

Developing a Smart City : Essentials, Execution and Evaluation

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ABSTRACT

Adoption of Information and Communications Technologies (ICTs) especially the internet is becoming the largest delivery podium for providing public and private services to the rural and urban populace. This paper adopted the Narrative Textual Case Study (NTCS) using qualitative approach to conduct content analysis of relevant literature. The study observed that over 50% of mankind occupies urban spaces and this will increase to two third by 2050. This situation is as a result of the opportunities that are available in the cities and it spells great challenges on environment, energy need, waste management, etc. Cities are responsible for nearly three quarters of greenhouse gases worldwide and must be seen to be a solution providers too. Hence to maintain high standard of living for the long term cities as well as nations must reduce ecological footprint and seek alternatives to scarce fossil resources. This requires comprehensive development of physical, institutional, social and economic infrastructure. Science, Technology and Innovation (STI) policy driven mechanisms are essentials for development of Smart Cities.

Keywords: Smart, Technology, ICT, Infrastructure, Developing, Policy

I. INTRODUCTION

The term smart is widely used by Americans to mean ideas and people that provide clever insights to issues. It was framed towards the end of the 20th century (Batty, et al., 2012). Batty, et al (2012) also observed that lately, this term was adopted in city planning through the cliché *smart* growth. Rather than letting the market dictate the way cities grow and sprawl; smart growth, a multi-faceted system, orates greater efficiencies through coordination of forces that lead to laissez-faire growth in areas such as transportation, land speculation, conservation, and economic development (Batty, et al., 2012). This approach is better done through policy promulgation and implementation. Thus, Smart city tackles today's global challenges associated with urban areas such as

climate change, scarcity of resources, etc while ensuring economic competitiveness and quality of life for the ever rising urban population.

Scholars share divergent opinions about the conceptual meaning of smart city. Key to most definitions however are: inclusion of wide range of technologies, human involvement, natural resources, infrastructures, power, transportation, education, healthcare, government, environment and public safety (Nuaimi et al, 2015). Also, majority of them focus on integrated solution for achieving an efficient and sustainable utilization of resources, attainment of high standard of living and efficient urban planning. It is also broadly used as a synonym of a city considered to be modern and intelligent.

In a United Nations 2014 survey (IEC, 2016), it was recorded that the total urban population is likely to grow by 63% between 2014 and 2050 against the 32% total population growth in the same period, the fastest increase occurring among megacities hosting over 20 million inhabitants and situated mostly in developing countries. The challenge will be to supply these populations with basic resources like safe food, clean water and sufficient energy, while also ensuring overall economic, social and environmental sustainability (IEC, 2016).

Cities grow people’s needs. City people want a city where things are done easily and securely, a city where they would have access to more information as well as resources allocated wisely. They also want a city where their privacies are protected and would protect them from any sort of abuse. A city where things run efficiently and effectively.

To buttress the divergent nature of the various definitions, table 1 is a presentation of areas of focus of some scholars on the concept Smart City.

Table 1. Some definitions of Smart City highlighting key focus areas.

Definitions of Smart City	Areas of Focus	Scholars
Smart City is a very broad concept, which includes not only physical infrastructure but also human and social factors	Included the social aspects and agreed that smart city has a broad focus	Aguilera et al., 2013
The concept of Smart City (SC) as a means to enhance the life quality of citizen has been gaining increasing importance in the agendas of policy makers. However, a shared definition of SC is not available and it is hard to identify common global trends	-Policy makers are an additional aspect of the smart city definition. -Consents to the lack of a shared definition of smart cities.	Neirotti et al., 2014
Smart city, the important strategy of IBM, mainly focuses on applying the next-generation information technology to all walks of life, embedding sensors and equipment to hospitals, power grids, railways, bridges, tunnels, roads, buildings, water systems, dams, oil and gas pipelines and other objects in every corner of the world, and forming the “Internet of Things” via the Internet”	Addresses the technological aspect of smart cities and focuses on how next-generation information technology is the key.	Su et al., 2011
A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent, and aware citizens	Views a smart city as a futuristic model of collaborative components.	Chourabi et al., 2012

