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Appraisal of Smart City, Compact/Resilient City and Sustainable City: implications for Design

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ABSTRACT

In recent times the concepts of smart city, compact city, resilient city, resilient design, sustainable design and sustainable city have crept into city/ environmental planning/design discourse and practice. While the meanings are not clearly understood especially as they apply to cities of a developing country like Nigeria, there seems to be a very thin divide between them. This study appraised these terms with respect to their intrinsic design principles in a bid to make the professionals and the stakeholders in our built environment aware of their implicit need for application to Nigerian cities. The methodology relied on literature review of the terms and concepts. The study drew examples from the developed world to establish that the definitions of these concepts and terms are overlapping and complimentary. The concepts are also found to be applicable to Nigerian cities in the identified circumstances therein. Although some frameworks were identified, no cook-book or methodological pathways for their application to cities generally was encountered in the literature surveyed. It is hoped that the study has exposed their implications for current and future urban planning and design paradigms in Nigeria.

1.0 Introduction

The world is evolving so fast that we are losing trends in our efforts to be apace with developments in the urban arena. Many terms have come into play in shaping cities. Initially, it was the agricultural age when agriculture was the focal point. Then, from 19th century came the industrial age when industrial production dictated what happened to cities. Subsequently the garden city concept which proposed growth and spread outward from the city centre, along came the city beautiful and other urban concepts of the 20th century, (Gallion & Eisner, 2004). Presently we are again faced with new terms or/and concepts such as: 'smart city' with its talk of hi-tech inputs and intelligent systems; 'compact city' which connotes high density, mixed land use and closely–knit districts where living and working areas are within walking, cycling or riding distances and public transportation; 'resilient city' which emphasises ability to resist and recover from a catastrophe or unexpected perturbation and then 'sustainable

city' which implies sustainable use of city's resources and regeneration of such resources. In all these new concepts, there, certainly should be some kind of overlap in meaning, guidelines, principles and functions.

In the search for directions for urban design and planning in a developing country like Nigeria, it becomes imperative to evaluate these new concepts in order to harness their salient attributes for best practices. This would shape spatial design of Nigerian cities to be smart, compact, resilient and sustainable all at the same time. To this end, the aim of this paper is to briefly explore some existing literature on prevailing understanding of the concepts of smart, compact, resilient and sustainable cities and draw examples from some cities of the developed countries for application in developing countries like Nigeria. This is in answer to cognate questions namely: the design principles embedded in these terms; whether these principles are compatible with each other and our environment and how Nigerian cities can benefit from them.

1.1.1 Smart City

Smart City is an urban area that uses different types of electronic data collection and sensors to supply information which is used to manage assets and resources efficiently, (Townsend, 2017). Further, the author says that it is a designation given to a city that incorporates information and communication technologies (ICT) to enhance the quality and performance of urban services such as energy, transportation and utilities in order to reduce resource consumption, wastage and overall cost. The Smart City Council says it is one that has digital technology embedded across all city functions. The presence of digital system has become a symbol of urban-ness which enhances the quality, performance and interactivity of urban services. It also reduces cost and resource consumption, increasing contacts between citizens and government. It is seen as a vision for an inclusive and accessible urban future that aims at enhancing quality of living for its citizens through smart technology. Also, it is a city that has developed some technological infrastructure that enables it to collect, aggregate and analyzes real time data and makes concerted effort to use that data to improve the lives of its residents (NLC, 2016). Beyond a city, a view sees smart city as a local entity, a district, city, region or small country which takes a holistic approach in deploying information technologies with real-time analysis that encourages sustainable economic development (IDA, 2012). For some authors, the term smart city is an umbrella concept with the necessary ingredients for its composition such as smart urbanism, smart economy, sustainable and smart environment, smart technology, smart energy, smart mobility, smart health, smart people, smart living and smart governance (Lazaroiu and Roscia 2012; Lee *et al*. 2014; Jong *et al*. 2015; Lara *et al*. 2016: Trindade *et al*. 2017).While all these illuminate this concept in diverse ways and while ICT and intelligent solutions are the common trends, wide ranging definitions have been advanced in Giffinger *et al.* (2007), Nam and Pardo (2011), Caragliu *et al.* (2011), Bakıcı *et al.* (2012) and Lombardi *et al*. (2012) and others as amply summarized in Albino *et al*. (2015).

