghana Urban Health Assessment report, more measures are still being implemented to combat urban health challenges (Taylor et al., 2002). The informal sector dominates housing in Accra and in terms of housing tenure, two out of every five households in Accra rent their home, while another 27% live in rent-free situations. Three out of every five households in rural areas own their homes. In both rural and urban areas, one-third of households have more than two sleeping rooms, while around 2.7 million urban homes have only one room (Sarfoh et al., 2016). Though some parts of Accra are full of slums, informal and scattered settlements, residential areas, and estate places, it can be classified into indigenous low-class residential areas, migrant low-class residential areas, middle-class residential areas, and high-class residential areas (Agyei-Mensah & Owusu, 2010). The western half of Accra (mostly the Ga settlements) is rapidly evolving into a huge residential area with estates and high-rise flats. Currently, the ownership of lands and homes by families or stools is an interesting feature of Accra, which makes it difficult for the government to implement more apartment and affordable housing schemes. Still, it also has a benefit in that more people tend to own homes or lands by themselves and profit from them (Crentsil & Owusu, 2018). Yet, at the municipal level in Accra, the authorities are doing everything they can to implement measures that would make the city smarter, such as the Participatory Slum Upgrading Programme, Phase One (Sarfoh et al., 2016).

Smart People: This is defined by social and human capital within the city. This takes into account the many possible approaches Accra inhabitants acquire knowledge, skills, values, and attitudes in their daily lives. As more people join in all levels of education, educational

[38] https://www.4icu.org/gh/greater-accra/a-z/#:~:text=uniRank%20tries%20to%20answer%20this,Ghanaian%20higher%20education%2Drelated%20organization

infrastructure must be upgraded regularly to reach all pupils enrolled within the city. Accra can now talk of its populations' willingness to embrace urbanization and growth and their desire for advanced literacy. Despite the city's high rate of informal employees, their average level of education is high school, and the majority of them speak and understand the official language solely to communicate during commercial transactions. Most parents are also ensuring that their children complete at least an undergraduate degree, with those who can afford it ensuring that they get a master's degree. The peculiarity of Accra, particularly in terms of ethnic diversity, can be properly understood in the context of Ghana's socioeconomic structure (Agyei-Mensah & Owusu, 2010). Constant social meetings, including naming ceremonies, parties, burial and funeral rites, festivals, religious gatherings, and public events, notably by groups, organizations, and individuals, are visible in Accra's public and social life with high levels of participation from most people. These are supplemented by numerous recreational facilities such as hotels, clubs, pubs, the Accra International Conference Centre, and other magnificent auditoriums for events, but locals believe that additional and specific ones are required. Creativity, flexibility, corporate entrepreneurship, and innovativeness are seen in most information technology firms within Accra and as such promotes organizational performance (Boatemaa et al., 2019). Through the Accra Cultural Capital / African Creative Cities project, the Foundation for the Creative Industries has been established in Accra to expose and sensitize local and international stakeholders about Ghana's creative industry which is increasing the number of local and international audiences for cultural activities and art events, building collaborations to improve and encourage creativity and innovation, and is assisting in the development of art professionals' careers and abilities in the city (Luis & Moncayo, 2010).

3.5 Accra Climate Action Plan- A Climate-Neutral Accra Initiative

The Accra Climate Action Plan is the Accra Metropolitan Assembly’s first climate action plan (CAP) at the subnational level. Ghana's Sustainable Development Goals are aligned with the Climate Action Plan, which builds on national climate policies. The Plan identifies a series of activities that, if executed, will result in significant reductions in greenhouse gas emissions, improved quality of life, green job creation, and put the city on a road to climate resilience and carbon neutrality by 2050. Projects are therefore ongoing in that stead, and a few will be highlighted here (Accra Metropolitan Assembly; C40 Cities, 2021).

Waste Management in Accra Initiatives under the Accra Climate Action Plan: The mayor of the city has launched a waste segregation campaign, which includes the provision of clearly labelled containers. In some of the city's elementary schools, a pilot program is now underway. Informal rubbish collectors have been formalized and registered. A waste optimization strategy is now being implemented, which includes the separation of wet and dry waste at the source. Using technical techniques, organic waste is diverted from landfills (doubling composting capacity). Mixing food waste with sewage to make biogas is one example. Preliminary geophysical and geotechnical feasibility studies for a newly engineered sanitary landfill with gas collection have been conducted for this project. The sanitation infrastructure coverage has also been extended, and it works in tandem with the AfDB-financed Accra Sewage Improvement Project (ASIP), which aims to enhance Accra's central sewage network (Accra Metropolitan Assembly; C40 Cities, 2021).

Ongoing Energy & Housing Initiatives in Accra under the Accra Climate Action Plan: The city has assured that renewable energy sources are increased by purchasing renewable energy from independent power producers in accordance with the city's energy demand. Industrial facilities, such as the Regional Hospital, commonly known as RIDGE, and the AMA office, have enhanced efficiency. These amenities, as well as other residences, buildings, and facilities throughout the city, have been greened (Accra Metropolitan Assembly; C40 Cities, 2021).

Ongoing Transport Initiatives in Accra under the Accra Climate Action Plan: The transition to a low-emission bus rapid transit system has begun in the city. To safeguard pedestrians, it has built shaded sidewalks (part of Jamestown, Ussher Town, Accra Central). In several parts of the city, new pedestrian walkways with green infrastructure, including covered drains, have been built, eg, Korle-Bu (Accra Metropolitan Assembly; C40 Cities, 2021).

Ongoing Land Use & Physical Planning Initiatives under the Accra Climate Action Plan: Food production, storage, and processing strategies, as well as innovation deployment, are helping to keep foods sold on the market fresh before being purchased by consumers (Accra Metropolitan Assembly; C40 Cities, 2021).

3.6 Innovation Situation In Accra

Ministry of Science, Technology, and Innovation (MESTI) is the government agency in charge of all types of innovation, development, and research across all sectors of the economy[39]. It has also established a Science, Technology, and Innovation (STI) Directorate to assist with policy formulation and STI advising. In addition, the Ministry has founded specialized institutions to carry out specialized functions in the fields of the environment, science, technology, and innovation. The Ghana Atomic Energy Commission (GAEC), the Environmental Protection Agency (EPA), the Land Use and Spatial Planning Department (LUSPD), the National Biosafety Authority (NBA), and the Nuclear Regulatory Authority (NRA) are among them. The Ministry's STI functions are carried out through these institutions (Ghana Statistical Service (GSS), 2021).

Innovation is classified into two forms in Accra, thus the science-centric nature of Ghana's STI framework and the non-science aspect (Oduro-Marfo, 2015). Accra is a West African innovation hotspot, with an increasing number of young people looking for local solutions to local issues[40]. Both radical, semi-radical, and incremental inventions thrive in the metropolis (Amoako et al., 2014). MESTI is the government agency in charge of all types of innovation, development, and research across all sectors of the economy[41]. According to MESTI's innovation budget report, innovation indeed is taking a stand in Accra.

Waste Management: E-waste collection at Old Fadama, Agbogbloshie, a suburb of Accra. Previously, in this part of Accra, the waste collection was done by private contractors.

There has been a construction of an e-waste Handover Centre (HOC) at the premise of the Ghana Atomic Energy Commission. The Ministry has established a Technical Committee in collaboration with the Ministries of Sanitation and Water Resources (MSWR) and Local Government, Decentralization, and Rural Development (MLGDRD) to develop a plastic waste management roadmap to be piloted in selected communities within a specific Municipal

[39] https://www.unesco.org/en/articles/contributing-strengthening-ghanas-science-technology-and-innovation-systems

[40] https://www.voanews.com/a/africa_ghanas-innovation-and-startup-culture-thriving/6179679.html

[41] https://www.unesco.org/en/articles/contributing-strengthening-ghanas-science-technology-and-innovation-systems

Assembly in the Greater Accra Metropolitan Area. This is being funded by the National Plastic Waste Recycling Fund.

Energy Innovation: A parliamentary ratification of the Bilateral Cooperation between the Government of Ghana and the Swiss Government towards the implementation of Article six of the Paris Agreement, thus, an implementation of a National Clean Energy Access Programme reducing total emission by 2.0 metric tonnes of carbon dioxide (Mt CO2e) which will be sold to the Government of Switzerland.

Monitoring 1,046 Radio Frequency (RF) Base Stations and 1,997 personnel have been introduced to ionizing radiation, Ghana Atomic Energy Commission (GAEC) has also granted 809 Conditional Compliance Certificates. Evaluation of 256 samples to guarantee that food imports and water are free of radioactive contamination. Seismic equipment installation and monitoring have been 70% completed, Assessment of national and regional electricity grid network characteristics is also 75% completed, and Assessment of on-grid interface requirements for Nuclear Power Plants is also 45% completed. Ghana Nuclear Power has implemented these.

Agricultural/Food Innovation: Broiler male and female lines have been developed and released. Oil palm germinated seeds and coconut seedlings have been produced to support the Planting for Export and Rural Development (PERD) initiative. The no-GMO status of cashew nuts has been introduced in biosafety or biotechnology innovation, and a release of GMO Bt Cowpea has been made but has not gained formal consideration from the Food and Drugs Authority (FDA). A detection laboratory for genetically modified organisms has been established to improve regulation. In addition, the government has created CSIR AgricTech through the Council for Scientific and Industrial Research (CSIR). This is an interactive digital soil-based map with web-based access to all soil resources/information on Ghana for agricultural planning, policymaking, and technology transfer under the Modernizing Agriculture in Ghana (MAG) Project.

Housing Innovation: Introduction of plastic for bricks for building houses making houses earthquake resistant, firm, and well-insulated[42]. The introduction of RENMO- a credit scoring

[42] http://www.xinhuanet.com/english/2021-06/10/c_1310001165.htm

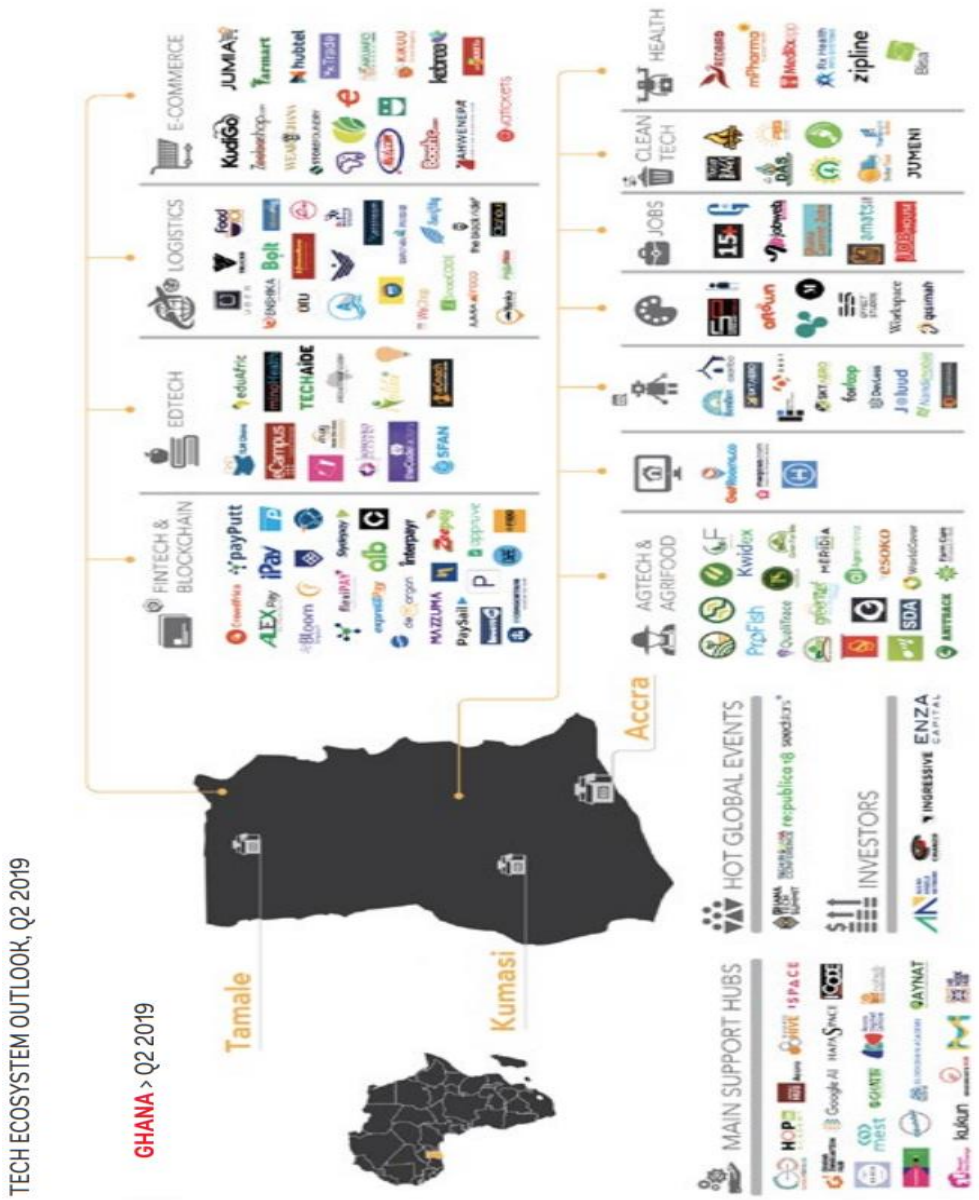
program that allows African residents to rent quality homes with monthly payments. Its purpose is to provide people with financial freedom in homes[43].

Financial Innovation: Introduction of Bethniel Finance, a financial literacy software that allows Ghanaians to keep on top of their finances by providing a streamlined manner to improve financial literacy, manage personal funds, and access financial services[44].

Health Innovation: Introduction of the Fuel Africa 2022 Innovation Challenge by the University of Ghana which seeks to bring universities across Africa together to generate and pitch practical solutions that will advance healthcare and the treatment of NCDs following the United Nations Sustainable Development Goals 3, 4, and 5 (Good Health & Well-Being, Quality Education and Gender Equality) in Accra and Africa as a whole[45].
Introduction of the African Health Innovation Centre (AHIC)which has introduced a start-up incubator, MEDspace, and has organized a series of digital eHealth meetups and created a summer research program for aspiring public health experts[46].

Figure 19 An image of the innovative solutions within Accra, Kumasi and Tamale but mostly dominated in Accra

[43] https://centers.fuqua.duke.edu/case/2021/04/12/translating-lived-experience-into-innovation-to-increase-housing-equity-in-ghana/
[44] https://www.digitaltimes.africa/bethniel-finance-emerges-as-a-winner-of-innovation-challenge-2022/#
[45] https://www.ug.edu.gh/announcements/fuel-africa-2022-innovation-programme
[46] https://africanhealthinnovation.org/



Reference: Source from Ghana Innovation/ Entrepreneurship Rankings

3.7 The Use Of The Quintuple Helix Approach In The Accra Context

This is a relatively recent concept in Africa as a continent and in Ghana as a country when it comes to Accra and the Quintuple Helix of innovation. The Triple Helix Approach to Innovation is not commonly recognized in Accra but based on the few observed relationships among actors and other concepts, it may be deduced that Accra uses it. According to Bartel's article, Ghana has continued to utilize the TH technique for several years till now (Bartels et

al., 2016), and if this is the case, then Accra utilizes the TH strategy designed by Etzkowitz & Leydesdorff (Etzkowitz, 2003)(Leydesdorff, n.d.). Accra will not be able to develop a smart city using this method since it lacks certain critical components (Carayannis & Campbell, 2010). The model cannot help in transitioning Accra into a sustainable smart city because it does not give much attention to social circumstances (Cai & Etzkowitz, 2020). The Quadruple Helix has been used to construct smart cities on other continents and have worked out (Kuzior & Kuzior, 2020). Nonetheless, several communities have chosen the Quintuple Helix approach to achieve the concept of sustainability and the already attained smart city concept. According to the research, the Quintuple Helix is the ideal way for creating a sustainable smart city since it pays attention to and considers the natural environment, in which all other helices are embedded, and in that sense, sustainable development can be attained using this model (Chen, 2015).

CHAPTER FOUR
APPROACH AND METHODOLOGY

4.1 Introduction

This chapter goes through the research process that was utilised to collect and analyse data for the Quintuple Helix of Innovation Approach to Making Accra a Smart City. It goes into detail on the data collection technique, analysis, and justification for the choice. The chapter also covers the many stages of the research, such as participant selection, informants, sampling method, the researcher's role, and ethical considerations. The article ends with a discussion of how to determine the validity and reliability of using a qualitative research approach and how these two characteristics are required for all research projects.

4.2 Constructivism Philosophical Paradigm

There are three major research paradigms in qualitative research: positivist, interpretivist, and critical, each with its own set of ideologies (Elshafie, 2013). With the premise that paradigms are important in any research, they are also important in this study because they provide a structure for studying and examining the specific type of helix model of innovation that would enable Accra to become one fully sustainable smart city. The study is based on the interpretive paradigm, to naturally investigate the characteristics of Accra as a sustainable smart city (current phenomena) by determining whether all of the actors involved understand their roles and how well they play them through cooperation and collaboration, leading to a thorough examination of the innovation model approach used in Accra (Abdulkareem, n.d.). This paradigm is more naturalistic because it applies to real-world circumstances as it occurs spontaneously; it is non-manipulative, unobtrusive, and non-controlling (Antwi & Hamza, 2009), revealing the real intent and purpose of the research. According to Manal & Galal, this paradigm will aid in evaluating intangible benefits, with stakeholder viewpoints and claims playing a pivotal role in the evaluation process (Abdel-Fattah & Galal-Edeen, 2009).

The paradigm, approach, and methods of the study were driven by the research objectives and questions, which focused on:

1. Examination of the characteristics of a Sustainable smart city and analysis of the aspects where Accra does not meet up as a smart city.
2. Investigation of the current innovation approach, whether Triple, Quadruple or Quintuple Helix being used to build Accra as a sustainable smart city.
3. Analysis of whether all the relevant actors understand their responsibilities toward building Accra as a sustainable smart city.

4.3 Qualitative Research Approach

A qualitative research approach is more appropriate in this circumstance, given the study paradigm, aims, and questions, which seeks to discuss the quintuple helix innovation strategy to build Accra as a sustainable smart city.

It is said that participant observation allows researchers to "come close" to their objects of study, allowing them to feel the subjective qualities of the phenomena they investigate for themselves. The researcher is the "instrument of data gathering" in qualitative research. Rather than utilising a standardised instrument or measuring device, the qualitative researcher asks questions, collects data, interprets findings, and documents findings. The qualitative researcher is continuously attempting to comprehend the individuals they are seeing from the participants' perspectives, "natives," or "actors". Empathetic understanding is seen in the qualitative research approach.

4.4 Exploratory Research

The study, which is concerned with understanding the quintuple helix of innovation approach in building Accra as a sustainable smart city, is exploratory by nature because it employs the qualitative method (Baker & Edwards, 2012). Its goal is to investigate the quintuple helix method of innovation to generate new ideas and hypotheses for transforming Accra into a sustainable smart metropolis, a substantive issue to be addressed in a powerful and inspiring model (Zahl & Reilley, 1958). The choice of the exploratory research is also to establish the stakeholders' current state of readiness, obstacles, and success factors in identifying the characteristics of Accra as a smart city and their respective roles in the process (Bohari et al.,

2019). Study data collection mechanisms such as semi-structured interviews, questionnaires, research strategy, philosophical perspectives, and data analysis procedures are all significant to exploratory research.

4.5 Research Design

This section provides information on how the participants were selected and how the collection and analysis of the data were done.

4.5.1 Participants

Whether quantitative or qualitative, every study necessitates respondents for the researcher to comprehend and provide legitimate data that will be used in future research and possibly comparison studies. Seven groups of participants were chosen for this aim and to provide credible and original data to understand how Accra may become a sustainable smart city using the quintuple helix of innovation technique. The study made use of various stakeholders, which are Government/ Policy Experts, Industry, Universities/ Research Institutions, Media, Citizens, and NGOs.

4.5.2 Sampling

The study employed non-random sampling approaches to aid in the analysis of real-life phenomena, particularly in this situation. Specific stakeholders were readily available and had rich knowledge to help comprehend the Accra context's quintessential helix of innovation and smart cities phenomenon. Therefore, convenient and purposive (deliberate selection) sampling procedures were chosen for this study.

4.5.3 Role of the Researcher

A researcher plays a substantial role in the research process, and in that same manner, during every phase of this study, the researcher was personally involved. The researcher acknowledges that their background, prejudices, observations, interests, and critical faculties influenced the study's design during data collection and analysis (Kaplan & Maxwell, 2005). Because the research used the interpretivist technique which provided a subjective viewpoint of human experience, a constraint such as a researcher's belief may be revealed (Strauss & Corbin, 1998).

According to the author of the International Journal of Qualitative Research, separation of the researcher and his or her values and opinions is impossible because it is an integral part of the research process, but transparency and reflexiveness of their own perception during the study was focused on (Galdas, 2017) and the researcher, in this case, makes full disclosure that she has stayed in the study location her entire life. To reduce such biases, the researcher worked closely with her supervisor to develop the major themes for this study.

4.6 Data Collection Methods

The study used the two types of data thus primary data, which involved collecting data from people to understand the situation or phenomenon and secondary data, which were gathered from sources that are already published and were reviewed and analysed to help gain a foundation from which the primary data may be assessed.

4.6.1 Instrumentation for primary data collection

Qualitative Interviews: This was accomplished through controlled and unstructured interviews (Houimli et al., 2019), which allowed the researcher to acquire thorough information on the realities and experiences surrounding the study's phenomenon in relation to the research paradigms, objectives and questions stated earlier (Denzin & Lincoln, 2018). The interviews were conducted as part of the triangulation process and as part of the many data sources used. Because the researcher could not travel from Rome to the study location for reasons beyond her control, such as financial and time constraints, the interview was conducted through Zoom. As a result, the researcher made certain that the subjects upheld the ethical guidelines (Qu & Dumay, 2011). Open-ended questions were used since in-depth information was to be extracted from the respondents. This allowed the researcher to elicit information from the respondents to better understand the notion and explain any unclear or difficult concepts (Strauss & Corbin, 1998). The respondents were asked for their permission to record the interviews to ensure that all the responses presented were acquired. The audio recordings were later transcribed to help with data analysis.

Questionnaires: Questionnaires were also given to students and people to fill out to obtain their thoughts and opinions on the subject. These were open-ended questions that were answered through Google Forms.

4.6.2 Instrumentation for the secondary data collection

Text-based research: Data was gathered from secondary sources such as books, international organisations, journals, conference reports, assessments from organisations, and internet sources relating to the quintuple helix of innovation theory and the previous innovation theories, Ghana and Accra and the smart cities concept. Secondary data is important for this study because it usually has a pre-determined level of validity and reliability that does not need to be re-examined by the researcher who is re-using it. It also aids in the planning of following primary research giving a foundation against which the outcomes of the acquired primary data can be evaluated (Buchanan, 1981).

4.7 Data Analysis

After the data was obtained, there were three main phases. Transcribing the audio recordings acquired from respondents who participated in the interviews was the first process, and the transcripts were checked numerous times to obtain the primary themes and repeating notions from the respondents. The data acquired from primary and secondary sources was investigated in the second phase by highlighting and clarifying the themes in relation to the study objectives, as well as addressing them with questions.

4.8 Establishing Trustworthiness

In qualitative research, trustworthiness is critical because it ensures research quality, rigour, and the authenticity of the data employed. The researcher employed the data triangulation method, which entails combining data from different sources to generate a more holistic understanding of the situation under investigation, which is the quintuple helix of innovation and smart cities in Accra (Sargeant, 2012).

4.9 Code Of Ethics

With reference to the American Psychological Academy ethics code, the code of ethics is intended to safeguard the study participants and the researcher, and in this study, the researcher ensured that these two key values were upheld, thus, informed consent and confidentiality.

Principle of informed consent: Before their availability was confirmed, the respondents were briefed about the study, its objective, and its impact. They were informed that they might withdraw from the study at any moment.

The second value is the principle of confidentiality and privacy, which states that the interviewees' responses will be treated with the highest confidentiality and will only be used for the purposes of this study. In analysing the personal data of respondents, there was respect for privacy.

4.10 Limitations Of The Study

The research took place in Accra, Ghana's capital city and a West African country. Because the researcher was in Italy during the data collecting period, the study site revealed itself as a restriction due to the researcher's and respondents' geographical locations. The researcher was unable to meet the relevant stakeholders in person. This restricted the intended population size of the study. Also, due to the limited timeline of the study, a few key aspects may be missing as all the relevant stakeholders within the different helices could not be contacted.

CHAPTER FIVE

RESULTS & DISCUSSION

5.1 Introduction

This research sought to understand Accra's approach to innovation better as it moves toward becoming a sustainable smart city and determine whether the actors involved in the innovation process collaborate, culminating in the quintuple helix of innovation. To gain background information on how the methods of innovation arose and how they will benefit, positively, and adversely, Accra in becoming a sustainable smart city and analyze the main data collected, multiple secondary sources were reviewed. However, secondary data alone will not suffice; thus, information was gathered from data interviewees who represented five different stakeholder groups and answered questions based on the research objectives.

5.2 Background Information Of Respondents

The findings of this qualitative study are based on 10 interviews and 20 open-ended questionnaires completed by 30 particpants. This is represented in the table below.

Table 2 Social demographics of respondents

Attribute	Frequency	Percent
Sex		
Male	21	70
Female	9	30
Age (Years)		
18-35	26	86.67
38-45	3	10
48-55	1	3.3
Marital Status		
Single	25	66.67
Married	5	16.667

Employment Status		
Employed	23	76
Student	7	23.33
Stakeholders		
Government workers/ Policy experts	4	13.3
Universities/ Academia	12	40
Citizens/NGO/Media	10	33.33
Industry	4	13.33
n=30		

5.3 Revisions of Interview Protocol

The problem statement, research objectives, and questions were included in the interview protocol to help participants understand the study and provide relevant information or data. It also included a code of ethics that addressed the respondents' consent, approval, privacy and confidentiality. Before the scheduled interview day, all participants got the interview protocol and questions. The interview questions were framed in an open-ended format that included "WH" interrogatives such as what, why, when, where, and so on. This allowed participants to openly express themselves, allowing the researcher to better grasp the study and more information.

Respondents who completed the questionnaire were given adequate time to submit extensive and accurate information while also adhering to the codes of conduct.

5.4 Research Question

"Could collective action, self-organization, and technology that enables self-sustainability, social norms & informality be the recipe that African cities and in paticular Accra adopt and contribute to the global quest for smartness and sustainability in cities ?"

5.5 Research Findings

The following major themes were derived from the data collection and analysis process. They include;

Table 3 Data Analysis Process using the thematic network analysis approach

Codes	Basic Themes	Organizing themes
…the quadruple helix of innovation approach …its an all-inclusive government and successive governments have proven the same	Accra uses the quadruple helix of innovation approach	
…Accra's economy is not smart …entrepreneurship is bad …there is no existence of technology in productivity …the responsibility for life or death can be heavy on you	Accra's economy is not wholly smart	Productivity Entrepreneurship Innovative Spirit
… Accra is stuck with the archaic way of doing things …there is no transparency in governance … policies and projects do not better the lives of average Ghanaians …public administration benefits from everything while the private sector struggles to get these …it is fairly smart …certain aspects of public and social services have become smart recently	Governance in Accra is not wholly smart	Transparent Governance Public and social services Participation in decision making
…there is an influx of real estate, but they are expensive …real estate is for the rich, not for the average Ghanaian who earns an average income …the best hospitals are in Accra, but they lack facilities and personnel … individual safety varies in the various neighbourhoods and the individual as well …	Living smart in Accra varies	Housing conditions Health conditions Individual safety
…we are nowhere close to smartness …pollution in Accra is massive … both human and raw materials in Accra need sustainable management	Accra is not a smart environment	Lack of pollution of natural resources, sustainable resource management, environmental protection
…people in Accra are way smarter than before		

…there has been an increase in the literacy rate recently …people in Accra live by a plan which defines them as smart	People in Accra are smart	Level of qualification, flexibility &creativity, open-mindedness
…cannot be characterized in any way as smart …lacks basic transport technologies …some of the roads are poorly maintained making them unsafe …. Easily accessible but expensive when using the private ones such as uber, bolt and taxis …just a minute aspect of technology is seen	Transportation in Accra is not smart	Accessibility ICT availability safety
…both work hand in hand to achieve a common goal …collaboration exists but it is not constant, it is slow and not steady …private sector collaborates more …media is doing an excellent job nowadays …universities and research institutions are doing a lot of research, but they are not being applied in practical life …citizens need to put in more effort, especially in their actions	Existence of collaboration	
…nothing foreign has ever benefitted us, the best way is to use our own model … as far as the ecosystem is concerned, let's adopt this approach …this approach will be relevant for all sectors of the economy … let's adopt the impactful part of the western world strategy	Use of Accra-based QH approach is recommended to Accra	
…they are a direct link to the people …they are extremely relevant because Ghana and Accra is ethnic-centred …they are the mouthpiece of the local people …they will easily participate if their people stand to benefit …because they are powerful and highly respected	Traditional authorities are relevant	

Findings

The systematic thematic analyses of data yielded insights into Accra and the innovation approach to becoming s sustainable smart city and the context where this study took place. In all, ten basic themes emerged from the codes that were generated from the data. This findings section is organized along with three organizing themes in some of the major themes that emerged for clarity and simplicity.

Quadruple Helix of Innovation

It emerged from the data analyses that the specific innovation approach being used by Accra is the quadruple helix of innovation as the actions of both actors are visible in the city, thus, government, industry, universities & academia, and the media-based culture consisting of media, citizens and NGO's:

> *"...I would say Ghana is on the quadruple helix. Because this current government is an all-inclusive government and successive governments have proven the same"* (Government worker)

Another participant confirmed this by saying:

".... Yes. First, this is the combination of the industry, the government, the universities, and the media, citizens, NGOs.

> *..."* (Industry expert)

For other participants who filled the questionnaires, 80 per cent out of 100 percent confirmed that Accra uses the Quadruple Helix.

Accra's economy is not smart

The experiences shared by the participants also shed light into Accra's economy capitalizing on productivity, entrepreneurship and innovative spirit:

> *"...I will say to an extent, so perhaps I'll say to in percentage-wise, I'll say 50%, in essence, that we use some form of technology, but it is not fully utilized. That only saves 50%. So, if I say 50, I mean, some things as we use, we leverage on technology. So, we have smartphones, smart laptops, some infrastructure based on technology, some environmental initiatives, plans and some transport. We leverage on technology to make some of these things. And the rest of the 50 making me say no, is in relation to the fact that we are not using it to its maximum benefit..."* (University staff, Graduate Assistant

Another participant recounted:

"...In Ghana as a whole, entrepreneurship is bad. Very bad. Because one, our credit system is bad, it's wicked. You can't go for a loan and then have a moderate interest rate. Like it's way out there. And then there's not much avenue for startups to really like stand on their feet, its like the system itself has been built to pull down startups. So entrepreneurs find it a lot difficult unless maybe they have help from other big companies that will be ready to support them that I would say entrepreneurship. In Accra, not Accra alone in Ghana, as well. So in terms of raw materials, we have raw materials, but then how to process them, energy-wise, as fuel, electricity and all that. The cost keeps rising day in, day out. And it's not easy with the inflow of money and the outflow like with expenses, and the inflow of money, there is not much inflow of money, and then commodities and stuff gets increased almost every time ..." (Industry player)

Another participant said:

"...Well, to a certain extent, once again, I would not be able to say absolutely, but to a certain extent to a particular group. They are willing to be entrepreneurial, to be innovative, and I love that. Well, I wouldn't say a lot to some of the population here, to a segment of the population, like the idea they have about entrepreneurship is they are not intuitive and rather want to be employed in a way than to be entrepreneurs themselves and extract something. So although accepting a section of the population is open-minded, some too relatively closed-minded ..." (Media personnel)

Governance in Accra is not wholly smart

The experiences shared by the participants further gave some insights into whether Accra's governance approach was smart:

"...No.Most government institutions are stuck with an archaic way of doing things. For instance, a typical example will be my place, and this is speaking off the record. We have clients who come in for various research purposes, to be done on your products. Now, these clients are, so they're supposed to be a system where anyone in any department at any point in time, or specific people at any point in time, can be able to track the progress of whatever service the clients came to request from us. Unfortunately, there is no such system in place , you have to manually go there, receipts are manually printed, and they are manually generated. And even for approval, you pick your hardcopy receipts, and you take it to the head of the division for him to sign and stamp. So imagine if the head of the division is out for lunch, you wait for him or her to come before you get your document. But if the system is in place, and it's been

approved, he can just log on from wherever he is by attaching a signature, attach a time stamp on it, and just send it back to you. And you can print it wherever you get to your destination. So clinical to the government institutions in terms of being smart, I'll give them two over 10 and that's been generous..." (Government Research expert)

For transparent governance:

"...There's never been transparency in governance in Africa, let alone Ghana. Not only Africa, the whole world. Politics is never transparent. I wouldn't put the blame on Ghana alone. Politics in itself is transparent, It's politics after all..." (Industry expert)

For services, some aspects can be identified as smart:

"...Yeah, for now, we'll see that some of the services are actually smart. Because most of them are now technology-driven. As I said, if you want to apply for a passport, you can do that online. If you want to renew your driver's license or acquire a new one, you can do that online. There are other services that you just basically have to go online, sign up for it, then maybe later to go for it, which maybe we'll see that its not that healthy because we need everything to be very smart so that we will just have to apply here, get it delivered to me, take the goods. One that has been done as I think with NSS national service, you finish your service, you don't necessarily have to go for your certificate at the office, you sit where you are, fill your form. Wherever its being done, it will be delivered to you. That one, it's laudable, and it's very smart. But I think there are some still loopholes in how to address this madness in terms of government services. Because even research is also online, now there's no need to go to the office. But I think there's progress in terms of smartness. Some of the things, now you can even buy electricity, you can buy it just via mobile phone combined...." (Media personnel)

"...Well, in my opinion, governance is fairly smart. As some areas even in the city are deprived of certain social services, are not considered when making some decisions and as such, these areas are poorly developed..." (Student)

"...Services, projects and policies by governments recent times are being smart therefore these can be improved upon..." (student)

For citizen participation, respondents stated that:

"...mainly because citizens feel that their opinions are not welcomed..." (student)

Living smart in Accra varies

"...in terms of housing quality, we have an influx of real estate now, unfortunately, they're expensive now and in order to bridge the gap between the normal average Ghanian and then a good housing unit, my definition of a good housing unit would be a place where you have access to potable water, well-demarcated area, the house is good enough to accommodate a standard family..." (policy expert)

"...Quite a number of residents living in Accra are smart. Some sides of Accra have smart residents but other parts don't have smart residents..." (4 students)

For health conditions:

"...Okay, there has been little progress because now there are online apps that you can actually download that if you have genuine prescriptions it will aid you to get your medication, wherever you are. But the health system itself, there's still a problem, because it's still a manual system that you have to go and pick a folder, get it filled..." (Government research expert)

"...The health facilities are many but the technology and personnel are few and so the health facility doesn't match up with the population. So you end up spending the whole day seeking medical care. And that's very bad and you will not be encouraged to go to the hospital, you will just want to rely on self-medication..." (university staff)

For individual safety:

"...So in relation to the peace, we have the political stability. And in relation to the people here, I will say that there's peace, unity and stability among the people living in Accra.."(University staff, Graduate Assistant)

"...So for individual safety, just like the word describes, individual safety- you have to put your individual safety first, you can't leave it into the hands of Accra being a smart city to make sure that you are you are safe, your individual safety is a responsibility of your own..." (Research expert, NGO)

Accra is not a smart environment

Participants explained in numerous ways that Accra's environment is not smart, and this was indicated by:

"...We are nowhere near Accra being smart. We have the capability and there's a future and successive governments have tried to implement Accra to be a smart city, but it is tough..." (Research expert, NGO)

"...has no idea and this is closer to the negative than the positive and no single way possible is Accra a smart environment..." (Media personnel)

"...we're not doing a lot to manage the environment, you know, the pollution there is still a lot, a lot of pollution there..." (Government worker)

"...Accra is really not near smart in the area of pollution despite various approaches by the government over the previous years... I think it's not about the people's behaviour but the consistency and transparency of the approach or measures put in place to fix it..." (student)

In terms of sustainable resource management:

*"...In sustainable resource, we do have a long way to go in terms of sustainable resource management. You see, Ghana as a whole has a lot of resources, both human and raw material. But we have limited systems that can actually churn out the best in these raw materials. We are limited. So in turn, we try to import all those things that we are not able to manufacture in the country and all that management-wise..." (*Industry player)

People in Accra are smart

When posed this question, participants responded that:

"...There was this term that we used to say, in Accra, we stay by plan and yes if you're not smart, you can't survive in Accra. I tell you, no one. You can bear witness to it. If you're not smart, you can't survive, and you end up going back to your hometown. And you know, one wonderful thing about Accra is it's full of diverse cultures. So, you can have educated people, you can have semi-educated persons, you can have non-educated persons, all living within their limits, like hand to mouth, people do business and then they make enough money. So in terms of qualification and all that I think there's an avenue for each and every person to succeed..." (Industry expert)

Transportation in Accra is not smart

"...I can never do that, I cannot characterize the transport service as smart, maybe not as much..."

"...there is nothing smart about mobility, smart transportation in Accra..." (media expert)

*"...Honestly no, because smart transportation to me, I will say, includes the use of several technologies I mean from basic management systems, such as car navigation to traffic signal control systems and all that. In most of these areas, we are lacking..." (*Industry expert)

Existence of collaboration

When asked about the level of collaboration amongst the various actors, respondents stated that:

"...I think the NGOs, the media and the universities are playing a very important role and responsibilities in doing something to make Accra smarter..." (NGO, research expert)

"...I would say that the reality is that the government, private citizens, and the traditional institutions, nongovernmental organization, civil society, all together, they provide what is the backbone of Ghana working together, and they all play different roles..." (University, Professor)

For universities: *"...They can do more than they are doing at the moment and critical attention has to be given to them since they are the main building blocks in this context, these institutions are only involved when they are allowed to be involved and definitely support good policies, these institutions through their researches are putting in the effort to make Accra a more modern and sustainable city, Researching and developing human capital, Basically, through formal education. some social courses studied in these institutions are geared towards supporting the objectives of making Accra sustainable and smarter…*" (students)

Citizens' level of collaboration: *"...I would say the citizens themselves are gradually embracing technology, most people are aware and abreast with the current trends around the world..."* (Government research expert)

Media level of collaboration: *"...so we will say that most of this is done through our stories, we are there to monitor, observe, reports tell you that these are the challenges people are facing..."* (Media personnel)

Ngo level of collaboration: *"...I think NGOs are doing incredible work in Accra and in Ghana, especially the northern part. Sometimes they just need extra funding to reach their targets..."* (NGO, research expert)

Use of Accra-based QH approach is recommended to Accra

"...Accra does need the Accra-based module for itself, maybe take excerpts from others but Accra is Accra..." (University, Professor)

"...Nothing foreign has ever been helpful in Ghana so I think getting our own model would go a long way in helping us..." (Industry player)

Traditional authorities are relevant

"... *I think traditional authorities are very important. First, traditional leaders are very highly respected. So, for most Ghanaians, the traditional leader represents a very important authority. Secondly, traditional leaders are very, very close to reality. Like your chief really lives in your community, they understand what is going on, they know thet people, as well as anybody, could. And very often, the other thing is, like very often traditional authorities control the land. Traditional authorities have huge political influence, even though they're not supposed to be, they are apolitical, but when I'm talking about political influence, I say, you know, influence on the policy, meaning the people, and to me, it's a resource that needs to be really, really relied upon to implement many, many of the ideas that you were working on. Absolutely. I think in the African context or in other contexts, where you have traditional leaders, they should be part of the solution..."* (University, Professor)

"...I believe that Traditional authorities customary and conventionally respected, I mean, for generations to come and predecessors, we all understood what they stood for and if we had the traditional system, it would have gone a long way, that is if it is not too muddled or involved in politics..." (NGO, research expert)

5.6 DISCUSSION

The themes discovered are interconnected and reliant on one another to address the study's research questions. To further comprehend the situation in Accra, the data received from all stakeholders for this study is integrated and triangulated with current empirical data.

5.6.1 Theme 1: Accra uses the quadruple helix of innovation

When asked what kind of innovation technique Accra employs, all respondents stated emphatically that Ghana currently employs the Quadruple Helix of Innovation Approach. They believe that all stakeholders, including government/policy experts, universities, media-based culture (NGOs, people, media), and industries, collaborate and play different roles in making Accra sustainably smart and climate-neutral. According to one responder, the current administration is inclusive, as evidenced by prior governments in which all four actors perform diverse roles. Despite the fact that about 80 percent of them felt the government's efforts are insufficient and that they can do more, some actors such as the media was highly praised considering how much information they disseminate, discovering hidden agendas and reaching out to locations where information is difficult to come by, in order to keep some citizens informed about information in the country. Universities have also increased the quantity and variety of courses offered over time and their infrastructure, manpower, and research activities. The city's university population has grown throughout time, including both public and private universities and research centers. Citizens also play an important role because they comprehend citizen participation in all aspects, from the local to the national level. The majority of them now participate in communal functions and use online platforms, the media (radio and television stations), and other tools to influence the administration. In Accra, NGOs have also been extremely effective as they fund the majority of initiatives and have the power to advocate for or against specific policies on behalf of citizens. The industry often called the private sector by Accra locals is an active player in practically every economy sector. They are a source of major employment, help the city with environmental issues, transportation, telecommunications, and so on.

5.6.2 Theme 2: Accra’s economy is not wholly smart

As the smart economy characteristic suggests, the theme centered on entrepreneurship, productivity, and innovative spirit. About a quarter of the respondents said Accra did not have

a smart economy, while 75 percent stated that only pieces of them could be identified. According to a University professor, identifying Accra as a smart city was dependent on the context of the definition of the smart city. For example, if a model based on Silicon Valley was utilized, Accra would be classified as a smart economy. Others then explained why and how much smarter Accra had become now than it was a few years ago and how far the industrial sector has advanced in a smart method of doing business by utilizing ICTs to make it easier, more reliable, and more convenient.

Concept of entrepreneurship: For entrepreneurship, the concept exists, but it is at an all-time low. Accra is Ghana's business hub, with everything from small firms to multinational corporations. It is the starting point for doing business in Ghana, and it accommodates all types of firms, from sole proprietorships to partnerships. Risks, innovation, and creative thinking are important to entrepreneurship, according to Osman & Murat, and the entrepreneur is the one who produces and innovates something based on anticipated opportunities while embracing risks and mistakes. His or her original culture's values (Eroglu & Picak, 2011). As a result, while the notion is vast and encompasses a lot, only a few components were visible in Accra. Accra, according to one participant has a poor credit system in terms of loans where a respondent stated that he worked in the private sector and that getting bank loans was challenging. Even finding a bank willing to lend comes with a high-interest rate; however, if entrepreneurship is to thrive in Accra, a flexible lending system with a low-interest rate should be considered for these start-ups to assist them to grow into solid businesses.

Another concern that was addressed is the lack of opportunities for start-ups to succeed. A respondent stated how Accra's system does not allow start-ups to grow and thrive. He said: "*…existing businesses receive a lot of attention, which is excellent yet unhealthy when trying to establish a smart city. The government and large independent multi-national corporations should pay attention to these start-ups and assist them in becoming successful businesses…".* One other issue in Accra is a business monopoly, where certain successful corporations see start-ups as a threat and competition and ensure that the system keeps start-ups down, thereby making it favorable to them only. These large corporations want to be the only ones reaping tremendous profits and receiving client or customer attention.

Concept of innovative spirit: Accra residents are, overall, inventive, and creative by finding simple yet diverse solutions to daily challenges that arise. They tend to reproduce existing

models and make them more appealing during their exploration. The only difficulty is gaining recognition and appreciation due to a lack of understanding of intellectual property rights which restricts them from fully owning or fighting for the contents or items they make or create since they do not know how to be recognized for them. Therefore, people steal them indirectly. Residents of Accra's creativity is hampered by a lack of technological tools, thereby relatively reducing their level of inventiveness.

Concept of productivity: The presence of technology aids productivity, while its absence in an industrial context indicates that manpower will be used, which will limit output. Technical gadgets, like smartphones, computers and their peripherals, internet coverage, and many others, are owned by Accra residents, but their use is limited. One respondent claimed that : "…these smart technologies are not being used to their maximum potential for the sake of profitability, sustainability, and efficiency, when they might be used for much more than merely boosting social media material...". Another responder indicated that due to a lack of technology-driven factors that have the potential to boost productivity in industries, including the government, enormous development in productivity is unseen.

5.6.3 Theme 3: Governance in Accra is not wholly smart

Transparent governance, participation in decision-making, and public and social services have all been identified as indications of smart governance, and it has been suggested that the government, both local and central have the capacity to do more. Public participation in decision-making is found to be insufficient and not sufficiently people-centered, and transparent governance is evaluated as very low. Transparent governance is regarded as weak, participation in decision-making is lacking and not sufficiently people-centered, and public and social services exist but are insufficient. One of the fundamental characteristics of a smart city is smart governance, with the components of accessibility and availability of public and social services, transparent governance, and citizen participation in decision-making being prioritized. While the key factors were being considered, several minor details were mentioned.

Accessibility and Availability of Social and Public Services: About 75 percent of the respondents felt that the government has been effective in delivering social and public services in recent years, but that more could be done. For example, in online passport applications, driver's license applications and renewals, the use of digital street addresses, and even the recently concluded 2020 general elections, ingenuity was evident in ensuring that the elections

ran smoothly and without incident, in contrast to previous years. Although some gaps were detected, the stakeholders concerned have been attempting to make NSS registration and certificate delivery more solid and efficient for all of its beneficiaries. Water, electricity, and gas can also be purchased and paid for online. Online financial services have grown in popularity as they have proven to be effective, simple, dependable, and efficient. Nonetheless, as others have pointed out, a lot can be done. One participant indicated that in the field of client-monitoring systems, which are inadequate in Accra's government institutions, improvement can be done. The government is still seen as employing outdated, time-consuming procedures. For example, there is no way to follow the status of an inquiry or an application, thus clients or consumers cannot maintain track of their government-related actions.

Transparent Governance was seen to be on the low as much could not be said about transparent governance and accountability, as 85 percent of respondents stated that they were not visible enough, more attention was required, and there was nothing noteworthy that indicated any form of intelligence in transparency and accountability, in fact, Accra lacks accountability in government dealings. In truth, the government does not hold itself sufficiently accountable to its citizens, much alone smart accountability. According to one reply, *"…openness in politics does not actually exist anywhere in the world, thus Accra cannot be criticized for not being entirely transparent…if transparency prevails, policies will be tremendously beneficial to the entire country and will be free of bias…"*.

When it comes to resource allocation, one respondent admitted that the public sector benefits from the majority of the government's sharing while the private sector struggles to get a small share. However, the government cuts a huge chunk for the private sector industries when it comes to tax allocation, implying that transparency is lacking. Still, in terms of revenue, repealing certain levies, such as road tolls, was pointless, and one responder noted how much of a burden this places on the private sector, which ends up carrying the entire expense. Some participants discussed how market women in the informal sector pay market tolls yet are denied access to governmental market services such as cleaning, power, and drainage clearing. The reply exclaimed, *"This is not smart enough on the part of the government."* This places a significant strain on the private and the informal sectors as they bear all the costs.

Participation in decision-making is not people-centered: In previous years, the government maintained a platform on their website where citizens could send their problems to the

government on a district level or occasionally to the central system, and they were documented, treated with confidentiality, and addressed in the order of priority. As a result, the platform is no longer used as certain residents do not participate because they believe their ideas are not valued and, in some circumstances, are not even used, according to some respondents. Some also claimed that people's ideas and opinions were taken into account before the recently concluded 2020 general elections, but that this stopped after that. The e-levy bill, for example, was recently passed despite the fact that it did not get widespread support. A respondent also highlighted faith or trust in the government as an essential concern. Locals in Accra have little faith in local and central government and are currently uninterested in whether the government achieves anything for their city. Residents of different Accra neighbourhoods banded together to accomplish certain goals for themselves. For example, a neighborhood in Ablekuma, Ga Central District, had a road that was in poor condition, untarred, and produced heaps of dust, which deteriorated beautifully painted houses and caused various health-related issues. The community joined together and contributed to the tarring and maintenance of the road. This is not possible in some disadvantaged neighborhoods within the city, as some residents cannot afford a three-square meal. As a result, some communities achieve smartness on their own through local initiatives, while others cannot. This indicates that governance in Accra is indeed relatively smart as most respondents stated.

5.6.4 Theme 4: Living smart in Accra varies

Individual safety, health conditions, housing quality, and aspects of cultural and educational amenities were all part of the smart living concept. According to this approach, Accra needs emerging technology in industries relevant to these variables. Individual safety is relative because it depends on the individual's community or constituency, and most of these technologies are missing under health conditions. Housing quality varies by community and municipality, with some areas of Accra meeting the standards while others did not. When it comes to cultural and educational amenities, these are deemed plentiful, and most tourists visit them more than Accra locals. As a result, the notion of smart living is also simple and might be implemented. For the purposes of this study, the smart living idea is defined primarily by health conditions, housing quality, and individual safety. All particpants agreed that smart living in Accra is relative, but that it does not match the requirement. As a matter of fact, living smart in Accra is almost impossible and again, one has to be extremely smart to be able to live in Accra.

The Health Conditions Factor: There has been progress in comparison to past years, but it is insufficient. One respondent indicated that the government has done a good job of providing ambulances to every constituency (276) but that little can be said about it because the people in charge utilize it for personal advantage. A few highlights are identified from the responses pertaining to healthcare.

Lack of health facilities: The Korle-Bu Teaching Hospital is the most important of the three government hospitals in Accra, followed by the Regional and 37 Military Hospitals. Other minor government polyclinics such as the Mamprobi Polyclinic, and Ussher Clinic, just to name a few, assist these major hospitals in their efforts. One responder noted that these public health centers are insufficient and that when the number of Ghanaians living in Accra is compared to the number of health facilities available, the ratio does not match, putting strain on both health facilities and personnel (high doctor-patient ratio). Basically, these health centres are not adequate enough and according to relevant sources, Ghana is one of the countries with a high mortality rate due to factors such as these.

Affordable Healthcare in Accra: The National Health Insurance Scheme (NHIS) was introduced by the Kuffour-led administration in 2000 and has been in effect since then. It provides essential health services to the typical Ghanaian at an affordable price. Users can use government health facilities for free or at a reduced charge, depending on their membership. Others can utilize it at private-owned medical facilities, but just a few of them. The NHIS has benefited some people, but if it is adequately designed, it can reach several Ghanaians. As stated earlier, privately-owned health centers outnumber government-owned centers and they give excellent healthcare, but the question is whether they are economical and affordable to the average Ghanaian. The average Ghanaian is unable to afford health services due to their high cost, making them inaccessible. Only the wealthy and powerful Ghanaians can afford these services and do not waste time considering them when health challenges arise.

Provision of manual healthcare and services: Partcipants believe that services could be provided efficiently and effectively using technological devices. The promotion of telehealth or e-health could also be introduced but it is unavailable in the public-owned hospitals, just the e-pharmacy option is available. The private sector hospitals have introduced that aspect in their services and physicians can also provide home services to patients though it is not on a large scale.

Improper record-keeping: Improper record-keeping is also found in government-run health centers. This slows down services, renders them unreliable, and makes them untrustworthy. The Covid 19 Contact tracing, for example, had several flaws when it started but was eventually recognized and fixed.

Inaccessible Healthcare: Healthcare in Accra is dependent on the individual's and his or her household's income or revenue. Although health facilities are available, they are limited, and their affordability is relative. The ones that are accessible lack essential amenities and equipment or are far away and difficult to reach.

The Housing Quality Factor :All respondents focused on housing as a matter of urgent attention. Some industry players mentioned the current trend- the introduction of smart buildings in Accra, where individuals are now building and installing solar panels, low-power systems like sensor installations, and other things. Nonetheless, there are a slew of other issues that come up with this and will be covered briefly below, as each respondent expressed it in a unique way.

A surge in real estate prices that is still unaffordable: Numerous housing units are available in Accra; however, they are beyond reach for the average Ghanaian. This makes closing the poverty gap impossible. These housing units are decent, with running water and essential home amenities, as well as well-defined spaces, but the costs are exorbitant.

High cost of building materials: One responder who works as a Quality Assurance surveyor also brought up the issue of rising commodity prices. "*..this makes selling or renting a home very impossible. Construction in Accra is progressing, but if the prices of goods or commodities continue to rise, even the most basic of dwellings will be out of reach for the typical Ghanaian. Cement, labor, iron rods, and even timber, to mention a few building materials, have risen by more than 200 percent in the last three years and is absurd…"*

Lack of uniform and strict housing regulations & policies: Accra and Ghana lack a standardized system or range of prices for renting and selling properties. In fact, one of the primary issues stated by a respondent is that everything sold in Ghana has distinct pricing. A tin of Ideal milk, for example, costs 2.50 Ghana Cedis at Makola, 2.70 Ghana Cedis in Kaneshie Market, and 3.50 Ghana Cedis by the petty trader who sells within the vicinity. As a result, most citizens

choose to purchase products from large markets or shops rather than from these petty traders. Everyone in Accra has their own pricing scheme, which cannot be regarded as a smart way of living. The sale and rental of homes or houses are also advertised on websites and other social media platforms, and although some are legitimate, others are frauds that are not even true or real.

Politicization of Housing in Accra: Another respondent emphasized the politicization of the housing issue, pointing out how successive governments fail to complete or take over housing projects left unfinished by past administrations. This applies to nearly everything in Accra and Ghana, not just housing. A respondent referenced the Kuffour Students Hostel project at the University of Ghana, which began before the Kuffour administration ended and remains unfinished to this day because succeeding governments have refused to complete it. The project was designed to accommodate between 1500 and 2000 tertiary students. Prior to the emergence of the Covid 19 virus, the number of students accepted at the University far outnumbered the available housing. Some students had to rent highly expensive spaces outside of universities, while those who could not afford to rent had to "perch" with their classmates. This, of course, places a strain on the limited existing infrastructure available to the public at the University of Ghana.

The Individual Safety Element**:** Ghana is one of the most peaceful countries in Africa and the globe, with peace, stability, and orderly transitions of leadership since the fourth republic, according to one respondent. Individual safety, however, is difficult to assess. Each person is accountable for his or her own safety, and on a broader scale, Accra's safety is determined by the neighborhood or community. Security patrols on the road stop to track and inspect all cars that use that route to ensure safety in the key regions, ensuring roughly 80% safety. The Spintex-Sakumono road is an example. This cannot be true for the outskirts and certain parts of Accra, where one's safety cannot be guaranteed, and reliance on Ghana's security services has proven to be detrimental over time. One respondent stated that, in his opinion, crime in the city is increasing daily, and that some security personnel are even engaging in social vices. He mentioned the recent bullion van incident in Jamestown, in which another police officer was slain. As the investigation progressed, the perpetrators in the bullion van attack were identified as Ghana Police Service officers, who shot the other officer because he recognized them and was likely to blow the whistle. Other respondents agreed with this and added that some

motorways, highstreets, and overheads could not be utilized at night since they are vulnerable to assault and robbery.

5.6.5 Theme 5: Accra is not a smart environment

As indicators, the smart environment characteristic focused on the lack of pollution of natural conditions and pollution, environmental protection, and sustainable resource management. Accra fails in every way for this feature. As a result, all respondents explicitly stated that Accra's environment is not smart. Accra has lately expanded and continues to grow as Ghana's capital and industrial hub, keeping up with urbanization like other cities. It is densely populated, which creates sanitary and environmental problems. GAMA has implemented several projects to benefit Accra citizens, including the provision of at least one water closet toilet for each residence at a reduced price. Although the Ghanaian government and certain non-governmental organizations funded this project, all of the respondents agreed that much more could and should be done. Respondents declared that Accra's environment cannot be a smart environment.

Pollution & Lack of pollution of natural conditions: According to respondents, Accra is clogged with people, making it densely crowded since everyone wants to travel there and seek greener pastures. This has resulted in clogged drainage systems, extensive littering, particularly of plastics, open defecation, pollution of water bodies by dumping trash into them, such as the Korle lagoon, and a variety of other issues. Previous and succeeding governments have made efforts to address this socioeconomic problem, but it appears that they are insufficient.

Waste minimization & management: According to one respondent, trash minimization will come first, followed by waste management. A strategy for minimizing waste should be introduced. For instance, in Rwanda, the law of the ban on plastics has been helpful to them and if Accra takes that on, numerous tonnes of waste will be avoided. This might include garbage segregation, which is now only in place in schools and a few areas of the city but could be implemented throughout the city. In some locations, privately owned waste management organizations (locally known as kaya borlar) are also assisting with waste management, but some of these are either expensive or inconsistent with the task. Some of them remark that even when they collect garbage from homes, businesses, and institutions, finding a primary trash site or container is difficult since it is either full or the container has deteriorated and can no longer hold the waste.

Release of toxic substances into the atmosphere: This focuses on the high levels of hydrocarbon produced by fossil fuel combustion, second-hand vehicles with defective engines, and scrap metal burning by scrap merchants in the Agbogbloshie market (Sodom & Gomorrah). Manufacturing enterprises and other industries generate harmful chemicals and gases, like CO2, because Accra is an industrial center. Some waterbodies are usually affected as well, resulting in the poisoning of the aquatic organisms. Both local and central governments have attempted to transfer traders and hawkers into well-built and structured market sheds, but they say that sales drop when they do so because potential purchasers find it difficult to identify them.

Severe man-made floods: Although some neighborhoods of Accra are known to be flood-prone, some inhabitants dump garbage into drainage systems. Once it rains for more than 30 minutes, these places flood due to clogged gutters and drainage systems. Others build houses on waterways since there is no structural building plan in certain Accra parts that allow for tight river demarcation. One responder mentioned that in the 1990s, there was a structured building plan in place, and those who did not follow it were fined or penalized. People currently do not build with pathways, canals, or vegetation routes in mind, and settlements are so crowded, clumsy, and slummy that there is no good source of ventilation.

Sustainable Resource Management: Ghana is a resourceful country, but it is limited by a lack of mechanisms for processing raw materials into completed commodities, forcing it to import some of the things it requires. Both the municipal and central governments are working to maintain Accra's resources, but some individuals are resisting this call. For example, anyone can cut down any tree in his or her home or place of business without obtaining prior approval. And while this person cannot be held accountable for his or her activities, the natural environment must be considered. Ghana has a lot of work to do for this element as both human and natural resources need to be managed sustainably.

Environmental Protection: In Accra, government entities such as the Environmental Protection Agency and the Natural Disaster Management Organization are responsible for environmental protection. These institutions do their functions, and it is up to residents to conserve the environment by following established legislation and treating the environment as a subject of rights, as it is in other countries such as Brazil and Columbia.

5.6.6 Theme 6: People in Accra are smart

The four important parts of the smart people characteristic are level of qualification, creativity and adaptability, open-mindedness, and participation in public life. About 80 percent of respondents claimed that the people of Accra are smart to a large extent, while 20 percent stated differently with reasons for the choice made.

Level of qualification: Ghana has the greatest literacy rate in ECOWAS, owing to its lower population density than a few years ago. More people are reading doctorate and master's degree programs, and many more are reading and eager to earn a bachelor's degree. As a result, Ghanaians living in Accra have a high level of qualification and the desire to learn more. The present administration has been supportive, implementing a free senior high school policy that allows most young people to obtain a high school diploma. Most people in Accra have been unable to obtain higher academic levels due to financial constraints but scholarship opportunities have been introduced to address this.

Creativity & Flexibility: *"...living in Accra is living by plan and living by plan suggests a certain level of smarts..."* one respondent remarked. This explains why most Accra inhabitants are intelligent; they work hard to create opportunities for enterprises, money, and success. Another responder claimed *"...that because the industrial sector is Ghana's business hub, it is full of smart individuals, and the private sector assists them in improving themselves through capacity-building initiatives...*". Another noted how intelligent Accra's informal sector employees are, stating: *"tend to discover basic yet innovative solutions to complicated problems,"* citing the transportation system as an example, which would be covered in the smart transportation concept.

Open-mindedness: Accra residents are willing to learn more, be more adaptable, and multilingual so that they can connect with people of different tribes and build good interpersonal and cordial relationships with them. Three respondents noted a few challenges, and they are:

Lack of government dedication and aid: These respondents said that the difficulty of the government's dedication and assistance limits the complete perspective of the characteristic of

the smart people notion in Accra. This is attributed to high costs of raw materials, rigid credit systems with hefty interest rates, and high taxes and levies issued to all but especially private-sector workers.

Authorities' inability to maintain decisions: Accra's municipal administration is unable to ensure that decisions or policies are long-term in nature. According to one respondent, the longest a radical decision by the local government has taken is between 6 and 9 months. One example is the migration of traders and hawkers from the Makola market's streets to market shelters erected specifically for them but were back on the streets in less than three months. The same event occurred in the Madina market, Agbogbloshie market, and other parts of the country.

Another issue discovered is that some Accra residents prefer to remain conservative on certain issues, limiting their commitment level. This stifles their desire to effect change in their communities by framing it as a government obligation, forgetting that government is *"for the people, by the people, and of the people"*, and thus they as citizens form an integral part of the government.

5.6.7 Theme 7:Transportation in Accra is not Smart

As indications, the smart transport characteristic looks at the availability of ICT infrastructure and sustainable, innovative, and safe transportation methods. Although it is determined that Accra's transportation system is innovative, the majority of Accra's transportation systems are privately owned, with only a few being publicly owned. This quality is subjective because ICT infrastructure is present in the privately owned transportation system. In such situation, the trait matches the criteria in some respects but falls short in others, making it minor. As a basis, the *"smart trotro system"* is endorsed by respondents. In Accra, the "trotro" system exists, however it is inefficient in most circumstances. As a result, the "smart trotro system" is required for the development of a smart transportation system in Accra. The smart transportation concept in Accra is characterized by the accessibility of the transport system, safety, and the availability of ICT infrastructure within the sector in Accra. 90 percent of respondents stated that they would not classify transportation in Accra as smart while the 10 percent stated that a smart concept is highlighted.

Accessibility: It was noted that transport in Accra is easily accessible, but this is privately owned and monopolized. The local name given to it is "trotro" or "trosky" by generation-Z.

This trotro system forms part of the informal sector and is regulated by the GPRTU. There is no fixed rate to pay for transportation, it varies from distance to distance and within the communities. To some, the trotro system counts as a smart innovation and is an effective system from a mobility perspective though it needs to be well structured and strategized to make it an effective and more convenient system.

Existence of the private transport system: In Accra, private commercial transportation services such as Uber, Bolt, Taxify, and a few others have been introduced. This means of transportation is likewise safe and dependable, but cost becomes an issue because the average Ghanaian would rather pay less for transportation and arrive at his or her location than pay more for the same service. Another challenge is that this means of transportation is a pay-as-you-go system, and because Accra has significant traffic congestion, passengers tend to pay more. As a result, fewer people are willing to use this service.

Poor public transportation system: A few public transit systems exist in Accra, although they have largely failed over time, despite prior and successive administrations' efforts Ghana to revive and preserve them. The Aayalolo transportation system, one of the public transportation networks, failed due to low patronage among the Accra people. It was tough for them to transition from the Trotro system because they had grown accustomed to it. The Aayalolo Transport System, which was implemented to ensure that government employees arrived at work on time without having to drive and to cut CO2 emissions, could not be sustained with drivers. The government employees interviewed concluded that the choice was undesirable, and they returned to driving their own cars, which increased traffic and contributed significantly to CO2 emissions. Starting with the police service, the new NPP government has attempted to resurrect the public transportation system. Shuttles have been supplied for the security service to help them be more productive by assisting them in being on time for work, which is a brave step yet the main problem is that sometimes they refuse to follow traffic laws.

Availability of ICT infrastructure: It was revealed that this element is lacking in a variety of ways, particularly in the public transportation system; for example, basic road management systems such as car navigation with traffic signal control, container management, automatic number plates, online ticket booking, and reservation, online payment, and swipe card system are all lacking. Buses in the private transportation sector travel across regions, hence VIP buses

have an online booking and reservation system with online payments. The issue of affordability was noted as a problem with the private transportation system and when compared to the public one, it is rather costly.

Safety: When commuting significant distances in Accra, one of the most important factors to consider is safety, which the private transportation system can provide. One respondent cited that private transports are more dependable than public transportation, and the only issue is well-constructed highways. Some of the roads are badly maintained, unpaved, and poorly built. Because most Accra highways lack container lanes, all types of vehicles use them. Although the number of vehicle accidents documented annually in Accra is lower than in other regions, more may be done to maintain road safety.

5.6.8 Theme 8: Existence of collaboration

The study's findings revealed that the players collaborated and that a multi-stakeholder approach to innovation was evident yet there is a need for more engagement, cooperation, and collaboration between various groups. All respondents indicated that traditional authorities have to be included because they are a key stakeholder in the development and innovation process and back policies and initiatives in a number of ways. In that sense, people need to be a part of the creative process if Accra is to become a sustainable, climate-neutral smart city. According to about seven respondents, all actors are essential to developing a smart Accra, and all actors in the approach play different roles and a level of collaboration, cooperation, and interaction is acknowledged, however, this is satisfactory and there is still room for improvement. Two said there is more collaboration where the players have a chance to benefit, while ten said it is steady but slow, that it occurs but not consistently, and that collaboration occurs through various mediums such as conferences, workshops, and seminars, but that the actions are not visible enough.

The role of government in building a smart Accra: The government helps Accra become smart in a variety of ways, including through programs, policies, the passage of bills, laws, and regulations, direct and indirect funding of projects, and so on. According to some respondents, the government's funding in research is insufficient, but they manage to push their way through to conduct research, albeit infrequently. Others complained about how much time, money, and effort students put into doing research studies, but that these studies are never published or used

for the objectives for which they were conducted, preventing the government from acting on local community needs. Security, transportation, statistics, taxes and levies, environmental protection, and other areas of government are becoming more focused on digitization.

The role of NGOs in building a smart Accra: NGOs provide support, awareness, advocacy role, and public training for the public. Without government funding, non-governmental organizations (NGOs) help individuals and minority groups, and they accomplish incredible work. They raise awareness of sensitive and social issues as well as support health, legal, and environmental challenges in Accra, despite the fact that most NGO projects are in Ghana's northern regions rather than Accra and more can be done.

The role of media in building a smart Accra: The media assists by producing and posting stories, as well as monitoring, watching, and reporting on social difficulties that people in and around Accra face. The media disseminates information to even the most remote regions of the city and beyond. They also educate neighborhood members on social concerns and spread information about how Accra plans to be smart in certain areas. For example, the media reported that the "Aaayalolo" bus system will be digitalized with a card scan system and would no longer accept cash after a certain date. The media also informs its beneficiaries and people about and for an NGO. The government and the media also work together to inform the public about what the government should do and to promote change in small ways, including through digital tools and projects.

The role of industry in building a smart Accra: The private sector was commended by respondents for their enormous efforts and constant collaboration with the majority of the actors. In partnership with the government, the corporate sector is working hard to help Accra's poor. Telecommunication networks, for example, are not government-owned; they are private enterprises that work with the government to operate in the country. Apart from the informal sector, they have employed a large number of individuals. Some businesses have even sponsored and assisted the government in the construction of roads, schools, hospitals and clinics, dams, and tourism attractions. As a measure of assistance, the sector regularly participates in Corporate Social Responsibility projects and sponsorships. According to one reply, a company donated automobiles to the Ghana Police Service. Some have remarked that even though they are accomplishing a lot in Accra and that the channels and degrees of

coordination between them and the government are quite beneficial, there is a lack of transparency.

The role of universities/ research institutions in Accra: About 30 percent of respondents rated universities' collaboration with the government as low because they are not involved in government decision-making, yet the government might use the research done by universities to design and implement policies because most data for research is obtained from the ground up. Universities have modified their programs of study to place a greater emphasis on ICT, making it an obligatory course for all students before graduating. In academia, one problem noticed is the inability to detach personal interests from research, which usually leads to greater bias in the research output produced, which is often lacking in authenticity, credibility, and unbiased judgments. Applications and admissions are entirely done online in Accra universities, including payments. For example, at the University of Ghana, the Vice-Chancellor has implemented various measures to assist students in making learning easier and more practical than theoretical. Some innovations have been implemented at the institution to help and assist students with their academic demands.

The role of citizens: Citizens in specific regions of Accra find answers to their concerns, indicating that there is a significant amount of citizen-government collaboration. While some citizens are prospering, others have lost their patriotism. Citizens gradually accept technology change and growth because they see it as a critical component of urbanization, development, and smartness. The only impediment is the high cost of internet services provided by telecommunication service providers, which keeps them away despite the desire of the typical Ghanaian to be technologically savvy. On social media, citizens collaborate; *"for example, on LinkedIn, most people are connected with others who share similar interests and backgrounds. Citizens have access to the many articles or links that a media outlet is considering, and conversations and other comments are permitted in the comment sections, and taking advantage of media sharing and micrblogging"*, a participant stated.

5.6.9 Theme 9: Use of Accra-based QH approach is recommended to Accra

About 93 percent of respondents agreed that the Quintuple Helix model of innovation should be employed since it is environmentally friendly, and they are all concerned about Accra's

environmental smarts. They feel that if the environmental issue is addressed, other issues will be influenced, both directly and indirectly. They also argued that because westernized cities differ from African cities, notably Accra, it would be more acceptable and recommended to build and deploy an Accra-based quintuple helix model of innovation. They also believe that what succeeded in another city might or might not work in Accra, that importing components of it that might work in Accra is worthwhile, and that they could be altered to suit Accra and used. Accra, according to the responses, is a resourceful city that should view the ecosystem as a subject of rights, and that a helix would aid in achieving technological sustainability.

5.6.10 Theme 10: Traditional authorities are relevant

Because traditional authorities play key roles in every facet of development in Accra and Ghana as a whole, all respondents stated and agreed that establishing Accra as a sustainable smart city could not be done without them. Ghana is an ethically oriented country, and ordinances are an important element of Accra and Ghanaian law. Bylaws are derived from a community's traditional and sociological traditions. As a result, our traditional authority in Accra should fulfill the monitoring and oversight responsibilities entrusted to them by society and the state. Traditional authorities are cherished and highly regarded; they are closer to reality and so have more interaction and cooperation with local communities; they are powerful and wield a great deal of authority in the community. Traditional authorities already work with the actors by providing data and information to NGOs, the government, researchers, and the corporate sector. Most traditional rulers are now literates and involving them in the innovation process would not only be simple but also profitable.

This may also result in some roadblocks, such as the fear that the government will refuse to collaborate deeply in particular areas, or the issue of cultural differences. The majority of respondents said that all traditional authorities play different and unique roles in society and that some may be more needed for collaboration, cooperation, and engagement than others, thus the most relevant ones should be solicited.

CHAPTER SIX

RECOMMENDATIONS AND CONCLUSION

6.1 Recommendations

Respondents made many suggestions for the study to assist Accra in its transition to sustainability, climate neutrality, and smartness. These are important and relevant to the study since it focuses on multi-actor collaboration. It is critical to bring their perspectives, ideas, and suggestions to light for both current and future investigations and comparative analyses. The informal sector controls a major portion of the market.

6.2 General Recommendations

6.2.1 Recommendations for the Government

- Firstly, it is recommended that both local and national governments work together to provide flexible credit systems with low-interest rates. Also, to discourage market trickery and deception, a suggestion for the government is to ensure that the prices of products, commodities, and services are uniform across the city and country. Another thing the government can do is to digitize the public sector's services, products, and goods since a large number of clients go to public sector organisations for various types of product research. The system should be accessible such that clients may be able to track the progress of the service they have applied for or requested. Smart makes it easy to monitor and assists customers in receiving comprehensive services from the convenience of their own homes. For example, in the transportation sector, a suggestion to the government is to learn from the VIP transportation system, which is privately owned and uses digitalization techniques in the delivery of its services, to increase the use of emerging technologies in the transportation sector, which is appealing to the youth to use and willing to learn.
- One other recommendation to the government of Ghana is to continue developing and executing solid policies that prioritizes the Accra people's health, personal safety, and mobility. For example, a policy that will require all government employees to use their IDs while using approved public transportation services and receiving a 30% discount on fuel when using their own automobiles. Many government employees will make use of the public sector shuttles to save money. This has the advantage of monitoring when

public employees report to work and assisting them in arriving on time, this will assist in worker tracking in order to determine the number of workers who report to work in a given month. As most government employees own private vehicles, this will greatly reduce traffic congestion and contribute to traffic patterns, therefore calibrating traffic patterns. One recommendation to the State is to design drainage systems that will feed rainfall into dams and be used as another source of energy in selected regions of Accra. When it rains, this will help to lessen flooding in Accra's flood-prone districts.

- Another suggestion is for political parties to continue projects and programs that are carried out by consecutive governments regardless of whether or not their political parties are elected to power. A suggestion is for housing concerns to be depoliticized as a result of this. Furthermore, it will be great to have the government verify that the security service follows all traffic management protocols.
- Another point worthy to note is that NGOs need greater funding, and the private sector, individuals, and the government, particularly in the sphere of IT and digitalization training, may be able to help. To encourage investors to invest in digital tools, the government is recommended to subsidize them.
- Finally, traditional authorities also give recommendations for urbanization initiatives, legislation, and other actors. A similar technique might be used to encourage smart cities and innovation. Traditional authorities also have the capacity to recommend initiatives, legislation, and other actors to support urbanization. A similar strategy might be applied to smart cities and innovation. The multi-stakeholder strategy is crucial for the development of a sustainable,and Accra is advised to utilize this approach.

6.2.2 Recommendations for the residents of Accra

Accra residents have been recommended to learn to reduce trash naturally, and garbage should be controlled through segregation and recycling where it is generated. The objective of a circular economy is to reduce, reuse, recycle, and recover, and the same notion needs to be implemented in Accra's waste minimization and management systems.

Specific Recommendation for the Transport Sector in Accra

From the findings of the study, one key issue that was constantly mentioned was transport and waste management in the aspect of smart environment but the smart trotro system will be

discussed here. Some respondents suggested a smart public transport system which may take years to construct. They therefore suggested that the current commercial buses can be transformed into a smart public transport system and the suggestions are briefly discussed below;

6.2.3 Smart Trotro System in Accra

The "Trotro" system is Accra's principal mode of transportation, carrying 70-75 percent of the city's people to and from their destinations. It is monopolized, held by private persons and groups, and is termed as informal due to the lack of structural and formal procedures. Almost all respondents propose formalizing the "trotro" system by incorporating emerging technologies to make it safer, more convenient, and more comfortable, as simply being registered and governed by the GPRTU is insufficient. The smart trotro system is an innovative system that Accra is proud of, as the train, bus, and other public transportation systems have all failed miserably over time. The Mobility as a Service concept needs to be explored for a smart “trotro” system. This should not just entail the use of smart technologies, but also a holistic approach to the "trotro" system. Among them are:

Incorporating Mobility as a Service (MaaS) technology into the Trotro System: Mobility as a service aims to integrate various modes of transportation into a single platform, using the concepts of digitization and technology to reduce the number of privately owned vehicles while also ensuring sustainability (Utriainen & Pöllänen, 2018). Technology-based solutions from the MaaS function as avenues to provide improved regulation of the “trotro” service to develop a long-lasting and effective “trotro” system. If Accra can structure this concept successfully, it will benefit transportation operators, regulators, commuters, and many other cities that employ the paratransit system can learn from it.

The Transport Authority is advised to encourage the following;

- Firstly, ensure installation of service quality technologies will improve commuter service while also assisting in the resolution of systemic issues. This will also help regulators better coordinate the “trotro” service, which will benefit the GPRTU. Include technologies that can assist commuters in planning ahead of time travels, such as the swipe system, bank, card, and mobile money payments, “trotro” location monitoring, and reporting operator misconduct (Dzisi et al., 2021). Improve and construct more

private vehicle parks, bus stops, and bus stations for the “trotros”. Sensors, cameras, and tracking devices must be installed in traffic management systems.

- Also reduce fares' variability by establishing a uniform amount based on the distance of kilometers traveled. Set uniform timing for “trotros” to reduce variability in their departure and arrival times. One key suggestion is to make provision for pregnant women, the elderly, and people with disabilities should be provided to ensure equality, justice and inclusion as stated by Forster and Iaione, 2016.
- Formalizing the Trotro System: To formalize the trotro system, the transport authority is encouraged to;
- Firstly, create an official database for “trotro” drivers, as it has been noticed that most “trotro” service providers are not covered by a pension plan and having a database will make it easier to enroll them in one, thereby strengthening the trotro service providers labor union.
- Secondly, for easier identification and tracking of "Trotros", the authority is recommended to issue automatic number plates. For example, the "trotro" drivers, conductors, and regulators should be provided with a uniform, tags, and driver's identification cards for simple identification and reporting to authorities in the event of misconduct.
- Thirdly, to encourage learning, training, and capacity-building sessions for drivers as they will need on-the-job training to assist them to understand and interpret new road signs and symbols that may have been added. Digital and driving software pieces of training should also be designed for drivers. To help develop a cordial relationship between drivers and “trotro” conductors, regulators should design a coaching and mentorship session for both.
- Another recommendation is constant health checks for the transport service providers. “Trotro” service providers are encouraged to do health checks on a regular basis, particularly for eyesight or sight, diabetes, blood pressure, and other conditions that will assist them to understand their health status. This will assist authorities in allocating drivers for long and short trips. This is a strategy for lowering the number of car accidents.

Conclusion

This thesis concerned the study of the quintuple helix of innovation and its suitability to support the evolution of Accra towards a smart city. The world has evolved from knowledge-based industrial systems to the triple helix of innovation, to the quadruple helix and to the existing quintuple helix of innovation which reveals greatly the concept of sustainability. Following a literature review on the key research topics, the data outcomes were discussed from a series of interviews conducted with smart city stakeholders. The data from respondents were compared to the empirical findings mentioned in the study's second and fourth chapters.

As mentioned in chapter two of the thesis, smart cities are the current trend, and countries worldwide are changing from normal-smart cities to sustainable smart cities. The quadruple helix is used in most African cities, and Accra too was highlighted as using the quadruple helix of innovation. Accra is suggested to learn about collective action among the numerous actors, self-organization and self-sustaining technology, social norms, and informality with formal frameworks in order to become more sustainably smart from this study.

Previous chapters have established that collective action among the key components of the innovation helix-government, industry, academia, and media-based culture (NGOs, citizens, and media) communicate, collaborate, and cooperate, allowing for a smooth transition. The study suggests that Accra uses the Quintuple Helix of Innovation, which considers five major actors: the government, industry, universities and research institutions, media-based culture (which includes the media, NGOs, and citizens), and the natural environment.

Further objectives for the study sought to examine the characteristics of a sustainable smart city and analyse where Accra does not meet up as a smart city. From the findings and discussion, it was identified that Accra is not smart in environment and transportation. For the economy and governance, Accra was not wholly smart. It was identified that smart living varied among the communities in Accra.

In investigating the current approach of innovation being used to build Accra as a sustainable smart city, it was revealed that Accra uses the quadruple helix of innovation approach considering the constant players which are the government, industry, universities and media-based culture (media, citizen & NGO).

In exploring whether all the relevant actors collaborate in their responsibilities towards building Accra as a sustainable smart city, it was found out that all the actors played their roles, interact and collaborate with each other. Notwithstanding, the level of collaboration can be increased to cause social change especially in the sustainable smart cities context. Both players need to understand that collaboration is key when innovation is mentioned and for this approach, it is key. In ensuring that the sustainable development goals are met, the players need to interrelate, inter-collaborate and interact more as this will help speed up the process of Accra to become smart and sustainable while adhering to the Paris Agreement with the goal to reduce gas emissions to 2 or 1.5 degrees celsisus above pre-industrial levels, thereby making the environment a subject of right, preserving it and making it liveable for both current and future generations.

In finding out these objectives through the questions posed to participants, they recommended both general and specific recommendations. The specific recommendation stressed the role of smart transportation, suggesting that Accra needs to formalize the transport sector with regards to the trotro system as well as introducing the Mobility-as-a-service concept which considers new technologies, digital tools and ICT-infrastructure for transport. This recommendation was discussed extensively because transportation is a daily necessity, has a direct bearing on environment and sustainability and needs urgent attention in Accra.

While analyzing both primary and secondary data, it was brought up that traditional authorities are relevant and need to be regarded as important in assisting Accra's transformation into a sustainable, climate-neutral, smart metropolis. Particpants of the study explained that an Accra-based context of the quintuple helix of innovation approach would be very useful to cause the transition. Using solely the westernized model from westernised cities would not be applicable to Accra but rather picking the relevant aspects that would be beneficial to Accra and mixing it up with the Accra-based context. Therefore, traditional authorities will be added to the natural environment or ecosystem in this way, preserving the quintuple helix of innovation and answering the research question.

BIBLIOGRAPHY

Abane, A., Amoako-Sakyi, R. O., Owusu, S. A., Agyemang, K. K., & Odame, P. K. (2019). *Transport and Social Exclusion in Ghana*. *June*.

Abdel-Fattah, M. A. K., & Galal-Edeen, G. H. (2009). Why an interpretive paradigm is needed for evaluating e-government systems? *Proceedings of the European Conference on E-Government, ECEG*, *October*, 1–10.

Abdulkareem, A. (n.d.). *Understanding the Interconnection Between Interpretive Research Paradigm and Qualitative Methododlogy in Library and Information Science Research: A guide for Qualitative Data Collection, Data Analysis and Data Interpretattion*. *Kamba 2010*, 1–9.

Accra Metropolitan Assembly; C40 Cities. (2021). *Accra Climate Action Plan*. 1–70.

Accra Metropolitan Assembly. (2019). Accra Resilience Strategy. *100 Resilient Cities*, 63. https://ama.gov.gh/documents/Accra-Resilience-Strategy.pdf

Achieng, M., Ogundaini, O., Makola, D., & Iyamu, T. (2021). The African perspective of a smart city: Conceptualisation of context and relevance. *2021 IST-Africa Conference, IST-Africa 2021*, *May*, 0–9.

Africa, J., Logan, A., Mitchell, R., Korpela, K., Allen, D., Tyrvainen, L., Nisbet, E., Li, Q., Tsunetsugu, Y., Miyazaki, Y., Spengler, J., & Group., on behalf of the N. E. I. working. (2014). *The Natural Environments Initiative: Illustrative Review and Workshop Statement*. *February 2015*.

Africa, W. (2012). *Among world's fastest growing countries*.

African Union Commision. (2014). *STISA-2024 Science, Technology and Innovation Strategy for Africa 2024*. 52.

Agbontaen-Eghafona, K. (2019). The Changing Phases of African Marriage and Family: Perspectives on Nigeria in the African Context. *The Pontifical Academy of Social Sciences*, 1–13. http://www.pass.va/content/scienzesociali/en/events/2019-23/family_ecology/agbontaen-eghafona.html

Agyei-Mensah, S., & Owusu, G. (2010). Segregated by neighbourhoods? A portrait of ethnic diversity in the neighbourhoods of the Accra Metropolitan Area, Ghana. *Population, Space and Place*, *16*(6), 499–516. https://doi.org/10.1002/psp.551

AIMS. (2017). *Ghana Open Data Portal : unleashing the power of Open Data*. 2–7.

Al-Nasrawi, S. A. Al, Adams, C., & El-Zaart, A. (2016). A Conceptual Multidimensional

Model for Assessing Smart Sustainable Cities. *Journal of Information Systems and Technology Management*, *12*(3), 541–558. https://doi.org/10.4301/s1807-17752015000300003

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, *22*(1), 3–21. https://doi.org/10.1080/10630732.2014.942092

Alika, I. J., & Aibieyi, S. (2014). Human Capital: Definitions, Approaches and Management Dynamics. *Journal of Business Administration and Education*, *5*(1), 55–78.

Amoako, G. K., Doe, J. K., & Heer, F. De. (2014). Innovation and marketing in Africa - a Ghanaian perspective. *International Journal of Technology Marketing*, *9*(4), 356. https://doi.org/10.1504/ijtmkt.2014.065407

Antwi, S. K., & Hamza, K. (2009). European Journal of Business and Management EJBM. *European Journal of Business and Management*, *7*(3), 217–225. https://iiste.org/Journals/index.php/EJBM/article/view/19543

Appiah, D. (2019). *Expected roles of Libraries in developing Smart Cities: The case of Accra, Ghana*. 1–7.

Appio, F. P., Lima, M., & Paroutis, S. (2019). Understanding Smart Cities: Innovation ecosystems, technological advancements, and societal challenges. *Technological Forecasting and Social Change*, *142*(December 2018), 1–14. https://doi.org/10.1016/j.techfore.2018.12.018

Arrazola, J. R. (2015). *Management of scientific knowledge through an intelligent system*. 1–8.

Arsova, S., Genovese, A., Ketikidis, P. H., Alberich, J. P., & Solomon, A. (2021). Implementing regional circular economy policies: A proposed living constellation of stakeholders. *Sustainability (Switzerland)*, *13*(9). https://doi.org/10.3390/su13094916

Bahari, B. A., Susanto, T. D., & Gunawan, J. (2021). Smart City Measurement: Identification of Smart Economy Performance Indicators in Indonesia. *Proceedings of the 2nd International Conference on Business and Management of Technology (ICONBMT 2020)*, *175*, 294–300. https://doi.org/10.2991/aebmr.k.210510.046

Baheti, R., & Gill, H. (2011). Cyber-Physical Systems. *Cyber-Physical Systems*. https://doi.org/10.1007/s10559-017-9984-9

Baker, S. E., & Edwards, R. (2012). How many qualitative interviews is enough ? *National Centre for Research Methods Review Paper*, 1–42.

https://doi.org/10.1177/1525822X05279903

Barcellos-Paula, L., De la Vega, I., & Gil-Lafuente, A. M. (2021). The quintuple helix of innovation model and the sdgs: Latin-American countries' case and its forgotten effects. *Mathematics*, *9*(4), 1–24. https://doi.org/10.3390/math9040416

Bharucha, E. (2005). *Textbook of environmental studies: For undergraduate studies (Chapter 3 Ecosystem)*. 53–75.

Bibri, S. E. (2018a). Approaches to Futures Studies: A Scholarly and Planning Approach to Strategic Smart Sustainable City Development. *Urban Book Series*, *7491*, 601–660. https://doi.org/10.1007/978-3-319-73981-6_11

Bibri, S. E. (2018b). Transitioning from Smart Cities to Smarter Cities: The Future Potential of ICT of Pervasive Computing for Advancing Environmental Sustainability. In *Urban Book Series*. https://doi.org/10.1007/978-3-319-73981-6_10

Boatemaa, M. A., Oppong Asante, K., & Agyemang, C. B. (2019). The Moderating Role of Psychological Flexibility in the Relationship Between Organizational Commitment, Workaholism, Job Security, and Corporate Entrepreneurship Among Information Technology Workers in Accra, Ghana. *SAGE Open*, *9*(3). https://doi.org/10.1177/2158244019871063

Bohari, A. A. M., Bidin, Z. A., Rais, S. L. A., & Saferi, M. M. (2019). Exploratory Research as the way forward towards a green procurement practices for the construction industry; Research Methodology. *IOP Conference Series: Earth and Environmental Science*, *385*(1). https://doi.org/10.1088/1755-1315/385/1/012054

Buchanan, M. E. (1981). Methods of data collection. *AORN Journal*, *33*(1). https://doi.org/10.1016/S0001-2092(07)69400-9

Cai, Y. (2014). Implementing the Triple Helix model in a non-Western context: an institutional logics perspective. *Triple Helix*, *1*(1), 1–20. https://doi.org/10.1186/s40604-014-0001-2

Cai, Y., & Etzkowitz, H. (2020). Theorizing the Triple Helix model: Past, present, and future. *Triple Helix*, *7*(2–3), 189–226. https://doi.org/10.1163/21971927-bja10003

Cai, Y., & Lattu, A. (2021). Triple Helix or Quadruple Helix: Which Model of Innovation to Choose for Empirical Studies? *Minerva*, *0123456789*. https://doi.org/10.1007/s11024-021-09453-6

Caragliu, A., del Bo, C., & Nijkamp, P. (2009). Smart cities in Europe. *Journal of Urban Technology*, *18*(2), 65–82. https://doi.org/10.1080/10630732.2011.601117

Carayannis, E. G., Barth, T. D., & Campbell, D. F. (2012a). The Quintuple Helix innovation

model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, *1*(1), 2. https://doi.org/10.1186/2192-5372-1-2

Carayannis, E. G., Barth, T. D., & Campbell, D. F. (2012b). The Quintuple Helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, *1*(1), 2. https://doi.org/10.1186/2192-5372-1-2

Carayannis, E. G., & Campbell, D. F. J. (2010). Triple helix, Quadruple helix and Quintuple helix and how do Knowledge, Innovation and the Environment relate to Each other? a proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. *International Journal of Social Ecology and Sustainable Development*, *1*(1), 41–69. https://doi.org/10.4018/jsesd.2010010105

Carayannis, E. G., Campbell, D. F. J., & Grigoroudis, E. (2021). Helix Trilogy: the Triple, Quadruple, and Quintuple Innovation Helices from a Theory, Policy, and Practice Set of Perspectives. *Journal of the Knowledge Economy*, *0123456789*. https://doi.org/10.1007/s13132-021-00813-x

Carayannis, E. G., Campbell, D. F. J., & Rehman, S. S. (2015). Mode 3 knowledge production: systems and systems theory, clusters and networks. *Journal of Innovation and Entrepreneurship*, *5*(1). https://doi.org/10.1186/s13731-016-0045-9

Carayannis, E. G., Grigoroudis, E., Campbell, D. F. J., Meissner, D., & Stamati, D. (2018). The ecosystem as helix: an exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models. *R and D Management*, *48*(1), 148–162. https://doi.org/10.1111/radm.12300

Chen, H. S. (2015). Using water footprints for examining the sustainable development of science parks. *Sustainability (Switzerland)*, *7*(5), 5521–5541. https://doi.org/10.3390/su7055521

Ching, T.-Y. (2013). *Smart Cities: Concepts, Perceptions and Lessons for Planners*.

Choi, B. C. K., & Pak, A. W. P. (2006). Parseh Diffrantial Equations. *Clinical and Investigative Medicine*, *29*(6), 351–364.

Choque, J., Diez, L., Medela, A., & Muñoz, L. (2019). Experimentation management in the co-created smart-city: Incentivization and citizen engagement. *Sensors (Switzerland)*, *19*(2), 1–17. https://doi.org/10.3390/s19020411

Coker-Kolo, D., & Darley, W. K. (2013). *The Role for African Universities In A Changing World*. *30*(1), 1–10.

Colapinto, C., & Porlezza, C. (2012). Innovation in Creative Industries: From the Quadruple

Helix Model to the Systems Theory. *Journal of the Knowledge Economy*, *3*(4), 343–353. https://doi.org/10.1007/s13132-011-0051-x

Coleman, J. (1988). Social capital in the creation of human development. In *The American Journal of Sociology* (Vol. 94, pp. 95–120).

Crentsil, A. O., & Owusu, G. (2018). *International Development Policy | Revue internationale de politique de développement Accra ' s Decongestion Policy : Another Face of Urban Clearance or Bulldozing Approach ?* 1–12.

Dakhli, M., & De Clercq, D. (2004). Human capital, social capital, and innovation: A multi-country study. *Entrepreneurship and Regional Development*, *16*(2), 107–128. https://doi.org/10.1080/08985620410001677835

Denzin, N. K., & Lincoln, Y. S. (2018). The SAGE Hnadbook of Qualitative Research. In *Synthese* (Vol. 195, Issue 5). https://doi.org/10.1007/s11229-017-1319-x

Dipak, S. (2021). *Munich Personal RePEc Archive Blockchain Technology : A Driving Force in Smart Cities Development Blockchain Technology : A Driving Force in Smart Cities Development*. *105351*.

Doh, P. (2018). A Quadruple Helix Framework for University-led Community Innovation Systems in Africa. *Theoretical and Methodological Perspectives of Higher Education Management and Transformation: An Advanced Reader for PhD Students*, 87–104.

Durán-Romero, G., López, A. M., Beliaeva, T., Ferasso, M., Garonne, C., & Jones, P. (2020a). Bridging the gap between circular economy and climate change mitigation policies through eco-innovations and Quintuple Helix Model. *Technological Forecasting and Social Change*, *160*(August), 120246. https://doi.org/10.1016/j.techfore.2020.120246

Durán-Romero, G., López, A. M., Beliaeva, T., Ferasso, M., Garonne, C., & Jones, P. (2020b). Bridging the gap between circular economy and climate change mitigation policies through eco-innovations and Quintuple Helix Model. *Technological Forecasting and Social Change*, *160*(March), 120246. https://doi.org/10.1016/j.techfore.2020.120246

Dzisi, E., Obeng, D. A., & Tuffour, Y. A. (2021). Modifying the SERVPERF to assess paratransit minibus taxis trotro in Ghana and the relevance of mobility-as-a-service features to the service. *Heliyon*, *7*(5), e07071. https://doi.org/10.1016/j.heliyon.2021.e07071

EC, (n.a.). (2007). Smart cities: ranking of European mid-sized cities. *Digital Agenda for Europe*, *October*, 28. https://ec.europa.eu/digital-agenda/en/smart-cities

Eduam, E. (n.d.). *Smart City in Accra- Ghana : A Gold Coast again*. 1–15.

Elshafie, M. (2013). Research Paradigms: The Novice Researcher's Nightmare. *Arab World English Journal (AWEJ*, *4*(4), 1–10. www.awej.orgwww.awej.orgwww.awej.org

Elvidge, J. (2012). *The Enabling State: A discussion paper*. 1–49. http://www.carnegieuktrust.org.uk/CMSPages/GetFile.aspx?guid=b90e80a4-a243-4f6b-bfb1-34b15c3cb7b3

ESI Thoughtlab. (2021). *Smart City Solutions for a Riskier World*.

Etzkowitz, H. (2003). Studies of science Etudes sur la science Innovation in innovation : the Triple Helix of university - industry - government relations. *Social Science Information*, *42*(3), 293–337.

Etzkowitz, H. (2012). Triple helix clusters: Boundary permeability at university-industry-government interfaces as a regional innovation strategy. *Environment and Planning C: Government and Policy*, *30*(5), 766–779. https://doi.org/10.1068/c1182

Etzkowitz, H., De Mello, J. M. C., & Almeida, M. (2005). Towards "meta-innovation" in Brazil: The evolution of the incubator and the emergence of a triple helix. *Research Policy*, *34*(4), 411–424. https://doi.org/10.1016/j.respol.2005.01.011

European Commission. (2014). Advanced Building Materials, Business Innovation Observatory, Smart Living, Case study 18. *Directorate-General for Enterprise and Industry, Directorate B Sustainable Growth and EU 2020, Unit B3 Innovation Policy for Growth, Contract 190/PP/ENT/CIP/12/C/N03C01*, 1–16.

Falk, N., & Simmons, R. (2020). Smart Cities :Learning from the pioneers. *Policy Briefing, November 2018*.

Fern, J. (n.d.). *Global Population Growth and Environmental Effects*.

Fields, G. (1999). Urbanization and the transition from agrarian to industrial society. *Berkeley Planning Journal*, *13*, 102–128. https://doi.org/10.5070/bp313113032

Foster, S., & Iaione, C. (2017). Ostrom in the City: Design Principles for the Urban Commons. *The Nature of Cities*, 1–24. https://www.thenatureofcities.com/2017/08/20/ostrom-city-design-principles-urban-commons/

Foster, S. R., & Laione, C. (2016). The City as a Hybrid/THE CITY AS A COMMONS. *Nature, Society and Cyborg Urbanization*, *7*(25), 65–80.

Franc, S., & Karadžija, D. (2019). Quintuple helix approach. *Notitia*, *5*(1), 91–100. https://doi.org/10.32676/n.5.1.8

Frey, F. W., Politics, S. C., Jan, N., & Frey, F. W. (1985). *The Problem of Actor Designation in Political Analysis Published by : Comparative Politics , Ph . D . Programs in Political*

Science , City University of New York Stable URL : https://www.jstor.org/stable/421726 REFERENCES Linked references are available o. *17*(2), 127–152.

Galdas, P. (2017). Revisiting Bias in Qualitative Research: Reflections on Its Relationship With Funding and Impact. *International Journal of Qualitative Methods*, *16*(1), 1–2. https://doi.org/10.1177/1609406917748992

Ghana's Infrastructure Sector. (2018). *Infrastructure*.

Ghana Statistical Service (GSS). (2014). Accra metropolitan. *Ghana Statistical Service*, 66. https://new-ndpc-static1.s3.amazonaws.com/CACHES/PUBLICATIONS/2016/06/06/AMA.pdf

Ghana Statistical Service (GSS). (2021). *Innovation in the Ghana Statistical Service*. *September*.

Giffinger, R. (2010). Smart cities ranking: an effective instrument for the positioning of the cities? *ACE: Architecture, City and Environment*, *February 2010*. https://doi.org/10.5821/ace.v4i12.2483

GII 2021 at a glance. (2021). 2–7.

Gil-Garcia, J. R., Zhang, J., & Puron-Cid, G. (2016). Conceptualizing smartness in government: An integrative and multi-dimensional view. *Government Information Quarterly*, *33*(3), 524–534. https://doi.org/10.1016/j.giq.2016.03.002

Green, E. (2013). Production systems in pre-colonial Africa. *The History of African Development*, 1–13.

Grundel, I., & Dahlström, M. (2016). A Quadruple and Quintuple Helix Approach to Regional Innovation Systems in the Transformation to a Forestry-Based Bioeconomy. *Journal of the Knowledge Economy*, *7*(4), 963–983. https://doi.org/10.1007/s13132-016-0411-7

Guerrero-Pérez, A. D., Huerta, A., González, F., & López, D. (2013). Network Architecture based on Virtualized Networks for Smart Cities. *IEEE CCD Smart Cities White Paper*, *October*, 1–6.

Güneralp, B., Lwasa, S., Masundire, H., Parnell, S., & Seto, K. C. (2018). Urbanization in Africa: Challenges and opportunities for conservation. *Environmental Research Letters*, *13*(1). https://doi.org/10.1088/1748-9326/aa94fe

HABITAT, U. (2009). *Ghana : Accra URBAN*. https://unhabitat.org/wpdm-package/ghana-accra-urban-profile/?wpdmdl=110897

Hadi Razavi, S., & Attarnezhad, O. (2013). Management of Organizational Innovation. *International Journal of Business and Social Science*, *4*(1), 226–232.

Hamilton, D. K., & Stream, C. (2014). Regional environmental policy. *Urban and Regional Policies for Metropolitan Livability*, 324–345. https://doi.org/10.1007/978-1-349-05426-8

Harradence, F. (2009). New Models of Innovation For Economic Growth and Sustainability. *Spillovers, Macroeconomic Impact*, 1–7.

Houimli, M., Kahloul, L., & Benaoune, S. (2019). Performance Analysis of Internet of Things Application Layer Protocol. In *Advances in Intelligent Systems and Computing* (Vol. 756). https://doi.org/10.1007/978-3-319-91337-7_22

Housing, S. (2020). *Sustainable Smart Cities Definition of smart sustainable cities UNECE standard on Smart Sustainable Cities Cities under KPI evaluation by UNECE Sustainable Smart Cities with Innovative Financing approach*. 1–2.

Huet, J.-M. (2015). *Smart cities : the key to Africa ' s third revolution*.

IBIS Transport Consultants Ltd. (2005). *Study of urban public transport conditions in Accra, Ghana*. *February*, 12. http://www.ppiaf.org/sites/ppiaf.org/files/documents/toolkits/UrbanBusToolkit/assets/CaseStudies/summy/sum_accra.html

IFC. (2017). Creating Markets in Ghana. *Creating Markets in Ghana*, *November*. https://doi.org/10.1596/30212

Imoro Musah, B., Peng, L., & Xu, Y. (2020). Urban Congestion and Pollution: A Quest for Cogent Solutions for Accra City. *IOP Conference Series: Earth and Environmental Science*, *435*(1). https://doi.org/10.1088/1755-1315/435/1/012026

Ivanova, I. (2014). Quadruple Helix Systems and Symmetry: A Step Towards Helix Innovation System Classification. *Journal of the Knowledge Economy*, *5*(2), 357–369. https://doi.org/10.1007/s13132-014-0201-z

Jackohango, A. (2010). UN-HABITAT - WORKING GROUP B Good Urban Governance: Towards an Effective Private Sector Engagement. *Governance An International Journal Of Policy And Administration*, *November 2008*, 1–15.

Jacobs, A. J. (2012). The world's cities: Contrasting regional, national, and global perspectives. *The World's Cities: Contrasting Regional, National, and Global Perspectives*, 1–397. https://doi.org/10.4324/9780203723951

JICA. (2021). *Data Collection Survey on Intelligent Transport Systems (Its) in African Region Final Report República De Honduras Secretaría De Infraestructura Y Servicios Públicos*.

Joshi, S., Saxena, S., Godbole, T., & Shreya. (2016). Developing Smart Cities: An Integrated

Framework. *Procedia Computer Science*, *93*(September), 902–909. https://doi.org/10.1016/j.procs.2016.07.258

Kallinikos, J. (2010). Smart Machines. *Encyclopedia of Software Engineering*, 1097–1103. https://doi.org/10.1081/e-ese-120044162

Kaplan, B., & Maxwell, J. A. (2005). Evaluating the Organizational Impact of Healthcare Information Systems. *Evaluating the Organizational Impact of Healthcare Information Systems, January*, 29–55. https://doi.org/10.1007/0-387-30329-4

Keeley, B. (2007). How what you know shapes your life. *OECD Publishing*, 147. http://dx.doi.org/10.1787/9789264029095-en

Kim, H. M., Sabri, S., & Kent, A. (2021). Smart cities as a platform for technological and social innovation in productivity, sustainability, and livability: A conceptual framework. *Smart Cities for Technological and Social Innovation*, *January*, 9–28. https://doi.org/10.1016/b978-0-12-818886-6.00002-2

Kitsios, F., Kamariotou, M., & Grigoroudis, E. (2021). Digital Entrepreneurship Services Evolution: Analysis of Quadruple and Quintuple Helix Innovation Models for Open Data Ecosystems. *Sustainability (Switzerland)*, *13*(21). https://doi.org/10.3390/su132112183

Konig, J., Suwala, L., & Delargy, C. (2020). www.econstor.eu. *Helix Models of Innovation and Sustainable Development Goals*.

Kozlowski, W., & Suwar, K. (2021). Smart City: Definitions, Dimensions, and Initiatives. *European Research Studies Journal*, *XXIV*(Special Issue 3), 509–520. https://doi.org/10.35808/ersj/2442

Kuzior, A., & Kuzior, P. (2020). The Quadruple Helix Model as a Smart City Design Principle. *Virtual Economics*, *3*(1), 39–57. https://doi.org/10.34021/ve.2020.03.01(2)

LaGory, M. (2014). The World of Cities. *Contemporary Sociology: A Journal of Reviews*, *33*(2), 209–211. https://doi.org/10.1177/009430610403300244

Lara, A. P., Da Costa, E. M., Furlani, T. Z., & Yigitcanlar, T. (2016). Smartness that matters: Towards a comprehensive and human-centred characterisation of smart cities. *Journal of Open Innovation: Technology, Market, and Complexity*, *2*(2). https://doi.org/10.1186/s40852-016-0034-z

Larosse, J., Corpakis, D., & Tuffs, R. (2020). *The Green Deal and Smart Specialisation*. *February*, 1–20.

Lawrence, R. J. (2010). Deciphering Interdisciplinary and Transdisciplinary Contributions. *Transdisciplinary Journal of Engineering & Science*, *1*(1), 125–130.

https://doi.org/10.22545/2010/0003

Lea, R. (2017). Smart Cities: An Overview of the Technology Trends Driving Smart Cities. *IEEE Advancing Technology for Humanity*, *3*(March), 1–16.

Lee, J., Bagheri, B., & Kao, H. A. (2015). A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems. *Manufacturing Letters*, *3*, 18–23. https://doi.org/10.1016/j.mfglet.2014.12.001

Leydesdorff, L. (n.d.). *THE TRIPLE HELIX MODEL AND THE STUDY OF KNOWLEDGE-BASED INNOVATION SYSTEMS*. 1–13.

Leydesdorff, L. (2012a). The Triple Helix, Quadruple Helix, ..., and an N-Tuple of Helices: Explanatory Models for Analyzing the Knowledge-Based Economy? *Journal of the Knowledge Economy*, *3*(1), 25–35. https://doi.org/10.1007/s13132-011-0049-4

Leydesdorff, L. (2012b). *The Triple Helix of University-Industry-Government Relations. February*, 1–17. https://doi.org/10.1109/UGIM.2012.6247096

Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The New Production of Knowledge*.

Lom, M., & Pribyl, O. (2021). Smart city model based on systems theory. *International Journal of Information Management*, *56*(January 2020), 102092. https://doi.org/10.1016/j.ijinfomgt.2020.102092

Luis, F., & Moncayo, G. (2010). *Creative Economy Report 2010*.

M. Ahumada, J., Birtill, K., Charles, A., da Silva, J., Hewitt, B., Kalra, R., Eduardo Morera, B., Nadkarny, S., Stratton-Short, S., & Waters, J. (2016). Future Proofing Cities Metropolitan cities in Ghana. *Cities Alliance*. https://www.arup.com/perspectives/publications/research/section/future-cities-africa

Maher, H., Chraiti, A., Laabi, A., Oikawa, T., & Oyekan, T. (2021). *Igniting Innovation-Based Growth in Africa*. 1–14.

Maranesi, C., & De Giovanni, P. (2020). Modern circular economy: Corporate strategy, supply chain, and industrial symbiosis. *Sustainability (Switzerland)*, *12*(22), 1–25. https://doi.org/10.3390/su12229383

Marimuthu, M., Lawrence, A., & Maimunah, I. (2009). Humanan Capital Development and Its Impact on Firm Performance: Evidence From Developmental Economics. *Journal of International Social Research*, *2*(8). http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:No+Title#0

Martins, R. M. (2017). *Impact of Colonial Legacy on Development and Innovation in Africa*.

McAdam, M., Miller, K., & McAdam, R. (2016). Situated regional university incubation: A multi-level stakeholder perspective. *Technovation, 50–51*, 69–78. https://doi.org/10.1016/j.technovation.2015.09.002

Mdf. (2005). *Indicators*, *10 p*. *March*, 10.

Mêgnigbêto, E. (2019). Synergy within the West African Triple Helix innovation systems as measured with game theory. *Journal of Industry-University Collaboration*, *1*(2), 96–114. https://doi.org/10.1108/jiuc-03-2019-0008

Mendizabal, M., Feliu, E., Tapia, C., Rajaeifar, M. A., Tiwary, A., Sepúlveda, J., & Heidrich, O. (2021). Triggers of change to achieve sustainable, resilient, and adaptive cities. *City and Environment Interactions*, *12*, 100071. https://doi.org/10.1016/j.cacint.2021.100071

Meyer, J. W., & Rowan, BrianAcland. (1977). Institutionalized Organizations: Formal Structure as Myth and Ceremony. *American Journal of Sociology*, *83*(2), 340–363. https://security.ufpb.br/gets/contents/documentos/meyer_rowan_teoria_institucional.pdf

Mineiro, A. A. da C., de Souza, T. A., & de Castro, C. C. (2021). The quadruple and quintuple helix in innovation environments (Incubators and science and technology parks). *Innovation and Management Review*, *18*(3), 292–307. https://doi.org/10.1108/INMR-08-2019-0098

Mora, L., Deakin, M., Zhang, X., Batty, M., de Jong, M., Santi, P., & Appio, F. P. (2021). Assembling Sustainable Smart City Transitions: An Interdisciplinary Theoretical Perspective. *Journal of Urban Technology*, *28*(1–2), 1–27. https://doi.org/10.1080/10630732.2020.1834831

Mottur, E. R., McBee, C., Barrington, B. L. ., & Zarechnak, I. (1978). Government Involvement in the Innovation Process : A Contractor ' s Report to the Office of Technology Assessment. *Smithsonian*, *August*.

Oduro-Marfo, S. (2015). Toward a national innovation strategy: A critique of Ghana's science, technology and innovation policy. *Innovation Journal*, *20*(3).

OECD. (2013). *Development Results: An Overview of Results Measurement and Management*. 1–8. https://www.oecd.org/dac/peer-reviews/Development-Results-Note.pdf

Okonofua, F., Odubanjo, D., Balogun, J. A., Secretary, E., & Carayannis, E. (2020). *Assessing the triple helix model for research and development in sub-Saharan Africa*. *13*(2), 1–5.

Palincas, C. (2020). *Universities as orchestrators in digital innovation ecosystems*. 2019–2020.

Paquete, T. (2016). Smart Cities - the African story. *African Cities*, *5*.

Paskaleva, K., Evans, J., & Watson, K. (2021). Co-producing smart cities: A Quadruple Helix

approach to assessment. *European Urban and Regional Studies*, *28*(4), 395–412. https://doi.org/10.1177/09697764211016037

Peek, G.-J., & Troxler, P. (2014). City in Transition: Urban Open Innovation Environments as a Radical Innovation. *Real Corp 2014*, *8*(May), 151–160.

Pereira, G. V., Parycek, P., Falco, E., & Kleinhans, R. (2018). Smart governance in the context of smart cities: A literature review. *Information Polity*, *23*(2), 143–162. https://doi.org/10.3233/IP-170067

Praharaj, S., Han, J. H., & Hawken, S. (2018). Towards the right model of smart city governance in India. *International Journal of Sustainable Development and Planning*, *13*(2), 171–186. https://doi.org/10.2495/SDP-V13-N2-171-186

Qu, S. Q., & Dumay, J. (2011). The qualitative research interview. *Qualitative Research in Accounting and Management*, *8*(3), 238–264. https://doi.org/10.1108/11766091111162070

Quashigah, K. (2010). Religion and the Secular State in Ghana. *Religion and the Secular State*, *1*, 331–338. http://www.vatican.va/roman_curia/secretariat_state/archivio/documents/rc_seg-st_19930218_s-sede-

Radziejowska, A., & Sobotka, B. (2021). Analysis of the social aspect of smart cities development for the example of smart sustainable buildings. *Energies*, *14*(14), 1–14. https://doi.org/10.3390/en14144330

Ranga, M., & Etzkowitz, H. (2013). Triple Helix Systems: An Analytical Framework for Innovation Policy and Practice in the Knowledge Society. *Industry and Higher Education*, *27*(4), 237–262. https://doi.org/10.5367/ihe.2013.0165

Razak, A. A., & White, G. R. T. (2015). The Triple Helix model for innovation: A holistic exploration of barriers and enablers. *International Journal of Business Performance and Supply Chain Modelling*, *7*(3), 278–291. https://doi.org/10.1504/IJBPSCM.2015.071600

Rincón, C. A. R., Santos, J., Volker, L., & Rouwenhorst, R. (2021). Identifying institutional barriers and enablers for sustainable urban planning from a municipal perspective. *Sustainability (Switzerland)*, *13*(20), 1–24. https://doi.org/10.3390/su132011231

Rosenlund, J., Rosell, E., & Hogland, W. (2017). Overcoming the triple helix boundaries in an environmental research collaboration. *Science and Public Policy*, *44*(2), 153–162. https://doi.org/10.1093/scipol/scw045

Sadat, M., & Kuwornu, A. A. (2017). Views from the Streets of Accra on Language Policy in

Ghana. *Journal of Education and Practice*, *8*(2), 185–192.

Sarfoh, K. O., Kavaarpuo, G., & Ayitio, J. (2016). *Affordable Housing In Ghana- Sector Study*. *November*. https://doi.org/10.13140/RG.2.2.20870.57926

Sargeant, J. (2012). Qualitative Research Part II: Participants, Analysis, and Quality Assurance. *Journal of Graduate Medical Education*, *4*(1), 1–3. https://doi.org/10.4300/jgme-d-11-00307.1

Sassen, S., & Kourtit, K. (2021). A post-corona perspective for smart cities: 'should i stay or should i go?' *Sustainability (Switzerland)*, *13*(17), 1–15. https://doi.org/10.3390/su13179988

Sgaragli, F. (2014). *Enabling Social Innovation Ecosystems for Community-Led Terriotorial Development*. www.fondazionebrodolini.it

Sharifi, A., Khavarian-Garmsir, A. R., & Kummitha, R. K. R. (2021). Contributions of smart city solutions and technologies to resilience against the covid-19 pandemic: A literature review. *Sustainability (Switzerland)*, *13*(14). https://doi.org/10.3390/su13148018

Shinn, T. (2002). The Triple Helix and new production of knowledge: Prepackaged thinking on science and technology. *Social Studies of Science*, *32*(4), 599–614. https://doi.org/10.1177/030631202128967271

Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N. (2003). Commercial knowledge transfers from universities to firms: Improving the effectiveness of university-industry collaboration. *Journal of High Technology Management Research*, *14*(1), 111–133. https://doi.org/10.1016/S1047-8310(03)00007-5

Strauss, A. L., & Corbin, J. M. (1998). Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory, 2ndedn. In *Management Learning* (Vol. 31, Issue 4). https://doi.org/10.1177/1350507600314007

Systems, F. E. (2020). *Factbook Education Systems : Ghana*. *1*.

Taratori, R., Rodriguez-Fiscal, P., Pacho, M. A., Koutra, S., Pareja-Eastaway, M., & Thomas, D. (2021). Unveiling the evolution of innovation ecosystems: An analysis of triple, quadruple, and quintuple helix model innovation systems in european case studies. *Sustainability (Switzerland)*, *13*(14). https://doi.org/10.3390/su13147582

Taylor, P., Boussen, C. R., & Awunyo-Akaba, J. (2002). Activity report 114: Ghana Urban Health Assessment. *Environmental Health Project*, 1–149.

The World Bank Group. (2019). Ghana Digital Economy Diagnostic. *Ghana Digital Economy Diagnostic*. https://doi.org/10.1596/34366

Tura, N., & Ojanen, V. (2022). Sustainability-oriented innovations in smart cities: A systematic review and emerging themes. *Cities*, *126*(August 2021), 103716. https://doi.org/10.1016/j.cities.2022.103716

Utriainen, R., & Pöllänen, M. (2018). Review on mobility as a service in scientific publications. *Research in Transportation Business and Management*, *27*(October), 15–23. https://doi.org/10.1016/j.rtbm.2018.10.005

Vijaykumar Bhatt Shantaben Manubhai Patel, B., Gandhi, R., & Bhatt, B. (2017). Factors Affecting Green Building Based Smart City. *International Journal of Advance Research in Engineering*, *4*(2), 2394–2444. https://www.researchgate.net/publication/314229574

Wang, J., Alli, A. S., Clark, S., Hughes, A., Ezzati, M., Beddows, A., Vallarino, J., Nimo, J., Bedford-Moses, J., Baah, S., Owusu, G., Agyemang, E., Kelly, F., Barratt, B., Beevers, S., Agyei-Mensah, S., Baumgartner, J., Brauer, M., & Arku, R. E. (2022). Nitrogen oxides (NO and NO2) pollution in the Accra metropolis: Spatiotemporal patterns and the role of meteorology. *Science of the Total Environment*, *803*(2), 149931. https://doi.org/10.1016/j.scitotenv.2021.149931

Wang, Y., Mairinger, W., Raj, S. J., Yakubu, H., Siesel, C., Green, J., Durry, S., Joseph, G., Rahman, M., Amin, N., Hassan, M. Z., Wicken, J., Dourng, D., Larbi, E., Adomako, L. A. B., Senayah, A. K., Doe, B., Buamah, R., Tetteh-Nortey, J. N. N., … Moe, C. L. (2022). Quantitative assessment of exposure to fecal contamination in urban environment across nine cities in low-income and lower-middle-income countries and a city in the United States. *Science of the Total Environment*, *806*, 151273. https://doi.org/10.1016/j.scitotenv.2021.151273

WIPO. (2021). Global Innovation Index 2021. In *Malaysian Science and Technology Information Centre (MASTIC)* (Issue June). https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2021.pdf

World Bank Group. (2019). Digital skills in Sub-Saharan Africa-spotlight on Ghana. *International Finance Corporation*, 1–174. www.ifc.org.

Yudono, A., Satria, D., & Erlando, A. (2019). Toward Inclusive Development Through Smart Economy in Malang Regency. *IOP Conference Series: Earth and Environmental Science*, *328*(1). https://doi.org/10.1088/1755-1315/328/1/012008

Zahl, H. A., & Reilley, E. M. (1958). Exploratory research. *Physics Today*, *11*(8), 20–22. https://doi.org/10.1063/1.3062684

APPENDIX

INTERVIEW QUESTIONS

INTERVIEW with policy experts/ government officials

- How would you rate Accra as a smart city in terms of the economy??
- How would you describe the smart people aspect of smart cities in Accra, in terms of human and social capital?
- In your opinion, is the Accra environment smart?
- How would you describe the living smart characteristic in Accra?
- Being a government expert, would you say the government provides services smartly and in what aspects?
- In the transport sector, is there a concept of smart mobility?
- In your opinion, how well is the Private sector doing to support Accra in becoming sustainable and smarter, and does it collaborate with the government?
- In your opinion, how well are Ngo's, citizens, and the media doing to support Accra in becoming sustainable and smarter? Would you say they cooperate with the government?
- How would you describe the relationship between universities & research centers and the Government?
- What is the current model of innovation being used by Ghana?
- How would you describe the current model of innovation being used by Accra, a TH, or QH?
- Would you suggest an Accra-based QH model of innovation approach?
- In your opinion, are Traditional rulers relevant in supporting Accra in becoming sustainable and smarter, and do you think they can collaborate effectively with the Government and other actors?
- In your opinion, are Traditional rulers relevant in supporting Accra in becoming sustainable and smarter and do you think they can collaborate effectively with the Government and other actors; NGO/citizen/Media, Industries, and Universities?

INTERVIEW with industry

- In your opinion, how would you rate Accra as a smart city in terms of the economy?

- How would you describe the smart people aspect of smart cities in Accra, in terms of human and social capital?
- In your opinion, is the Accra environment smart?
- How would you describe the living smart characteristic in Accra?
- Being in the industry, would you describe services, policies, and projects provided by the government as smart, and in what aspects?
- In the transport sector, is there a concept of smart mobility?
- In your opinion, how well is the Private sector doing to support Accra in becoming sustainable and smarter, and does it collaborate with the government?
- In your opinion, how well are Ngo's, citizens, and the media doing to support Accra in becoming sustainable and smarter? Would you say they cooperate with the government?
- How would you describe the relationship between universities & research centers and the Government?
- What is the current model of innovation being used by Ghana?
- How would you describe the current model of innovation being used by Accra, a TH, or QH?
- Would you suggest an Accra-based QH model of innovation approach?
- In your opinion, are Traditional rulers relevant in supporting Accra in becoming sustainable and smarter, and do you think they can collaborate effectively with the Government and other actors; NGO/citizens/Media, Industries, and Universities?

INTERVIEW with NGO/Civil Society

- How long have you been working in the media/ with the NGO?
- In your opinion, how would you rate Accra as a smart city in terms of the economy?
- How would you describe the smart people aspect of smart cities in Accra, in terms of human and social capital?
- How would you describe the living smart characteristic in Accra?
- In your opinion, is the Accra environment smart?
- How would you describe the living smart characteristic in Accra?

- Being an NGO or in the media, would you describe services, policies, and projects provided by the government as smart, and in what aspects?
- In the transport sector, is there a concept of smart mobility?
- In your opinion, what are you doing as an NGO/Media to support Accra in becoming sustainable and smarter, and do you collaborate with the government?
- In your opinion, how well are Industries doing to support Accra in becoming sustainable and smarter? Would you say they cooperate with the government?
- How would you describe the relationship between universities & research centers and the Government?
- In your opinion, is the Government making efforts to make Accra a sustainable smart city?
- How would you describe the current model of innovation being used by Accra, a TH or QH? G-U-I or G-U-I-NGO?
- Would you suggest an Accra-based QH model of innovation approach?
- In your opinion, are Traditional rulers relevant in supporting Accra in becoming sustainable and smarter, and do you think they can collaborate effectively with the Government and other actors; industry, NGO/citizen/media, and universities?

INTERVIEW with Citizens

- Do you think Ghana is using a Triple Helix or Quadruple Helix Approach? TH consists of Government, Industry, and Universities. QH consists of Government, Industries, Universities, and Media-Based Culture (media, citizens & NGO's)
- Have you heard of the phrase sustainability, and or smart city? Briefly say something about it.
- In your opinion, do you think Accra identifies as a city with a smart economy? In terms of productivity, entrepreneurship, innovativeness.
- Would you describe Accra's environment as smart? In terms of pollution & pollution measures, environmental protection, sustainable resource management.
- What would you say about the people living in Accra as smart people (human & social capital)? In terms of the level of qualification, creativity & flexibility, Open-mindedness & participation in public life.
- Would you characterize transport services within Accra as smart? In terms of accessibility, safety, availability of ICT infrastructure.

- ❖ Would you describe the residents within Accra as living smart? In terms of Housing quality, health conditions, individual safety, and educational facilities.
- ❖ How would you describe the smartness of the services, projects, and policies provided by the government? In terms of accessibility of public and social services, transparent governance, and participation in decision making.
- ❖ How would you describe the level of cooperation, collaboration, and interaction among the Government, Industries, NGOs, Media, and Universities' responsibilities in doing anything to make Accra smarter?
- ❖ How do you think the citizens are supporting or collaborating with the other actors to make Accra become smarter & sustainable?
- ❖ Would you suggest an Accra-based-QH approach towards building Accra as a sustainable smart city? Or directly apply the Westernized models to build Accra as smart and sustainable.
- ❖ Do you think the traditional authorities are relevant in supporting Accra to become sustainable and smart? Would they cooperate and collaborate with the other actors to effectively support the concept of sustainability and smartness?

INTERVIEW with Research/Academia Community

- ❖ What is the name of your university and department of study?
- ❖ Do you think Ghana is using a Triple Helix or Quadruple Helix Approach? TH consists of Government, Industry, and Universities. QH consists of Government, Industries, Universities, and Media-Based Culture (media, citizens & NGO's)
- ❖ Have you heard of the phrase sustainability, and or smart city? Briefly say something about it
- ❖ In your opinion, do you think Accra identifies as a city with a smart economy? In terms of productivity, entrepreneurship, innovativeness
- ❖ Would you describe Accra's environment as smart? In terms of pollution & pollution measures, environmental protection, sustainable resource management.
- ❖ What would you say about the people living in Accra as smart people (human & social capital)? In terms of the level of qualification, creativity & flexibility, Open-mindedness & participation in public life
- ❖ Would you characterize transport services within Accra as smart? In terms of accessibility, safety, availability of ICT infrastructure

- Would you describe the residents within Accra as living smart? In terms of Housing quality, health conditions, individual safety, and educational facilities.
- How would you describe the smartness of the services, projects, and policies provided by the government? In terms of accessibility of public and social services, transparent governance, and participation in decision making.
- How would you describe the level of cooperation, collaboration, and interaction among the Government, Industries, NGOs, Media, and Universities' responsibilities in doing anything to make Accra smarter?
- How do you think the Universities & Research Institutions are supporting or collaborating with the other actors to make Accra become smarter & sustainable?
- Would you suggest an Accra-based-QH approach towards building Accra as a sustainable smart city? Or directly apply the Westernized models to build Accra as a smart and sustainable.
- Do you think the traditional authorities are relevant in supporting Accra to become sustainable and smart? Would they cooperate and collaborate with the other actors to effectively support the concept of sustainability and smartness?

INTERVIEW with Media

- How long have you been working in the media/ with the NGO?
- In your opinion, how would you rate Accra as a smart city in terms of the economy?
- How would you describe the smart people aspect of smart cities in Accra, in terms of human and social capital?
- How would you describe the living smart characteristic in Accra?
- In your opinion, is the Accra environment smart?
- How would you describe the living smart characteristic in Accra?
- Being an NGO or in the media, would you describe services, policies, and projects provided by the government as smart, and in what aspects?
- In the transport sector, is there a concept of smart mobility?
- In your opinion, what are you doing as an NGO/Media to support Accra in becoming sustainable and smarter, and do you collaborate with the government?
- In your opinion, how well are Industries doing to support Accra in becoming sustainable and smarter? Would you say they cooperate with the government?

- How would you describe the relationship between universities & research centers and the Government?
- In your opinion, is the Government making efforts to make Accra a sustainable smart city?
- How would you describe the current model of innovation being used by Accra, a TH, or QH? G-U-I or G-U-I-NGO?
- Would you suggest an Accra-based QH model of innovation approach?
- In your opinion, are Traditional rulers relevant in supporting Accra in becoming sustainable and smarter, and do you think they can collaborate effectively with the Government and other actors; industry, NGO/citizen/media, and universities?

SUMMARY OF THE FINAL DISSERTATION

Introduction

Throughout the last decades, the introduction of Information Communication Technologies has created a trend of providing daily objects with smartness, intending to make human life more comfortable[47]. The paradigm of Smart Cities comes up as a response to the goal of building the city of the future, where (1) the well-being and rights of their citizens are guaranteed, (2) industry, and (3) urban planning is assessed from an environmental and sustainable perspective. (Sa'nchez-Corcuera et al., 2019). In 2020, Accra won the grant of the International Business Machines (IBM) Smarter Cities Challenge, but there is still a lot to be done in terms of equality, inclusion, diversity, social justice, as well as in terms of technology including the aspect of intelligent energy, smart citizens, smart health, and other technological dimensions despite this achievement[48]. This problem might emanate from not recognizing the importance of conceiving the city as a complex system and therefore the role actors different than governments and private companies play in the game, especially citizens, knowledge institutions, and non-governmental organizations (Frey et al., 1985). The Quintuple Helix Model of Innovation codifies the principles, tools, and processes of collaboration amongst five actors, thus, government, industry, universities, media-based culture and the natural environment, the various roles they play, and how they interact, might contribute to the development of an inclusive, sustainable, smart, climate-neutral city. The study is motivated by the need to understand if and how the relationships and forms of cooperation between the actors and interests that make up the quintuple helix of innovation model can be applied in African cities and whether they can help transform Accra into an inclusive sustainable smart city. In addition, it will serve as a guide to policymakers in Ghana on how to implement smart innovation, sustainability, and climate neutrality in all aspects of development. A literature review on the Quintuple Helix of Innovation and sustainable smart cities reflects increasing research on both developed and developing cities. This illustrates that the findings acquired will play a crucial role in addressing the gap and serve as a guide to policymakers in Ghana on

[47] https://www.pewresearch.org/internet/2019/10/28/4-the-internet-will-continue-to-make-life-better/

[48] https://www.thesmartcityjournal.com/en/articles/smart-city-accra-ghana-gold-coast

implementing smart innovation and sustainability in all aspects of development. Generally, studies look at the smart city initiative with Africa in focus, yet this study would consider one city, that is Accra, and carefully analyse measures that are being put in place to build it as a smart city. The study would also look at how to incorporate political, social, and economic elements with institutional and policy frameworks necessary to make the city of Accra a role model of an inclusive sustainable smart city for other African countries.

The quintuple helix of innovation is an innovation method which comprises of the government, universities/academia, industries, media-based culture (media, citizens, NGOs) and the natural ecosystem and was developed from previous helices namely the Triple Helix and Quadruple Helix of innovation. The triple helix exposes the relationship or interaction between the government, industry, and universities whereas the quadruple helix discusses the interaction between the government, industry, universities, and media-based culture which consists of citizens, media and non-governmental and or civil society organisations. The origin of the TH cannot be presented without mentioning Knowledge-based Production Systems featuring Mode 1 and 2. Mode 1 is characterized by a separation between science and society. Science is about an autonomous university, self-defined and self-perpetuating scientific disciplines and fields, and the determination by scientific peers of what counts as science and truth and what does not, which is why there is supposedly no interaction between science and industry (Shinn, 2002). Mode 2 is the direct opposite of Mode 1. In contrast to Mode 1, Mode 2, which was coined by Micheal Gibbons and other scholars in 1994 goes beyond traditional knowledge production and is more heterogeneous and distributed across networks that are not tied to traditional research institutions. It is transdisciplinary, contextual and uses practice-based problem solving enabled by different types of networks, and focuses on the integration of academic and other relevant factors that have been ignored in the technological and scientific field (Rosenlund et al., 2017). The quadruple helix (QH) is an extension of the triple helix of innovation and emphasizes academia/university, industry, state/government, and adds the fourth helix, which is recognized as twofold, i.e. the "media and culture-based public" and civil society. It emphasizes that a broader understanding of knowledge generation and application requires public participation in sophisticated innovation systems. Both the triple and quadruple helices were criticized by other scholars indicating that since they did not factor in the natural environment, it is insufficient. Therefore, in 2010, Carayannis and Campbell created the Fivefold Helix, composing of political, educational, economic, environmental, and social

systems. Each helix represents a knowledge subsystem that is spirally connected to the other systems, which in turn have a national, regional, and global reach (Barcellos-Paula et al., 2021). This helix aims to enable a place-based and triply profitable pioneering process of discovery followed by intensive experimentation and high quality and quantity of sustainable and social innovation (Carayannis et al., 2018). The utmost difference between the previous helices and the QH is its ability to provide a clear development strategy and serve as a framework for transdisciplinary, cross-cutting analysis of sustainable development (Limoges et al., 1994).

It was during the wave of sustainable development that worldwide societies saw the need to begin building instruments and indicators to assess sustainability, so the QH is seen as one of these emerging tools (Chen, 2015).

Review of literature further reveals that the historical trajectory of innovation has always been associated with the European Union, North America, and lately, the Asian continent as they transition from the initial triadic thesis to a more integrated, internationally orientated perspective (Limoges et al., 1994). Though not explicitly seen in the westernised description of innovation, Africans have also been characterized as innovative and good with adaptation before colonial times according to Erik Green, who writes on Production Systems in Africa, because of the low population density and other factors, a flexible production system existed, and institutional regulation was favorable because the family system was in use (Green, 2013). But because of colonization and slavery, most of these societies have been destroyed[49] (Agbontaen-Eghafona, 2019). Notwithstanding the challenges the continent is facing, it has managed to pick up its pieces and is moving with speed. Considering the speed that the continent is moving with, it has noted a trend and finds it beneficial as well, thus the concept of smart cities which per the "Digital Agenda for Europe," a city must meet a criterion and possess certain characteristics or qualities following review to be classified as smart. As a result, this definition is revealed, with six qualities linked with it based on various works of literature and a round-table discussion. They are smart economy, smart people, smart governance, smart mobility, smart environment, smart governance (Giffinger, 2010). Giffinger and Gudrun further explain that the characteristics are not the only thing that goes into making a city smart, but that they also have elements and indicators inherent in them. A collection of connected indications has scientifically determined every smart characteristic factor; hence

[49] http://www.pass.va/content/scienzesociali/en/events/2019-23/family_ecology/agbontaen-eghafona.html

these factors have been identified, counting as 31. For incorporating and collecting the relevant components, 74 indicators have been defined and employed (Giffinger, 2010). Theories have conceptualised smart cities from different perspectives but the city as a common's perspective is highlighted here. The intention of the city as a common's is to alter the city's democratic and economic functioning shifting it to establish a city that better serves the needs of all of its people, but also to recognise the trend of huge urbanization and the fact that cities are increasingly becoming the focal point of political life. It focuses on urban collaborative governance which is a system that redistributes decision-making power and influences a more involved population, not just the State authorities. The facilitator state establishes the environment for residents to form collaborative connections with one another and collaborate with public authorities to protect common resources, including the city itself as a resource (S. R. Foster & Laione, 2016).This is more aligned to the quintuple helix of innovation that is the focal point of the study and is recognised by Lab.Gov as the urban commons and the public, private, knowledge, social sectors[50], therefore upholds the concept of the study. The city as commons concept further exposes the factors that influence the building of smart cities using the design principle as authored by Forster & Iaione. It is briefly exposed below;

Factors that influence the building of Smart cities (The Design Principle)

In both advanced and emerging economies, there is a steady migration of people into cities, resulting in high resource consumption and disadvantages ranging from pollution to an increase in social vices. Some authors have termed it as "factors", others call them the" driving force", while some also call it "enablers". Forster & Iaione call it the design principles and they are elucidated as:

Collective Action/ Collective governance : This is also termed Principle 1 by Forster & Iaione as the presence of a multistakeholder governance scheme in which the community emerges as an actor and partners (through sharing, collaboration, cooperation, and coordination) with four other possible categories of urban actors in a loosely coupled system (S. Foster & Iaione, 2017).

[50] https://labgov.city/commonspress/the-co-city-cycle/

An enabling State or Principle 2 expresses the involvement of the state (typically local government) in enabling the construction of urban commons and supporting collective governance systems for their administration and long-term viability; and in addition to doing what it does best, government should assist individuals, families, and communities in doing what they do best. This is seen in three key dimensions; thus, seeing and engaging in people's lives on the round, Involving governments and public agencies are considering how they might support people who require assistance to maintain as much control over their lives as possible and to progress in small steps (Elvidge, 2012).

Social and Economic Pooling/Principle 3 refers to the presence of specialised institutions (e.g., civic, financial, social, economic, etc.) that are accessible, socially inclusive, and controlled or operated local communities functioning within quasi economic structures (e.g. cooperative, social and solidarity, circular, cultural, or collaborative economies, etc.) that pool resources and stakeholders, resulting in the creation of new opportunities (e.g. jobs, skills, education, etc.) and services (e.g. housing, care, etc.).The variable highlights social elements that drive smart city development. To begin, these considerations analyse the smart city's social component, describing its four key aims as follows: a) development of human capital, which includes building intellectual capital and creating knowledge, as well as enhancing the position of the resident (aware, educated, and participating); b) social capital development, which involves long-term social progress and information literacy; (S. Foster & Iaione, 2017) c) changes in behavior, such as a sense of cause and value, as well as a sense that all residents are co-owners and accountable for their city; d) implementing technology that reacts to users' needs, talents, and interests while respecting their diversity and individuality is the social dimension (Radziejowska & Sobotka, 2021). Batt & Pitroda identifies poverty, demographic changes, recreational and cultural facilities, smart people, safety, security, social cohesion, and immigration friendly environment as social elements (Patel et al., 2017).

Experimentalism or Principle 4 is an adaptive, place-based, and iterative method to designing legal and policy changes that support the urban commons with an intention to position it with the concept of sharing and sustainability (S. Foster & Iaione, 2017). Therefore LabGov.city has gone ahead to conduct some experiments in both Italian cities and others and this experiment led to an approach being introduced called the C-City Cycle-this is a policy cycle

in which interested cities or single actors work together to test a commons-based strategy to any urban challenge and apply it to a variety of urban assets and services[51].

Africa is no longer left out of the smart city concept; like Kenya and South Africa are both taking steps to improve a variety of areas of their capital cities to satisfy smart town requirements per *The Smart City Journal*. Accra being the capital of Ghana is additionally one of the best places to put into effect smartness for other cities both in Ghana and beyond to replicate. Ghana is one of the sub-Saharan African countries amid rapid urbanization and this has largely bought into the concept of the right to the city and inclusive urbanization, as reflected in national policy. Indeed, Ghana's national policies emphasize urban renewal and the upgrading of slums and other informal settlements, as well as the promotion of the urban informal economy, such as the National Urban Policy Framework (NUPF) and Action Plan, 2012; National Housing Policy (NHP), 2015; National Spatial Development Framework (NSDF), 2015-2035; and other related national-level policies (Crentsil & Owusu, 2018). It is with no doubt that Accra received the IBM Smarter Cities Challenge grant in 2014, funding that would aid in the city's social and infrastructural development. Accra is one of the four African cities picked from a total of 33 candidates. The IBM Smarter Cities Challenge, which began in 2014 and is funded by IBM, is a three-year, $50 million initiative in which IBM sends teams of experts from various disciplines to cities to help them formulate strategies for improving the quality of life for their citizens, using ICTs as a driving tool (Eduam, n.d.).[52] Ghana is also one of the first 10 countries that willingly expressed interest in the Smart Africa initiative (The World Bank Group, 2019). The Ghanaian government launched the National Urban Policy Framework and Action Plan on March 28, 2013. The Policy highlights the difficulties of urbanization as well as the efforts that will be taken to meet the goals set out to address the issues in all the cities, especially Accra as the capital. Limited data and information on urban centers; environmental deterioration; insufficient urban infrastructure and services; rising urban insecurity; and poor urban transportation planning and traffic management are just a few of the issues faced in the city(Appiah, 2019).

Accra has minute aspects of the various characteristics of a smart city, thus, smart economy, smart governance, smart transport, smart environment, smart living and smart people and the

[51] https://labgov.city/commonspress/the-co-city-cycle/
[52] https://www.thesmartcityjournal.com/en/articles/smart-city-accra-ghana-gold-coast

intention of the study is to examine these characteristics and analyse aspects where Accra does not meet up, to investigate the current approach of innovation being used to build Accra as a sustainable smart city and analyze whether all the relevant actors collaborate in their responsibilities toward building Accra as a sustainable smart city. To make the study more exploratory, it discusses ongoing smart projects within the city, thus, the Ga Mashie Aerobic Waste Compost and the Accra Climate Action plan, its relevance, shortcomings and recommendations.

Thus, to gather relevant data, the qualitative research approach which is exploratory in nature was utilised to provide meaningful description and experience of the concept of smart cities in the context of Accra. Various secondary sources such as information from international organizations, conferences, books, journals, reports and internet sources of smart cities, sustainability, both the previous helices and the quintuple helix, especially in the case of Africa and Accra in Ghana were reviewed. Dealing with secondary data alone could not have been enough to draw valid conclusions for the study so primary data source was also adopted with participants with participants being categorised into policy experts, personnel from the industry, universities/research institutions, media, NGOs and citizens to support answering the question.

The research question posed is "Could collective action, self-organization, and technology that enables self-sustainability, social norms & informality be the recipe that African cities and in particular Accra adopt and contribute to the global quest for smartness and sustainability in cities?"

Findings

Data Analysis Process using the thematic network analysis approach

Codes	Basic Themes	Organizing themes
…the quadruple helix of innovation approach …its an all-inclusive government and successive governments have proven the same	Accra uses the quadruple helix of innovation approach	

...Accra's economy is not smart …entrepreneurship is bad …there is no existence of technology in productivity …the responsibility for life or death can be heavy on you	Accra's economy is not wholly smart	Productivity Entrepreneurship Innovative Spirit
… Accra is stuck with the archaic way of doing things …there is no transparency in governance … policies and projects do not better the lives of average Ghanaians …public administration benefits from everything while the private sector struggles to get these …it is fairly smart …certain aspects of public and social services have become smart recently	Governance in Accra is not wholly smart	Transparent Governance Public and social services Participation in decision making
…there is an influx of real estate, but they are expensive …real estate is for the rich, not for the average Ghanaian who earns an average income …the best hospitals are in Accra, but they lack facilities and personnel … individual safety varies in the various neighbourhoods and the individual as well …	Living smart in Accra varies	Housing conditions Health conditions Individual safety

…we are nowhere close to smartness …pollution in Accra is massive … both human and raw materials in Accra need sustainable management	Accra is not a smart environment	Lack of pollution of natural resources, sustainable resource management, environmental protection	
…people in Accra are way smarter than before …there has been an increase in the literacy rate recently …people in Accra live by a plan which defines them as smart	People in Accra are smart	Level of qualification, flexibility &creativity, open-mindedness	
…cannot be characterized in any way as smart …lacks basic transport technologies …some of the roads are poorly maintained making them unsafe …. Easily accessible but expensive when using the private ones such as uber, bolt and taxis …just a minute aspect of technology is seen	Transportation in Accra is not smart	Accessibility ICT availability safety	
…both work hand in hand to achieve a common goal …collaboration exists but it is not constant, it is slow and not steady …private sector collaborates more …media is doing an excellent job nowadays …universities and research institutions are doing a lot of research, but they are not being applied in practical life	Existence of collaboration		

…citizens need to put in more effort, especially in their actions	
…nothing foreign has ever benefitted us, the best way is to use our own model … as far as the ecosystem is concerned, let's adopt this approach …this approach will be relevant for all sectors of the economy … let's adopt the impactful part of the western world strategy	Use of Accra-based QH approach is recommended to Accra
…they are a direct link to the people …they are extremely relevant because Ghana and Accra is ethnic-centred …they are the mouthpiece of the local people …they will easily participate if their people stand to benefit …because they are powerful and highly respected	Traditional authorities are relevant

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Accra, according to the research, employs both the triple and quadruple helix interchangeably, however the Quadruple Helix of Innovation is the most common innovation approach because all four helices or participants mentioned within the model play important roles in Accra. Accra's development and innovation process is influenced by industry, government, universities, and a media-based society.

The six attributes of a sustainable smart city were examined in this research, and Accra was found to meet some of them using Giffinger's variables and indicators. Because there is no defined assessment for comparing or grading smart cities, it can be argued that Accra satisfied the indicators for the smart economy, which include innovative spirit, entrepreneurship, and productivity but not wholly. It lacked in aspects of entrepreneurship and productivity.

Transparent governance, participation in decision-making, and public and social services have all been identified as indications of smart governance, and it has been suggested that the government, both local and central could do more. Public participation in decision-making was found to be insufficient and not sufficiently people-centered, and transparent governance was evaluated as very low. Transparent governance was regarded as weak, participation in decision-making was lacking and not sufficiently people-centered, and public and social services were there but insufficient. It was therefore concluded that governance in Accra is not wholly smart.

The markers for smart people were their level of qualification, flexibility and innovation, and open-mindedness. The level of qualification was high and continued to rise at a significant rate, inhabitants of Accra displayed flexibility and innovation, although much more could be done, and they were very open-minded in all aspects. Regardless, there was still potential for development indicating that

As indicators, the smart environment characteristic focuses on the lack of pollution of natural conditions and pollution, environmental protection, and sustainable resource management. Accra failed in every way for this feature. As a result, it was agreed by the respondents that Accra's environment is not smart.

Individual safety, health conditions, housing quality, and aspects of cultural and educational amenities were all part of the smart living concept. According to this approach, Accra needs emerging technology in industries relevant to these variables. Individual safety was relative because it depended on the individual's community or constituency, and most of these technologies were missing under health conditions. Housing quality varied by community and municipality, with some areas of Accra meeting the standards while others did not. When it comes to cultural and educational amenities, these were deemed plentiful, and most tourists visited them more than Accra locals. As a result, the notion of smart living is was indicated as varying since it is subjective per communities, income generated and other factors.

As indications, the smart transport characteristic looked at the availability of ICT infrastructure and sustainable, innovative, and safe transportation methods. Although it was determined that Accra's transportation system was innovative, and several of Accra's transportation systems were privately owned, with only a few being publicly owned. This quality was subjective because ICT infrastructure was present in the privately owned transportation system. In such situation, the trait matched the criteria in some respects but fell short in others, making it minor. As a basis, the "smart trotro system" was endorsed by respondents. In Accra, the "trotro" system exists, however it is inefficient in most circumstances. As a result, the "smart trotro system" is required for the development of a smart transportation system in Accra. The finding therefore indicated that Accra's transport system was not smart.

The study's findings revealed that the numerous players collaborated and that a multi-stakeholder approach to innovation was evident. There was a need for more engagement, cooperation, and collaboration between various groups. Traditional authorities also had to be included because they were a key stakeholder in the development and innovation process and backed policies and initiatives in several ways. In that sense, people needed to be a part of the creative process if Accra was to become a sustainable, climate-neutral smart city.

Specific Recommendation for the Transport Sector in Accra

From the findings of the study, one key issue that was constantly mentioned was transport and waste management in the aspect of smart environment but the smart trotro system will be discussed here. Some respondents suggested a smart public transport system which may take years to construct. They therefore suggested that the current commercial buses can be transformed into a smart public transport system and the suggestions are briefly discussed below;

Smart Trotro System in Accra

The "Trotro" system is Accra's principal mode of transportation, carrying 70-75 percent of the city's people to and from their destinations. It is monopolized, held by private persons and groups, and is termed as informal due to the lack of structural and formal procedures. Almost all respondents propose formalizing the "trotro" system by incorporating emerging technologies to make it safer, more convenient, and more comfortable, as simply being

registered and governed by the GPRTU is insufficient. The smart trotro system is an innovative system that Accra is proud of, as the train, bus, and other public transportation systems have all failed miserably over time. The Mobility as a Service concept needs to be explored for a smart "trotro" system. This should not just entail the use of smart technologies, but also a holistic approach to the "trotro" system. Among them are:

Incorporating Mobility as a Service (MaaS) technology into the Trotro System: Mobility as a service aims to integrate various modes of transportation into a single platform, using the concepts of digitization and technology to reduce the number of privately owned vehicles while also ensuring sustainability (Utriainen & Pöllänen, 2018). Technology-based solutions from the MaaS function as avenues to provide improved regulation of the "trotro" service to develop a long-lasting and effective "trotro" system. If Accra can structure this concept successfully, it will benefit transportation operators, regulators, commuters, and many other cities that employ the paratransit system can learn from it.

Acca is also encouraged to formalize the trotro system through capacity building and literacy initiatives, create a database for the transport authority as a whole and ensure that drivers' health status are constantly checked and monitored by the authority.

Conclusion

Accra is suggested to learn about collective action among the numerous actors, self-organization and self-sustaining technology, social norms, and informality with formal frameworks in order to become more sustainably smart. Smart cities are the current trend, and countries worldwide are changing from normal-smart cities to sustainable smart cities. The study suggests that Accra uses the Quintuple Helix of Innovation, which considers five major actors: government, industry, universities and research institutions, media-based culture (NGOs, citizens, and media), and the natural environment. It identified that smart living varied among the communities in Accra. Ghana's government, industry, universities and culture are all stakeholders in building Accra as a sustainable smart city. In ensuring that the sustainable development goals are met, the players need to interrelate, inter-collaborate and interact more. This will help speed up the process of Accra to become smart and sustainable. Accra is advised to formalize the transport sector with regards to the trotro system as well as introduce the Mobility-as-a-service concept. Traditional authorities need to be considered as important in assisting Accra's transformation into a sustainable, climate-neutral, smart city.