<p>A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens”</p>	<p>Focuses on the integration of infrastructure and systems that monitor and control the resources to achieve sustainability as the main aspect of a Smart City.</p>	<p>Kitchin, 2014</p>
<p>Connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city</p>	<p>-A more generic view that puts together all main aspects of a smart city to achieve the goal. -Seems to be most comprehensive definition of a smart city.</p>	<p>Chourabi et al, 2012</p>
<p>A city striving to make itself “smarter” (more efficient, sustainable, equitable, and livable)</p>	<p>General definition, does not specify how a city will get smarter.</p>	<p>Chourabi et al, 2012</p>
<p>A smart city is . . . a city which invests in ICT enhanced governance and participatory processes to define appropriate public service and transportation investments that can ensure sustainable socio-economic development, enhanced quality-of-life, and intelligent management of natural resources</p>	<p>Views the smart city as specific and narrow, set of resources/services working together to achieve a better life.</p>	<p>Khan et al, 20012</p>
<p>“A smart city concerns innovation -not necessarily but mainly based on ICT- that enhances urban living in terms of people, governance, economy, mobility, environment and living.”</p>	<p>Views smart city as innovation that optimizes standard of living of urban people</p>	<p>Anthopoulos and Reddick, 2016</p>

Adapted from (Nuaimi et al. 2015)

From the definitions above, we can conclude that Smart City is an integration of living solutions that connect life aspects such as power, transportation and building in a smart and efficient way to improve the quality-of-life for citizens of such city while focusing on the future by emphasizing the importance of sustainability of resources and its application for the future generations.

Thus, Smart City’s core components with their sub elements are identified to be Technology and Data (ICT, data and information); Physical environment (natural environment and city infrastructure); Society (knowledge economy, human capital and governance) as well as Government (institutional arrangements, city administration and public services). Components of Smart City are: mobility, governance, environment, and people as well as its applications and services such as healthcare,

transportation, smart education, and energy. Characteristics of Smart City include sustainability, resilience, governance, enhanced quality of life, and intelligent management of natural resources and city facilities.

Smart City is the implementation of user-friendly information and communication technologies for urban spaces. Its meaning is also related to the future of cities and their developments. Smart cities are forward-looking, progressive and resource-efficient while providing high quality of life, promoting social and technological innovation and linking existing infrastructures. They incorporate new energy, traffic and transport concepts that are eco-friendly. They support new forms of governance and public participation.

This paper discusses the steps to building a Smart City, drawing inferences from successful cases with the intent of proposing steps needed to drive home the requirements for the development of a smart city. Challenges and benefits were also x-rayed. Indicators used for monitoring Smart City performance and the need for major stakeholder's engagement were also identified. The paper concluded by offering policy directions to city planners, ICT experts and decision makers.

II. Challenges and Benefits

There was a profound agreement on the potential innovation capacity of ICT within the City context (Gil-Garcia, 2013), the challenge, however, is to deliver that potential alongside the wide-scale diffusion of technology.

The decision to convert or redesign a city to become a smart city ensures enhanced levels of sustainability, resilience and governance. Apart from that, it improves citizen's quality of life, ensures intelligent management of infrastructures and natural resources. Some other benefits of having smart city are:

efficient resource utilization, better quality of life, higher level of transparency and openness. The challenges in acquiring a Smart City are cost of acquisition due to the varying financial abilities and the scarcity of natural or human resources, regulatory systems that could greatly affect the chances of success and chief amongst the challenges is the requirement of highly advanced technological solutions (Gil-Garcia, 2013). Conversely, new and emerging technologies can help transform such challenges into opportunities, thereby making the city smarter.

To explore these opportunities require high level sophistication and involvement in terms of the applications, resources and people. Hence, STI policy (FMST, 2012) promoted the need to invest more in technology, better development efforts and effective use of big data. In general, a Smart city can be made smarter by utilizing new and emerging technology such cloud computing and/or big data analytics for many of its applications and services.

2.1 Smart City Services and Applications

Smart cities have a wide spectrum of application areas ranging from operations (e.g. real-time traffic management) to entertainment and tourism (i.e. augmented reality city tours). These applications need to support city environmental, socio-economic and policy requirements. It needs to support city requirements such as continuing lifecycle, incremental evolution, collaboration between diverse city stakeholders, and privacy concerns when working with the personal data of citizens.

A Smart City creates an ecosystem where vast amount of data can move between actors within complex information supply chains and leveraging this data flow could result in Smart City applications in the following areas - Economy, Environment, Energy, Water, Waste, People (intellectual

endowment and engagement), Lifestyle, Building, Mobility (Transportation), and Public spaces.

Smart cities utilize multiple technologies to improve the performance of health, transportation, energy, education, and water services leading to higher levels of comfort of their citizens. This involves reducing costs and resource consumption in addition to more effectively and actively engaging with their citizens.

III. Lessons from the Five Smartest Cities in the World

Juniper Research recently compiled its list of top-five “smart cities.”

Singapore

The Republic of Singapore announced its quest of becoming the first smart nation. The nation deployed cameras and sensors to track everything from cleanliness to traffic. Already, the city can detect if people are smoking in unauthorized zones or if people are throwing litter out of high-rise buildings. The country has smart mobility policies and technology as well as wireless connectivity. In 2014, the city-state announced that it was developing software it calls “Virtual Singapore,” a dynamic 3-D model that enables city planners to run virtual tests—verifying, for instance, how crowds might evacuate from a neighborhood in the case of an emergency.

The government made much of the data it collects public for citizens to check closed-circuit TV footage and monitor parking, thanks to sensors installed as part of the Singapore’s Smart Nation program.

Singapore has aggressively implemented congestion charging while also making substantial investments in road sensors, phased traffic lights, and smart parking. In the 1970s, it launched an initiative to address what was then a chronic congestion problem.

The systems Singapore has put in place since then have been pretty effective in terms of improving the average speed travelled by cars on the main roads. The city-state also has high smart phone penetration and scores well regarding in broadband availability

Barcelona

The chic capital of Catalonia region in north-eastern Spain, Barcelona has made extensive use of sensors to help monitor and manage traffic. The city is doing more than using smart-city technology to reduce traffic. It has installed smart parking technology as well as smart streetlights, and sensors for monitoring air quality and noise. It is also expanding a network of free Wi-Fi in public spaces. Barcelona's strength is in its sustainable energy—smart grid pilot projects, smart meters, and its comprehensive plan for reducing carbon emissions. On top of that, it is rolling out smart LED lighting.

Barcelona has also been a trailblazer regarding how it has addressed drought. The city ran out of water a few years ago. As a result, it has developed a smart city sensors system for irrigation. Sensors in the ground analyze rain alongside the predicted level of rain forecasted to occur and will modify the city’s sprinklers accordingly to help conserve water.

The city has also made its Sentilo sensor and actuator platform available on the Internet. The open-source software platform can be found on Github. The availability enables city planners around the world to study data from Barcelona’s smart city projects and learn from them.

London

London has long ranked near the top of the list in roundups of smart cities in the world. It began to take early action in using technology to help tackle

congestion and make parking simpler. One of the tech hubs of the world, London is doing relatively well in making broadband available. In recent time, information technology is adopted to curb congestion. London has also committed to making available data from its smart city initiative public via its London Data store. For instance, London has an app built on open data that will take your location, and you can say where you want to go, and the app will tell you the routes you can take. In 2014, London began rolling out a smart parking initiative in the Westminster neighbourhood. Notwithstanding, the city rely on unclean energy and its relatively poor in energy use reduction initiatives.

Already, the city has made big investments in smart traffic technology. Not only do the traffic lights respond in favour of buses to smooth the progression of public transport, but there also is a congestion charge that was implemented in 2003. There is messaging available to inform drivers of congestion. It is a cohesive effort by the city to reduce congestion.

San Francisco (SF)

San Francisco is one of the very first cities that adopted smart technology. The recent tech boom has made SF the unofficial capital of Silicon Valley. As CNN declared last year, San Francisco is now a hipper spot for start-ups than cities like Palo Alto, Mountain View, or San Jose. San Francisco's Connected City initiative enables residents to locate parking spots. The city is also forward thinking in its sustainability and smart urban development initiatives. It also has one of the highest densities of LEED-certified buildings in the United States.

The public transportation network in San Francisco, although aging, already fares well in certain areas, according to Juniper research. "The city scores high in terms of bus availability. San Francisco also has a

good payment system. You can pay online, and contactless payment is available as well. Still, the city is facing a growing congestion problem that has worsened amidst the recent tech boom. The time spent in traffic in San Francisco is relatively high compared to other cities among the top five smart cities

The city, however, has been a leader in terms of smart parking. The SF Park initiative, which was launched in 2011, leverages sensors to monitor parking spaces. The idea is that not only can you assess the level of occupancy for parking, which helps the cities manage new parking initiatives. San Francisco city officials use the data for dynamic parking system that adjusts the cost of parking based on whether spots are occupied or are vacant.

Oslo

The capital of one of the wealthiest cities in the world, Oslo is routinely cited as a contender in lists of the smartest cities in the world. The city has made strides in using information technology to curb energy consumption and greenhouse gas emissions. By 2020, the city is aiming to slash emissions by 50% by remaking its transportation grid; by 2030, it is aiming to be 95% climate neutral. Like other smart cities, Oslo has installed sensors to help it monitor parking. The city has installed a sensor network to help improve the care of sick, elderly patients. The city has also established a network of smart street lighting, which has reduced energy consumption by nearly two-thirds.

Oslo's smart-city approach is typical for a Nordic city and progressive with its emphasis on sustainable energy. "We would expect Oslo to be the first to launch commercial smart grid services, and they are living up to that expectation," Sorrell says. "Oslo is one of the leading Nordic countries with its smart

meter rollout. There have been some smart grid pilot projects as well.” The city also has a comprehensive electric-vehicle-charging network.

The city is also getting attention for its aggressive plans to cut carbon emissions from cars, hence they are looking at banning private vehicles by the end of the decade as the city has a high level of private vehicle ownership. Also, government plans to cut greenhouse emissions significantly by 2019.

Furthermore, like Barcelona, the city’s overall approach to energy reduction is very aggressive. There is a high percentage of sustainable energy and a policy to reduce carbon production.

Oslo has also started rolling out smart LED lighting and has launched a broad sensing network for monitoring traffic levels. They have license plate recognition technology which ties into their congestions charging scheme. There are apps available for smart parking, which offers mobile payment.

Table 2. Selected Cases of Smart Cities in Africa, Source: Adapted from <https://smartercitieschallenge.org> (2017)

S/NO	SMART CITY	YEAR	CHALLENGE	AREA OF FOCUS
1	Mombasa County, Kenya	2014	Administration	Revenue collection; to develop an integrated revenue collection system towards an improved service delivery.
2	Sekondi-Takoradi, Ghana	2015	Administration	Increase revenue; to develop methods to systematically identify properties and businesses for taxation purposes.
3	Lagos, Nigeria	2013	Transportation	Proposed technology-driven strategies to make travel easier and better coordination between agencies responsible for traffic management that are Big Data-driven transportation system based.
4	Rabat, Morocco	2012	Transportation	To create a more effective and efficient public

				transport system by 2020 anchored on multiple agencies coordination.
5	Durban, South	2014	Economic Development	To create 190,000 jobs by supporting the growth of new industries and foster inclusive economic development to address poverty and income inequality achievable through appropriate education and training programs.
6	Accra, Ghana	2012	Administration	Developing an integrated revenue collection system through innovative uses of technology such as automated direct payment systems, mobile payment, and Geographical Information System (GIS) technologies.
7	Abuja, Nigeria	2014	Administration	Better services to citizens around health, education, and the environment to fortify revenue collection systems.

IV. Developing a Smart City

Becoming a smart city requires intelligent decisions at strategic level as they are more than individual projects but careful decisions on long-term implementations. Viewing cities as systems can help them achieve their ultimate goal of being smart.

Implementing the Smart city initiative requires that we learn from these nations and adopt similar methods in order to becoming a smart nation. Several factors could be responsible for the adoption of the smart city solutions but the main challenge is the complexity of how cities are operated, financed, regulated, and planned. For instance, city operations are multidimensional and comprises multiple

stakeholders whose dependencies and interdependencies affect and ultimately determine the built environment. Smart Cities, however, present an opportunity to integrate physical city infrastructures—from utilities, transportation, and real estate to city services.

To introduce a significant change within a city, its leaders must be unhappy with the status quo and therefore capable of getting the populace to buy into its vision for a better future.