Smart city has functioned in the background as corporate projects not challenging existing power structure (formulation and solutions), (Baxter, 2012). In most existing cities, some form of smart technologies had been introduced in tackling one or two areas in the management of the city such as in transportation, fighting crime, etc. It focused on modest fixes to existing systems and solutions for better management enabled by digital technology. This is done incrementally as an upgrade on existing cities.

Angelidou (2017) opines that in the current 20 – year life span of smart cities, the subject has been studied not just by scholars in architecture and urban planning but has become a multidisciplinary interest in social sciences and engineering compelled by thinking about urban development, economic growth, and urban technology. However, the author contends that there still is a great deal of uncertainty about what smart cities stand for and how they can be realized, fuelled principally by the fact that the theoretical literature on how smart cities can be planned is inconclusive. As a result, the author argues that what is needed is a clearer view of the defining characteristics of smart city strategy.

Albino *et al*. (2015) and Anthopolous (2017) have summarized models of several authors into eight domains which include smart infrastructure (power, energy network, streets, building), smart transportation (mobility), smart environment, smart services, smart governance, smart people, smart living and smart economy. This can be illustrated as shown in Figure 1 below.

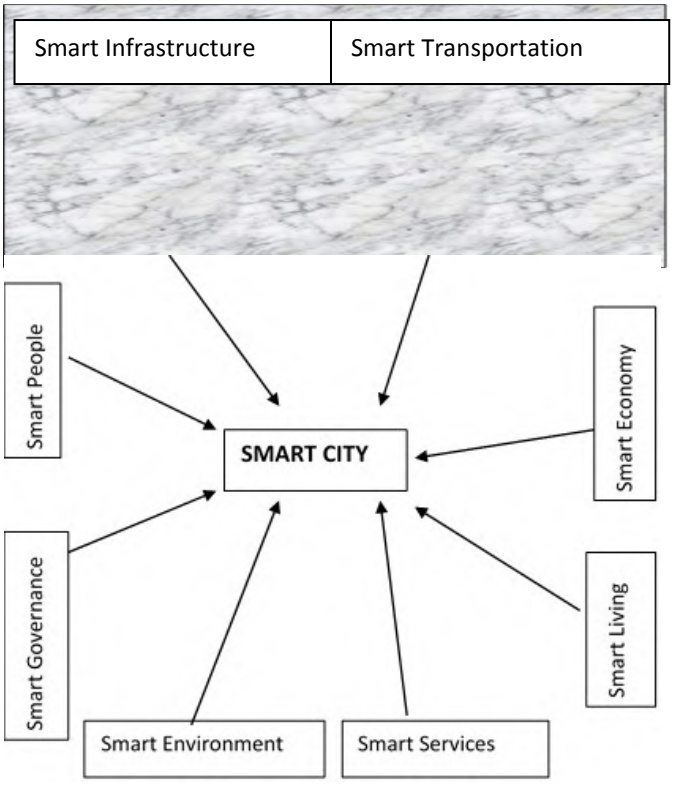

Figure 1: Components of a Smart City. *(Adapted from Albino et al.,2015 and Anthopoulos, 2017).*

1.1.2 Compact city

Today's cities are generally changing in shape and spreading out rather than retaining the compact nature that previously

characterized many old urban settlements in Europe and even in traditional African historical towns (Nuissl *et al.,* 2009; Rogatka & Ramos Ribeiro, 2015). The concept of compact city emerged as a reaction to the great increase in sprawling suburbs after Second World War. Compact cities are called "green cities" by some authors (Burton, 2002; XuanThinh *et al.,* 2002). Generally in a compact city, everyone lives and works within walking, cycling or riding distance of everywhere else, or a network of compact urban districts connected by rapid public transport which minimizes the need for cars and reduces impacts on the environment (Rogatka *et al.,* 2015). Compact cities minimize ecological footprint of developments. Although there are several components, a few important basic elements of compact city include the following: mixed land use and high density, short distances which encourage walking and cycling, social interactions, a well-planned city layout with efficient public transportation system or a network of compact urban districts linked by rapid public transportation. High densities imply less space consumed per capita with more land for agricultural and open spaces; bus and rail serve better in dense settlements with less reliance on automobiles; higher densities reduce society's environmental footprint and slow the consumption of non-renewable resource, (Ewing, 2008; Hussain *et al.* 2017). