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An Evaluation of Developing Smart Cities in Developing Countries – Challenges and Opportunities: A Systematic Literature Review

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ABSTRACT
The implementation of smart cities globally has been the subject of literature review since the twentieth century. However, the smart city concept has only become topical in the twenty first century, particularly in more recent times. While a lot of cities in developed countries have forged ahead with the implementation of smart cities, the same cannot be said about developing countries. Following the 2015 launch of the UN Sustainable Development Goals (SDGs), among the goals the development of smart cities across the globe, many countries have stalled on the achievement of this specific goal. The 2019 covid pandemic halted the development of smart cities while for those cities that have survived the epidemic, starting the smart city programmes that may have been started before the epidemic has proved a daunting task. This study looks at the challenges and opportunities developing countries have been faced prior to and after the covid pandemic. A systematic literature review was undertaken to consider the said challenges and opportunities, particularly in developing countries. The review has revealed that other problems like climate change have changed the development focus to the extent that smart city development agenda has been hurt and pushed aside. It is evident that the enthusiasm demonstrated in mid-1915s up to 2019 has waned. Any take-up of this programme will require concerted global effort to succeed.

Keywords: Smart City, Digital Twin, Sustainable City, SDGs, smart economy, smart mobility, smart governance, smart environment, smart living and smart people

I. INTRODUCTION

A. UNITED NATIONS (UN) SUSTAINABLE DEVELOPMENT GOALS (SDGs) VS. SMART CITIES

Although the concept of smart cities was mooted in the 60s and popularized in 2010, it is the UN Sustainable Development Goals (SDGs) that were approved in 2015 and published in January 2016 that gave global prominence to the concept. Totaling 17, the SDGs addressed various aspects of human life **[1]** with SDG Number 11 particularly speaking to the development of smart cities worldwide. The Sustainable Cities and Communities SDG Number 11, directly addresses the need for countries to develop smart cities by the year 2030. Since then, countries across the globe have been striving to attain this challenge. The market size of the global smart city industry is set to double, from $410.8 billion in 2020 to $820.7 billion by 2025 **[2].** It is predicted that smart cities will generate $20 trillion US Dollars by 2026 in economic benefits **[3].** According to Mohanty et al, about 60% of the world's population is expected to live in urban areas by the year 2030. A UN study, also projects that the world will have 10 million people inhabiting a megacity of approximately 43 megacities, and most of these will be in developing regions **[1].** A difference in the rate of development and of attaining the smart cities' goal has been noted between developed countries and developing countries. Developed countries are way ahead in attaining the said goal and will more likely have attained much of the other SDG goals by 2030. The opposite is likely to be the case for developing countries. While the factors affecting the development of smart cities in all countries are numerous, it is the recent covid-19 pandemic that affected the whole world which added another dimension to the challenges of the development of smart cities in developing countries. Although covid-19 affected the developed world more that the developing world, the development of smart cities in developing economies has been more negatively impacted upon in comparison to the effect on developed countries. This has led to the developing countries lagging in the development of smart cities.

This research paper looks at the barriers to the development of smart cities in developing countries and the opportunities for development therein. A lot of literature which considers smart cities from a developed country viewpoint is available but not much has been written on developing countries. This paper will attempt to consider smart cities in developing countries as well as consider the factors that could lead to the successful development of smart city status in these developing

B. RESEARCH PROBLEMS

This research addresses the following questions: What is a smart city and what are the major characteristics of a successful smart city? What factors have led to the fast growth of smart cities in developed countries in comparison to developing ones? What are the challenges of developing smart cities in developing countries? What are the opportunities for developing smart cities in developing countries?

C. RESEARCH AIMS AND OBJECIVES

The purpose of this research paper is to review the challenges faced by developing countries in developing smart cities, which challenges have led to disparities in the levels of smart city development between developed and developing nations. In addition, the paper considers the opportunities that could

arise from the development of smart cities. The research question for the research is therefore "What are the major challenges hindering the development of smart cities in developing countries and what opportunities exist to overturn this trend?"

Arising from this question, the objectives of the research are as follows:

a) To define a smart city in the light of the various definitions available:
b) To describe the main pillars or characteristics of a typical smart city:
c) To evaluate the success factors in the development of smart cities in developed countries:
d) To compare smart city success factors in developed and developing countries:
e) To review the challenges facing developing countries in developing smart cities:
f) To review the opportunities arising from implementation of smart cities:
g) To recommend the way forward for positive development of smart cities in developing countries.

D. IMPORTANCE OF RESEARCH

This paper is of particular importance to developing economies as it will assist them to map out an appropriate strategic approach to speedy development of smart cities in their countries for the benefit of their citizens. The basis of the study is literature published since 2010. Various countries in developed and developing economies will be reviewed but for purposes of this study, these will be limited to 10 developed and 10 developing countries. This does not however preclude reference to other countries not in the selected groups. The concept of smart city in this paper will mainly be the one given by the United Nations, to the exclusion of that given by other institutions or authors.

E. METHODOLOGY

A systematic literature review method was used to collect the literature alluded to in this paper. A six-step method was used;
i) literature search protocol design; several databases were explored and the major one selected was that via Google Scholar. Springer and Science Direct databases were also used.
ii) literature search; the literature searched for was hat which dealt with challenges and opportunities of the development of smart cities, with particular emphasis on developing nations.
iii) screening; Selected literature was screened and eventually narrowed down to 125.
iv) synthesis; this stage left the relevant literature at 95.
v) analysis; during this stage, some literatures were further discarded, leaving the final 58.
vi) reporting; this report is the result of the reporting stage. The first three steps dealt with finding and gathering data, and the last three dealt with using the said data for theoretical and empirical contributions.

In addition, a case study approach was adopted for the selected developed and developing smart cities, with a comparison being made of the success factors between them.

F. INCLUSION AND EXCLUSION CRITERIA

As alluded to above, the literature examined for this paper are between 2010 and the present times. All other literature outside this date range has been excluded. Literature particularly dealing with smart city characteristics, challenges and opportunities were considered relevant to the paper. Further, in examining success stories of smart cities, papers detailing such success stories were examined and related to smart cities in developing countries. Success stories were limited to 10 cities – developing smart cities considered were largely from Africa but a few were from other continents.

II. RELATED WORK

A. DEFINITIONS OF SMART CITY

As already alluded to above, the smart city concept was coined in the 60s. There is however no universally accepted definition of the concept of a smart city. Over the years, various authors have attempted to define the term but none of the definitions have been universally accepted. The diversity of definitions of a smart city range from *"what elements a city needs to encompass to be deemed as smart, to what resources it needs to employ, what characteristics it needs to present and what are the smart city's goals, purpose, and scope"* **[4],** depending on the person using the term, to definitions for example by a policy maker or a city developer, whose definition of smart city may differ, ultimately creating some ambiguity in the understanding of the term. In recent years the concept of city sustainability has taken root in the definition. This type of definition is in line with the UN SDG 11 which emphasizes sustainability. Below, we look at some of the definitions that have emerged over time, given by different authors and we then narrow down to the definition used in this paper.

The UN SDG 11 states that citizens should have adequate, safety and affordable housing and basic services with upgraded slums by the year 2030 **[5].** Read on its own, SDG 11 does not appear to address issues of smart cities. The UN however elaborates the SGD 11 by emphasizing the need for smart cities to continue to thrive and grow while improving resource use and reducing pollution and poverty at the same time. This would result.in cities of opportunities for all citizens, with access to basic services, energy, housing, transportation and more. (ibid). It is the related targets and indicators in this statement that give rise to smart city development. The UN defined 10 Targets and 15 indicators for SDG 11. Of the 10 Targets, the following directly point to the development of smart cities:

Target 11.3 - Inclusive and sustainable urbanization:
UN definition: "*By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries*."
Target 11.6 - Reduce the environmental impacts of cities:

UN definition: the definition speaks to the management of the environment, including air quality and municipal and other waste management.
Target 11.7 - Provide access to safe and inclusive green and public spaces:
UN definition: the concern of this target is the provision of the green environment, particularly for women, children, older persons, and persons with disabilities.
Target 11.A - Strong national and regional development planning:
UN definition: this target aims at supporting positive economic, social, and environmental links between urban, peri-urban and rural areas. This is expected to be achieved by the strengthening of national and regional development planning.
Target 11.C - Support least developed countries in sustainable and resilient building
UN definition: "*Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials*."
The International Telecommunication Union (ITU) alludes to a smart sustainable city as one that uses information and communication technologies (ICTs) and other means to improve citizens' quality of life, efficiency of urban operation and services, and competitiveness. Such a city should additionally meet the needs of present and future generations with respect to economic, social, and environmental aspects. **[6].** The emphasis of this definition is the use of Information technology to improve the social well-being of the city's residents.
The European Union defines a smart city as: *"A Smart City is a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business"*, **[7]**. Harrison and others in 2010 defined a smarter city in terms of infrastructure, a city connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure with a view to leveraging the collective intelligence of the city **[8].**
Estevez and friends define a smart city by looking at what smart cities should achieve. They argue that traditional urban development tends to manage urban infrastructure systems in silos which smart city initiatives can assist to overcome. The siloed systems are related with poor information sharing between systems, functions, and stakeholders, considered as citizens, businesses, government, and civil society organizations in a smart city. Smart City initiatives are seen to leverage data and services offered by digital technologies, such as cloud computing, open data sets, or the Internet of Things. This helps to connect city stakeholders, improve citizen involvement, offer new or enhanced existing services, and provide context-aware views on city operations. The resulting city-wide digital infrastructure helps to integrate different urban infrastructure systems including energy, water, sewage, or transport, and enable efficient management, control, and optimization of such systems. **[9]**. This definition also clearly pinpoints the use of information technology and related innovation in building smart cities.
Another definition of smart used by several authors alludes to smart cities as all urban settlements that capitalize on digital technologies to enhance livability, workability, and sustainability. Such a broad definition is part of a growing smart cities' narrative with the long-term goal of sustainable urban development **[10] [11] [12]**.
A recently suggested definition by Toll and Murtagh [4], is" *Smart city is a concept of urban transformation that should aim to achieve a more environmentally sustainable city with a higher quality of life, that offers opportunities for economic growth for all its citizens, but with respect to the particularities of each locality and its existing inhabitants*".
A lot more definitions exist. A close examination of all these definitions however point to the need of three things that a smart city should possess, deployment of smart information technologies for innovation, sustainable development, and social improvement of residents. In the light of these, many and more definitions are recognizing the need for these three elements to be present in a smart city. The definition used in this paper will be that of a sustainable smart city given by the ITU, which has been alluded to above. Such a smart sustainable city is an innovative one that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness. The city meets the needs of present and future generations with respect to economic, social and environmental aspects **[6].** This definition is inclusive and also rhymes with the requirements of the SDG 11 of the UN.

B. SMART CITY DEVELOPMENT APPROACHES

While the basis of the development of smart cities is the UN SDGs, there are different approaches that have been taken by different countries and cities. Kim and Kent **[13]** point to five main approaches to smart city development, these being, Technological perspectives, Institutional perspectives, Problem-solving perspective (I) - Natural disasters, Problem-solving perspective (II) - Energy alternatives and the SDGs, Comprehensive exemplar approach and Planning system perspectives. The technological perspectives approach emphasizes the adoption of Information Communications and Technology (ICTs) as a basis of a smart city. The institutional perspective approach considers institutional support as pertinent to smart city development. Three issues pertain to this, firstly that the presence of "smart urban development" institutions with a view to achieving the Sustainable Development Goals (SDGs) could actually lead to the development of a smart city despite weak technological input. Secondly, institutional backups tend to be perceived as barriers to technological development which in turn would lead to smart cities not being realized due particularly to possible loss of jobs arising from automation. However, the revolution of institutionalization can also be considered a driver to promoting technological innovation and hence to the realization of a smart city. Some cities in Australia and Glasgow in UK have evolved into smart cities based on the

institutionalization approach, with deliberate policies being put in place.

There are two problem-solving approaches to smart city development based on whether a city is prone to disasters or to energy problems while considering the attainment of SDGs. The Great East Japan Earthquake in 2011 and the declining population size and aging population in Japan are issues that drive smart city discussions in that country. Issues of energy security have been identified as key in turning the Fujisawa and Hamamatsu into Fujisawa Sustainable Smart Town **[14] [15] [16]**. Attaining SDG 11 also implies the attainment of SDG 7(renewable energy) and SDG 9 innovation and infrastructure.

The Comprehensive Exemplar approach means that the smart city should develop with the following areas in unison: mobility, health care and public safety, education, energy and environment, governance, culture and shopping and employment. These areas need to be supported by technological innovation. The Planning System Perspectives approach emphasizes urban planning as influencing smart city development. Kim and Kent **[13]** refer to the growing dominance of neoliberalism as influencing planning regulations. This has influenced the pace, form, and direction of urban development and therefore smart city development. The approach speaks to the involvement of government, nongovernment, and city residents in the planning for a smart city.

In recent times, a new approach to smart city development has been coined, dubbed digital twins' approach. Deren et al **[17]** define a digital twin as one which simulates processes – it makes full use of physical models, sensors, historical data of operation with a view to integrate information of multi-discipline, multi-physical quantities, multi-scale, and multi-probability. Implied in the definition is big data which is collected in virtual space. This is but one of the definitions yet to be universally agreed upon regarding a smart city. Generally, physical entities, virtual models, data, connections, and services are the [18] **[19]**. Although the concept of digital twins was initially related to industries of product and manufacturing design, and later to the aerospace industry among others, the concept has nowadays been used in relation to smart cities. This is because the concept combines dynamic digital technology and static 3D model **[20]**, elements which assist smart city construction. Boschert and Rosen **[21]** define a digital twin as *"a linked collection of only the relevant data and models. The models that make up the digital twin are specifically designed for their intended purpose."* This is relevant to smart cities as the intended purpose in this definition is achieving SDG 11.

C. CHARACTERISTICS OF SMART CITIES

Despite the lack of universal agreement on the definition of a smart city, a lot of literature alludes to the framework of smart cities being built upon specific Pillars. Sujata, Saksham, Tanvi and Shreya **[22]** came up with six pillars upon which a smart city should be hinged, these being Social, Management, Economy, Legal, Technology and Sustainability. This is viewed in some literature as the SMELTS framework of smart cities (short for Social, Management, Economy, Legal, Technology and Sustainability). They argue that the social conditions of a country's citizens are an intricate part of a smart city and that ignoring such conditions cannot result in a smart economy. E-Governance as part of management is considered a major pillar for a successful smart city, including within it, politics, public policy making, citizenry services, among other issues. The economy is seen to be a major driver of smart cities and entails entrepreneurship, trademarks, innovation, productivity, and flexibility of the labour market apart from the integration of these in the national and global market. Other services falling under the economy pillar include smart businesses – these are made up of citizens system, business and transport system, services system, communication system, water, and energy system. It goes without saying that cities cannot be said to be smart without adherence to some legal provisions which are made by local authorities as well as governments, both of whom have a large stake in smart cities. Technology is considered a major driver of smart cities, without which the concept of smart cannot be achieved. It is argued that *"Smart cities must exploit information and communication technology to increase sustainability and improve quality of life for the citizens*" **[23]** through innovation. The concept of sustainability emanates from the United Nations and is considered one of the bedrocks of smart cities. The term refers to the ways of economic and social development in a city without disrupting the environment. Sustainability can be categorized into social, economic, and environmental sustainability. In some literature the concept of smart city and sustainable cities are distinguished **[24] [25]**. Elgazzar and El-Gazzar **[26]** allude to the dictionary definition of sustainability as "*the ability to be used without being completely used up or destroyed*". To qualify this, they have referred to the definition of sustainable communities as, those places where people want to live and work, now and in the future. [27]. Based on the afore mentioned definitions of a smart city, for a city to be said to be sustainable, both the concepts of smart and sustainability should therefore apply. A sustainable smart city can thus be perceived to be an intersection of the city, smart and sustainable properties, as reflected in the figure 1 below:

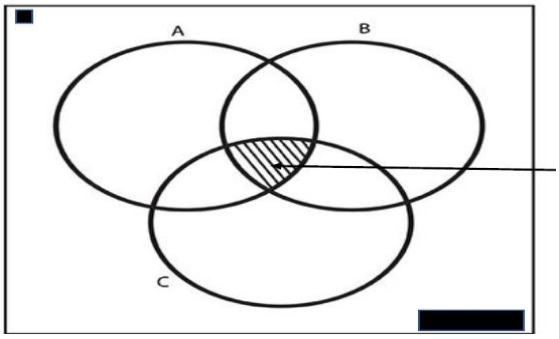

Figure 1: A + B + C= Smart Sustainability City
City + Smart + Sustainability = Smart Sustainability City
(Source: [28])

A more detailed similar view considers a smart city as the intersection of Technological, institutional and human factors, with various elements being related to a subset as show in figure 2 below [29].

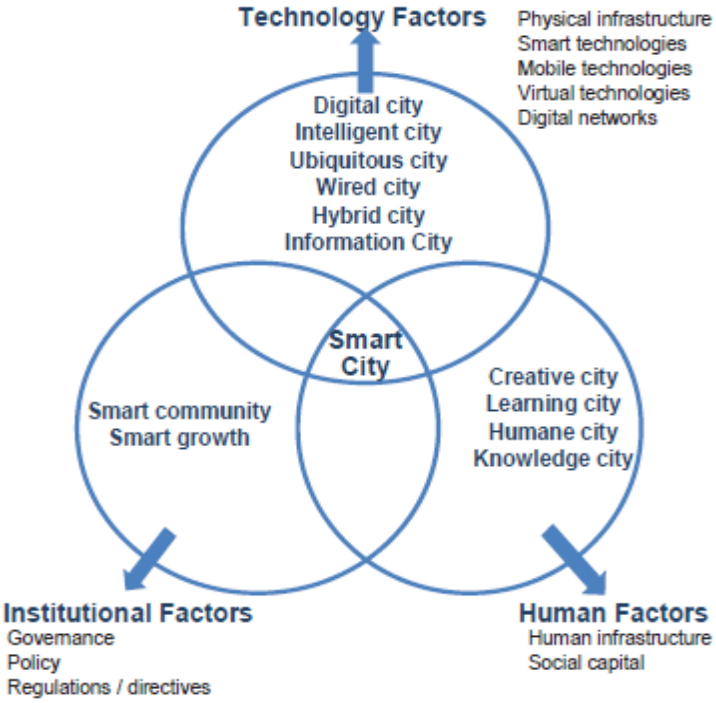

Figure 2: Fundamentals Components of a Smart City

The technology factors point to the absolute need for a well-functioning IT infrastructure and related applications for the existence of a smart city. These are pre-requisites which will facilitate *"real engagement and willingness to collaborate and cooperate between public institutions, private sector, voluntary organizations, schools and citizens.*" (ibid) making up a smart city. The relevant technologies are shown in the diagram.

The institutional factors are a pointer to the support of government and need for governance policy in the design and implementation of smart city initiatives. Integrated and transparent governance, strategic and promotional activities, networking, and partnerships are a requirement for successful smart city initiatives.

Human factors refer to the role human infrastructure, human capital and education in urban development play in smart city development. This is normally referred to as smart people characteristic of smart cities.

D. SMART CITIES AS DIGITAL TWINS

[30] Jones et al (2020) define a digital twin as a virtual representation of a physical product containing information about a said product. In relating digital twins to smart cities, Deren et al [17] in their paper "Smart city based on digital twins", note that the concept of digital twins is based on the bi-directional relationship existing between physical space and virtual space. In digital twin cities, virtual objects control physical entities without human intervention. This is seen to be how digital twin and smart city are related, with ICTs seen as controllers of physical entities without human intervention, particularly the internet of things (IoT), big data, cloud computing and artificial intelligence (AI). These are the construction basis of smart cities, and they evolve from the original static 3D model of cities towards the digital twin model which combines dynamic digital technology and static 3D models. These are elements of smart city construction which is assisted by digital twin city concept. The result is thus a complex giant system between the physical world and the virtual space – these can map each other and interact with each other in both directions. The result of this is a physical city that corresponds to a twin city with a pattern of co-existence of both physical and twin city and the integration of physical cities in the physical dimension and digital cities in the information dimension. The requirements for a twin city are the same requirements for a smart city, being data and technical foundation – these are provided for by ICTs. This ties in well with the views of smart cities by Evergreen [31] in Toli and Murtagh **[4]**, who describes smart cities as resilient and inclusive cities that are built collaboratively, and that use different types of technology and data to achieve a better quality of life for all their residents".

Tao et al [18] in Deren et al [17] perceive digital twins as being based on a "five-dimensional model" which is made up of the model, data, connection, service function and physical dimensions. They further argue that the digital twin city exhibits specific features of the digital twin which map into the five dimensions in the form of specific objects, specific applications, and specific needs. These concepts are extended to the smart city which is seen to also exhibit specific characteristics based on those of the digital twin. Thus, digital twin cities are additionally seen to exhibit four major characteristics of accurate mapping, virtual-real interaction, software definition and intelligent feedback. Accurate mapping relates to the construction of infrastructure using technologies such as sensors on the air, ground and river levels of a physical city - this results in accurate information and mapping of the virtual city to the physical city. Virtual-real refers to the racing of people, logistics and vehicles that can be observed in the physical city. Software definition relates to how software is used to establish a physical city virtual model which simulates the behaviour of city people, events and objects in the virtual space. Intelligent feedback refers to the early warning of possible adverse effects, conflicts, and potential dangers of the city through planning, design and simulation among others. How reasonable and feasible countermeasures can be provided is part of this. Thus, in relation to the digital twin city, the smart city integrates the IoT, cloud computing, big data, AI, and other new IT technologies with a view to optimizing the construction of smart cities.

E. PILLARS OF SMART CITIES

Different authors have identified different pillars or characteristics of smart cities. In some cases, clear distinctions have been made between pillars and characteristics **[32]** while in others **[33]**, the two terms are used interchangeably.

Alice Cruickshank [34], in her write-up on pillars of smart cities, allude to 2 main pillars (foundational and Tech-enabled) of smart cities which can be sub-divided into 10 pillars – these are as summarized in figure 1 below:

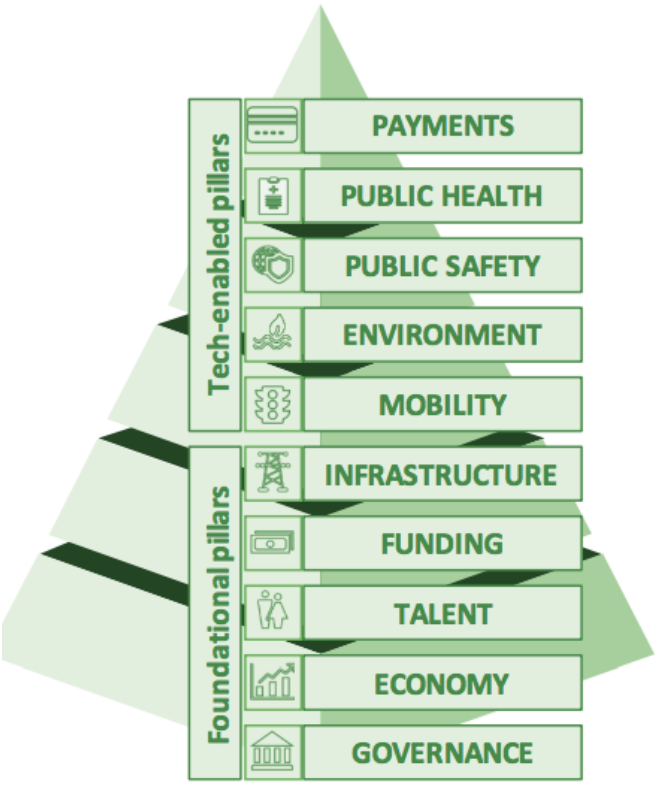

Figure 1: Ten Pillars of a Smart City

Click Vince [35], went further and increased the number of these pillars to 14, as reflected in figure 2 below. An attempt was made to map the 10 Pillars above and the 14 Pillars in terms of the major categories of Foundational and Tech-Enabled Pillars.

	10 PILLARS	14 PILLARS
TECH-ENABLED	PAYMENTS	NGOs and universities
	PUBLIC HEALTH	Regulation
		Water, wastewater and waste
	PUBLIC SAFETY	Cyber and physical security and privacy
	ENVIONNMENT	Environment, health and safety
		City and green space planning and buildings
	MOBILITY	Transportation and mobility
FOUNDATIONAL	INFRASTRUCTURE	Telecommunications
		Consumer engagement and community social infrastructure
	FUNDING	Energy
	TALENT	Technology and innovation
	ECONOMY	Finance, investment and economic development
	GOVERNANCE	Government leadership and public policy
		Global best practices

Figure 2. Mapping of 10 and 14 Pillars
Compiled by author

These are some of the many features that are necessary to consider when developing or implementing a smart city programme. Clint Vince believes that successful smart cities are those that focus on all the 14 key pillars simultaneously.

Different authors have identified different characteristics of smart cities. Some of the prominent writings are those by Silva, Khan and Han [36] who identified four characteristics of smart cities as sustainability, quality of life, urbanization, and smartness as quoted in [1] above. Mozūriūnaitė, & Sabaitytė, [37] alluded to six characteristics of a smart city, these being smart economy, smart mobility, smart governance, smart environment, smart living and smart people. Ayodeji Emmanuel Oke [38] view these as the major drivers of smart cities.

Regardless of whether we use the terms pillars, characteristics or indeed drivers, there are commonalities in the elements required of a smart city. Some of the commonalities have to do with both foundational and tech-enabled pillars, in particular smart economy, smart mobility, smart governance, smart environment and smart living and smart people. Technology thus plays a major if not the biggest role in smart city development. Halegoua **[39]** specifically speaks of the importance of information technology to the development of smart cities – he points to the following technologies as key components of smart city technological development, integrating big data, IoT, cloud and IT infrastructures, and mobile and social media.

F. SUCCESS FACTORS OF SMART CITIES IN DEVELOPED COUNTRIES

Several cities in the developed world have been identified as success stories in the development of smart cities, with the following being said to be the top seven smart cities in the world in August 2022, Singapore, Helsinki, Zurich, Oslo, Amsterdam, New York City and Seoul [40]. Other cities that have been recognized as success smart cities include Barcelona and those in the United Kingdom, Edinburgh,

London and Oxford. Table 1 below gives a summary of the success factors that made these countries succeed in being recognized as the best smart cities in the world:

CITY	SUCCESS FACTOR
Singapore	**Introduced** a wide range of smart technologies in both its public and private sectors **Adopted** contactless payment technology to efficiently direct movement and payments for Singapore's 7.5 million passengers who use public transports. **Introduced** a digital health system – normalising video consultations at the same time **Introduced** wearable Internet of Things devices to monitor patients. Had plans in 2021 for a new eco-smart city that is entirely vehicle-free with safe zones for both pedestrians and cyclists
Helsinki	**Has set** themselves an aim of going carbon neutral by 2035 **Set** to reduce traffic emissions by 69% within three decades by 2035, with measures like transitioning the entire city bus fleet to electric, and expanding its Metro and electric car charging networks. **Focused** on implementing energy-efficiency measures during renovations with emissions from buildings by expected to reduce by 80%, **Incorporation** of more renewable energy use in the city's buildings
Zurich	**Introduced** a series of streetlights that adapted to traffic levels using sensors, increasing its brightness or dim accordingly, resulting in energy saving of up to 70% **Established** a greater range of sensory technologies that can collect environmental data, measure the flow of traffic and act as a public WiFi antenna **Installed** a smart building management system, which connects the city's heating, electricity and cooling – his has been shown to be highly effective.
Oslo	**Introduced** electric cars and plans for all vehicles in the entire city to go electric by 2025 Zero-emission cars in place, including free parking, the use of bus lanes, and lower taxes and prices at tolls. To become carbon neutral by 2050 with zero-emission construction sites. Develop circular waste management and green energy systems.
Amsterdam	**Has 170** different smart city project operations across the city. **Has ability** to stay innovative, whether in the utilisation of renewable energy for electric garbage trucks, installing solar-powered bus stops, billboards and lights, or constructing floating villages to combat overcrowding and provide an alternative to land reclamation. **Thousands of operating** businesses and households have been modified with energy efficient roofing insulation, automatically dimming light switches, smart meters, and ultra-low energy LED lights.
New York City	**Installed** hundreds of smart sensors and technologies have been tested and placed through the different districts in New York City as part of its smart city pilot programme in 2020. **Programme** manages services like waste management and collection more efficiently. Introduction of smart hubs with contactless technology, WiFi capabilities as well as online charging stations in place of phone booths. Car sharing services established, which helps reduce total emissions and traffic congestions. To encourage innovation in smart city technology, holds an annual contest – with a generous cash prize – for apps that best utilise the city's open data sets.
Seoul	**Also known** as the world's first smart city, accumulates and analyses urban patterns such as traffic flow, speed and air quality measured by sensors and CCTV deployed across the city, form a strong basis for a smart infrastructure and services. **Has a safety** initiative was launched in aid of senior citizens who live alone. **Has environmental** sensors linked to relevant case workers and emergency services for immediate contact in various emergencies. **Using data platforms** to create an AI detective to flag up potential crime patterns. **Amongst the first** cities to utilise 5G technology in mobility and transportation.
Barcelona	Has in place a Smart City strategy in terms of Smart districts, living labs, initiatives, e-Services, infrastructures and Open Data. Has been growing and transforming itself into a knowledge-intensive city.

	Has 400 research centres for the creation, dissemination and use of knowledge. have built and/or use existing or new infrastructures—the 22@Barcelona innovation district, corporate fibre optical network, Wi-Fi mesh network, sensors network and public Wi-Fi network
Edinburgh	**Focus** on reusing, recycling and promoting paperless technologies. **Reduction** of carbon emissions, in line with Edinburgh's net zero carbon by 2030 ambitions. **Has adopted** SensorInsights360 smart city platform, developed in Australia. **Has adopted** the Internet of Things (IoT), asset data collection and asset management.
London	**Has** made full fibre connectivity and mobile infrastructure mandatory during the planning process for all new buildings. **Introduced congestion Charge**, contactless payment and the Ultra-Low Emission Zone. **Piloting emerging** technologies such as connected autonomous vehicles and advanced smart energy systems as well the large pilot-at-scale of e-scooters. **Introduced 5G networks** and smart city emerging technologies including networks of sensors, cameras, drones, robotics, mobility services, augmented and virtual reality, and automated and algorithmic decision-making. **Has enabled** collaboration across 32 boroughs to deliver common digital services that directly benefit Londoners **Plan to** transform London into a carbon-neutral city by 2050 **Has invested** and still investing in smart energy, smart water management, smart waste management, smart transport and health and assisted living.

Table 1: Achievements of Smart Cities in Developed Countries

It must be noted that there are other global cities that have successfully implemented smart city programmes, including in Africa (Kigali, Johannesburg, and Nairobi (Konza Technopolis in Kenya) [41] to name a few. What is obvious is that technology plays a major role in the successful implementation of a smart city. It can also be note that developing countries have had and have the financial clout to invest in smart cities.

G. SMART CITY DEVELOPMENT FACTORS IN DEVELOPING CITIES

As alluded to elsewhere above, Africa has its own share of cities that have attempted to achieve success in the development of smart cities. The most obvious are Kigali in Rwanda, Johannesburg in South Africa [42] and Nairobi in Kenya. Other countries with developing smart cities worth mentioning include Dhaka, Indonesia, Zambia, Angola (Luanda), Mozambique (Maputo), DR Congo (Kinshasa), Tanzania (Dar es Salaam) and Nigeria (Ibadan City) **[43]**. Table 2 below shows the factors that have made the smart cities in developing countries.

CITY	SUCCESS FACTOR
Kigali	Dubbed best smart city in Africa Has implemented Three-Tiered Digital Model involving digital life, digital business and digital banking, Has implemented ARED 'mobile smart city' initiative. Kigali and Africa50 envision to create the Silicon Valley of Africa. Has implemented "smart" in relation to Environment, Mobility, Connectivity, Ecology, Citizens, Life quality and government Optic fibres implemented and running across the Rwanda
Johannesburg	Harvesting rainwater and solar energy to limit carbon Has developed framework for developing smart city
Nairobi	Has implemented Konza National Data Center and Smart City Has ongoing smart city projects involving construction of Kenya Advanced Institute of Science and Technology, Konza Smart City and Horizonal Infrastructure for Konza Technolopolis
Dhaka	Plans for development of smart city in place
Lusaka	Has a designated implementation and collaborative authority – Smart Zambia, E-Government Division. Collaboration is with Ministry of Local Government and Local Authorities involved. Has implemented a Government Payment Gateway for all payments to Government Has implemented a smart Intelligent Mobility traffic monitoring system Has implemented an Electronic Health Monitoring system which proved handy in collecting data during covid-19 pandemic Has implemented Communication Data Portals, Websites to enhance collaboration between businesses and individuals. Has implemented National Data Centre (InfraTel)
Luanda	Has implemented the "smart wall" initiative which supports the green city agenda, through the use of solar energy initiatives. Has implemented roof gardens and vegetable plots to support sustainable livelihoods objectives
Maputo	In form of Uxene Smart City, Maputo has plans offer a full spectrum lifestyle in form of infrastructured stands, freestand homes, residential clusters and apartments buildings with options for everyone. Plan includes an abundance of green spaces and parks, an 18-hole championship golf course, largest open space amphitheatre in the country , an equestrian center, sports amenities and a cluster of world-class schools. Plan also includes a logistic park and a CBD with an administrative area (cluster of public institutions), commercial office park and malls. The smart-City to be protected with state-of-the-art smart security systems and all ICT enabled Solutions for a world-class Smart-City.
Kinshasa	Has potential yet to be realised in six focus areas: Urban Safety and Security to make cities safer; AgriTech to develop sustainable food security solutions for urban areas; FinTech for building cashless cities; City Planning for improved architecture, mobility and accessibility; Energy and CleanTech to reduce negative environmental impacts.

Dar er Salaam	Implemented crowdsourcing for creating flood maps. Has drone mapping for urban dynamics Plans for expanded smart city in place
Ibadan City	Has implemented 7,000 kilometers fiber optic cable to assist the city to implement the ambitious e-government project. 500 000 families supplied with internet access. Has implemented apps to check traffic flows and congestions.

Table 2: Achievements of Smart Cities in Developing Countries

A comparison of the factors under the developed and those under developing countries shows that developing countries are far from achieving the smart city status, except a few such as Kigali. The emphasis of smart city development appears different between the two worlds.

III. CHALLENGES FACING SMART CITY DEVELOPMENT IN DEVELOPING COUNTRIES

A. Rana et al **[44]** in their study of barriers to the development of smart cities Identified 31 barriers with respect to India. Some of these are alluded to by other writers as well [45] Most of these barriers are applicable to many developing economies. Discussed below are 10 such barriers which can be said to be common among developing countries.

B. Lack of cooperation and coordination between city's operational networks:

The creation and implementation of a smart city requires co-ordination between various administrative wings of not only the city but government as well. This is considered a governance challenge. Where the relevant various wings not working in unison, there is bound to be failure in the development of the smart city.

C. Unclear IT management vision:

It is necessary to have a clear vision on how the backbone of smart city development, Information Technology (IT) should be managed as a city develops. The development of a smart city will not be achieved without such vision.

D. Political instability or lack of political will:

Unless there is political stability, no development of any sort, let alone that of a smart city can succeed. Apart from political stability, political will to develop the city is needed, without which there will be definite failure in the development.

E. Poor private-public participation:

Without the participation of the private sector, in liaison with government, no success in developing a smart city can be achieved.

F High IT infrastructure and intelligence deficit:

Smart city development requires huge investments in IT infrastructure and intelligence. Most developing countries find themselves lacking in such infrastructure as solar based electrical systems, cloud computing and artificial intelligence-based systems like intelligent transport system, smart communities, e-health, smart grids, and smart energy solutions among the many required in a smart city.

G. Cost of IT training and skills development:

Developing countries have a huge skills gap in ICTs which is a result of the high cost of IT training and the related skills development programmes.

H. Lack of involvement of citizens:

The residents of a city need to be aware and involved in the development of smart cities. The non-involvement of citizens in smart city development can easily lead to failure of the development programmes.

I. Integration and convergence issues across IT networks:

Most cities already have in place legacy systems as well as some new systems. The lack of integration of these disparate technologies and convergence of heterogeneous networks (e.g. Bluetooth, WLAN, heterogeneous cellular networks such as 3G, 4G, 5G etc.) could be potential issues toward smart cities development.

G. Lack of regulatory norms, policies, and directions:

Without regulatory norms, policies and directions at both local and government levels, the development of a smart city cannot succeed.

K. Lacking ecological view in behavior:

A lack of ecological view in pro-environmental behavior toward consuming energy could lead to failure in smart city development.

One of the barriers that is rarely alluded to regarding smart city development in developing countries is the lack of donor funding and therefore inadequate budgetary support. Very few developing economies boast of being financially independent, as most receive donor funds even for their budgetary support. A lack of these funds will lead to administrators relegating the smart city agenda to very low priority. Therefore, the role of the private sector is critical in the development of sustainable smart cities as they assist in funding the cities. Other challenges to implementation of sustainable smart cities include system failures, information security, privacy issues, sustainability, and cost of operations **[46]**. In some countries like Zambia, the challenges include human capital development, change management, licensing costs, infrastructure setup and maintenance as well as interoperability **[47]**.

IV OPPORTUNITIES FOR SUCCESSFUL SMART CITY DEVELOPMENT IN DEVELOPING COUNTRIES

A. The development of a smart city leads to open data movement in a city, which this can be regarded as an engine for innovation and economic growth. It is a way of creating added-value services and applications as well as of enhancing efficiency, effectiveness, and cost savings at city level **[48].**

Degbelo et al quotes studies that have been carried out which have demonstrated that governance issues can be improved in a smart city by using big data analysis. This would result in citizens identifying errors, preventing abuses, and

inefficiencies and thus building trust between themselves and their cities. In most developing countries where governments are trying to eliminate corruption, smart city development would assist to monitor governance through open data movement. These opportunities would also help governments in improving their relationships with the donor communities.

B. Eiman Al Nuaimi et al **[49],** allude to three opportunities that arise as a result of the of big data in smart cities, these being:

a) Efficient resource utilization: The scarcity and expense of resources requires integrated solutions for better and more controlled utilization of city resources. With smart cities, systems at work will be monitored, resulting in easier spotting of waste points and better distribution of resources while controlling costs, and reducing energy and natural resources consumption. As smart city applications are designed for interconnectivity and data collections, this will additionally facilitate better collaboration across applications and services.

b) Better quality of life: Better quality of life will be a result of better city planning of living / workspaces and locations, more efficient transportation systems, better and faster services, and the availability of enough information to make informed decision.

c) Higher levels of transparency and openness: Better management and control of the different smart city elements and applications, will drive city interoperability and openness to higher levels. This argument has been alluded to above already.

C. For the pointed-out opportunities to come to fruition, high levels of sophistication and involvement in terms of the applications, resources and people will be required. These opportunities however require more investment technology, better development efforts, and effective use of big data in the smart city. In addition, policies will need to be set to ensure data accuracy, high quality, high security, privacy, and control of the data as well as use of data documentation standards to provide guidance on the content and use of datasets. Technology in the smart city will also be very useful when considering the management and protection of environmental resources and infrastructures, and natural resources with the goal of increasing environmental sustainability

V. ANALYSIS

A. There is a remarkable difference between the way cities in developed and those in developing countries achieve sustainable smart city status. A comparison of the factors that make a city a smart city between developed and developing countries show that both recognize the major role that information technology play in achieving smart city status, but issues dealt with to do so are different. It is generally agreed that a smart city should have certain components, particularly the six smart components of smart economy, smart mobility, smart governance, smart environment, smart living, and smart people. However, the differences in the development levels mean that developing countries will emphasize certain elements of the six components while developing countries will focus on different ones.

B. The advent of the covid-19 in 2019 into 2021 meant that certain elements of smart city development were halted while others were accelerated. As a result of the covid-19 pandemic, it was noted that smart city approaches strengthen urban resilience through risk reduction strategies and practices [50]. Smart cities in developed countries were noted to have a greater capacity to react to crises such as covid-19 particularly in the post-pandemic era than those that had not developed their cities to recognizable smart city status. [50] Hassankhani, M. and others state that, *"the smart city is known as an adaptive urban planning approach to cope with disturbances"*. Thus, during crises, smart city initiatives enabled by Information and Communication Technologies (ICTs) play critical roles in responding and recovering from crises efficiently and improving learning. The ability to trace covid-19 was higher in developed economies than in developing one, in part due to the extent of development of their cities into smart cities and the ultimate efficient use of ICTs.

C. A further observation regarding covid-19 was that there was a general slowdown in the growth of many sectors in all economies due to budget cuts and financial constraints posed by the pandemic. However, some sectors saw massive growth, particularly the Medical Infrastructure, Insurance, and eCommerce, made Smart Cities to have a strong focus on certain Smart Services related to medical facilities, IT infrastructure to facilitate contactless transactions, Telemedicine Service, Smart Isolation Wards etc [51] [52]. This growth was noted in developed countries and not in developing countries **[53]** with immature smart cities. The little growth in smart city development that could have been noticed prior to the pandemic literally came to a halt during and immediately after the pandemic. It will require new efforts to revive the development projects of smart cities in developing countries. The major issue is the lack of financial resources for such projects which in the face of the covid-19 are not priority projects.

VI. DISCUSSION

A. Smart city development in developing countries cannot be compared to the development of cities in developing countries. While every country is looking forward to achieving the SDG 11 in accordance with the UN SDGs, developing countries are handicapped by many factors. Not only is development of such projects reliant on donor funding, but developmental priorities also differ and hence commitment to smart city development is low.

As noted elsewhere above, there are many approaches that can be used for cities to attain SDG 11 of a Sustainable Smart City. It follows from this that no single approach can be said to be the best to follow in order to attain sustainable smart city status. Different cities across the globe are found in different environments and their attainment of smart city status depends on what issues they have to deal with. Developed countries are therefore seen to be better placed to develop their cities into smart cities due to their developed nature. The success factors for developing smart cities are also bound to be different from

one country to another although certain factors such as technological innovation are common and need to be in place for successful smart city development **[53]**. It is generally accepted that the development of smart cities in anchored on information and communications technologies (ICTs), but these are themselves a measure of developmental success – most developing countries have not achieved the same levels if technological development seen in developed nations. The challenges faced by developing countries are different from those faced by developed economies. It therefore goes without saying that the development of smart cities in developing countries will continue to lag behind that of developing nations. Pandemics such as the covid-19 have shown that any universally agreed developmental targets cannot be achieved at the same pace in all countries due to their differences in resource endowment and environments. Climate change as an inhibiting factor to smart city development has exacerbated the problem as resources as diverted to resolving climate change issues.

VII. CONCLUSION

There is a consensus about the benefits and opportunities that arise from a city attaining smart city status. For developing countries however, this is a tall order due to a multiplicity of factors, not least the differences in the levels of economic development. These levels include the development of ICTs in developing countries, without which the concept of sustainable smart city will remain a pipedream for most developing countries. There are many who argue that a smart city should not be perceived as an end in itself but that the rate of development of smart cities should be left to differ depending on circumstances, as long as the city contributes to improved productivity, environmental sustainability, and livability of its citizens. The timeline of 2030 for the global development of smart cities is not therefore bound to be attained due to the diversity of cities in the world. Cities should be left to develop themselves based on their capabilities and aid given.

VIII. RECOMMENDATIONS - THE WAY FORWARD

Jarmo Eskelinen, [54] suggested in his Forward to the report on Smart City Strategies – A Global Review made recommendations for successful implementation of smart cities. These recommendations could be very helpful for developing countries in the light of challenges alluded to above. Five recommendations are made, vis.

a. It is necessary for countries to establish strong leadership to develop capacity within local government for smart city development.

b. Countries should embed their smart city strategies their statutory frameworks and wider city planning.

c. It is necessary when creating smart city strategies to consider a collaborative approach, coupled with strong political support. Collaboration should include citizens, businesses, third sector organizations and academia. There cannot be any success without political will.

d. Further, core city funding must be tapped into to assist with smart city development by regularly scanning existing city assets and budgets. This may not work where donor funding is the mainstay for smart city development.

e. Countries and cities must create plans for private sector engagement and long-term collaboration

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