City leaders and stakeholders have to agree on the methodologies for implementing Smart City solutions. The process of planning and developing Smart City can be viewed in three categories. The tripod commences with public infrastructure, construction of public platform for smart city, and construction of application systems” (Su K et al, 2011).

It is important to have a clear, reliable strategic plans for smart cities that go beyond piecemeal initiatives or stand-alone projects which must consider various Smart City requirements (physical, social and technological) while taking a holistic, well thought out model. This will ensure a better view of what is needed, a more rounded, better designed complete solutions for Smart Cities. Nuaimi et al, (2015) proposed the following steps for the development of workable SC:

1. Set up the smart city’s direction by identifying its mission, vision and strategic and operational Objectives.
2. Establish policies, principles, resources and expertise guidelines to control ICT and big data usage.
3. Build smart-ready public infrastructures and platforms including the ICT required to support smart City applications. This would involve evaluating and analyzing the current situations

and the necessary Modifications to reach the desired result.

4. Identify priorities and use them to determine the most important smart city components and applications that would offer the greatest effects with the smallest investment.
5. Integrate infrastructures, services and big data smart city applications to develop better and more efficient Citizen experiences.
6. Optimize smart city services and operations using the data and focusing on environmental improvement needs.
7. Monitor current development, impact and effects for future opportunities.

Pivotal to the development of a Smart City is the application of ICT and adoption of big data for decision making. While developing an optimized SC, (Nuaimi et al, 2015) suggested the need for:

1. Simulation systems to help predict and view possible changes and forecast potential problems.
2. Lesson Learnt from other smart city experts to follow successful models
3. Collaborate with experts and researchers to study available market systems for discovery of new possibilities.
4. Investigate the correlation between big data and smart city applications. This understanding will help include the right data into the right applications to reach better decisions and optimize various functions in the smart city.

V. Stakeholders and their Inter-relationship

Government, Industry, Academia and NGO are key stakeholders in developing a Smart City and the following advantages accrue from the partnership amongst these stakeholders:

-Lowers R&D costs for firms: Recent research conducted by university-industry alliances shows that such collaborations are critical to bring down the R&D costs of firms while achieving a higher innovative output for developing smart solution.

-For the Academics and NGOs, collaboration enhances sources of public and private funding as well as helps partake in technology transfer and human training activities. It also helps enhance focus on secondary research of immediate industrial relevance.

-Some other advantages include the private sector support for basic research, participation in technology development involving some exploratory work, academic intervention in solving specific industry problems. Others are laboratory utilization by industry, industry – Academia collaboration through learning programmes including e-learning and data accessibility. The following are stakeholders in the development of Smart City:

Government

The main role of the government is to support the smart city initiative by providing appropriate policies and fund towards its implementation. While fairly new, joining the City Protocol Society and setting up one specifically for a city that is considering being smart will be a step in the right direction in integrating groups together to establish common language for Smart Cities.

There will be need to work more closely with the private sector to educate them on stakeholders' roles and, in particular, the "how"—policies and business models necessary for implementing Smart City solutions as well as avoid policy paralysis as much as possible.

Private Sector

It is better not to start developing end-to-end solutions until there is a clear understanding of who will pay for and operate them. Rather, processes should be developed to enable open and collaborative innovation with potential clients, NGOs, and academics to ensure solutions are both functional and economically feasible.

Academics and NGOs (Non-Governmental Organizations)

More time should be spent on the "how" the initiative will work rather than on the "why." Both, of course, are important, but focusing too much on the "why" smart city will hinder quick adoption of Smart solutions and initiatives.

VI. Measuring Smart Cities' Performance

A set of indicators was developed by Boyd Cohen in 2012 which could be adopted to track the performance of a smart city's development with the use of technologies and it is aimed at improving the efficiency of city operations, the quality of life of its citizens and economic growth.

The development in the smartness of a city is categorized as indicated in the figure 1 below. It captures parameters that affect the following components of a smart city: smart government, smart living, smart environment, smart mobility (transportation), smart people and a smart economy.

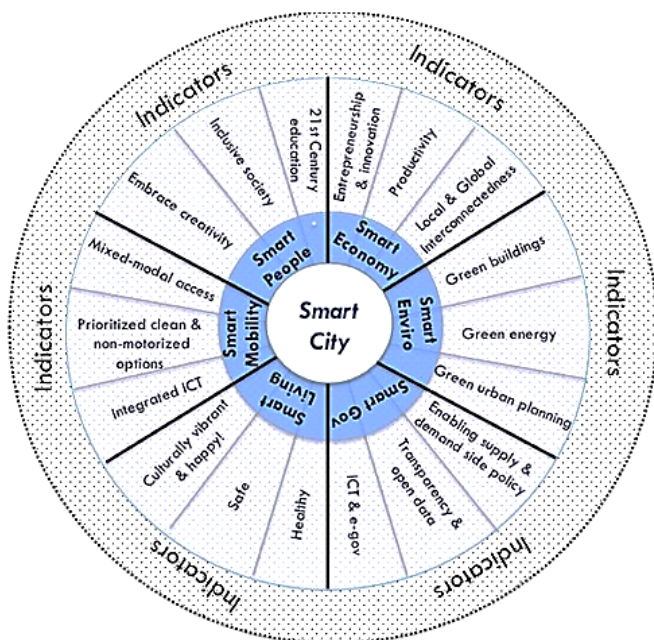


Figure 1 : Cohen’s Smart City Wheel

Source: DeAngelis, 2013

VII. The Case of Nigeria

Development on the continent of Africa has been very slow in the recent past. The advent of information and communications technologies (ICTs) has somewhat carved out an alternative path to its development.

In the late 1990s, Information and Communication Technologies (ICTs) was the largest contributor to growth within capital services for both Canada and the United States (Harchaoui, 2002). Similar trend has been witnessed with the economic development of China, Korea, Taiwan, India, South Africa, and other emerging economic powers Fuss and (Waverman, 2005).

Investment in ICTs in Nigeria as was practiced by emerging economic powers has made a significant contribution to the growth of the nation. If this trend continues, the chance of Smart City looms. Mega Cities like Lagos, Abuja had made concerted efforts towards the delivery of smart services in administration, transportation and revenue

generation (smartercitieschallenge.org, 2017). In the instance of Lagos, a Memorandum of Understanding (MoU) was signed with Smart City Dubai in June 2016.

Worthless to re-invent the wheel, since Nigeria could adopt and adapt existing SC policies and framework that were proven productive and successful by top smart cities of the world.

VIII. Common Ingredients of Successful Smart Cities

Components required for a successful smart city include robust policies supported by government commitment. These policies will be used in harnessing relevant technologies to achieve energy efficiency, consumption and to curb greenhouse gas emissions. The role of an optimal and economically viable technology-driven public transportation network, crowd management and parking organization are also pivotal to a successful smart city. Practices traceable to the successes recorded by smart cities also include adequate traffic and waste management policies. Availability and accessibility to broad band services were a common feature to successful smart cities.

IX. CONCLUSION

Cities that are smart aim at synchronizing systems of operations for better service delivery to citizenry and administration of infrastructures. The idea of a smart city is an innovative engagement of relevant stakeholders anchored on a systemic and strategy-driven planning to enhance the quality of life. Cities that have implemented the innovation benefited in the areas of smart administration of resources, transportation, economic development and urban planning, etc. Implementing a Smart city initiative requires undergoing the learning curve principles as there is need to adapt templates engaged by the

pioneers of the innovation. Deliberate steps must be made to bring all stakeholders on board and understand their Inter-relationship for a successful SC. The challenges in acquiring a Smart City ranges from financial constraints to scarcity of natural or human resources and regulatory systems. SC performance Indicators embraced elements of the government, living, environment, mobility (transportation), smart people and a smart economy. This paper encourages an elaborate synergy among the Government-Industry-Academics and Finance (GIAF) for a successful SC implementation strategy and delivery. By implication, a tool that will pull all stakeholders to common table is the STI and ICT policies. However, both policies were due for review even before they were implemented. Based on the above, policy makers in city planning, particularly in developing countries, should embrace innovations directed at building SCs as urban cities challenges are inevitable, more so, in emerging markets. The paper also yields to the need for policy review and implementation and the buy-in of policy makers to build required experts for a development plan and successful execution of a smart city as advocated by the Nigeria STI policy.

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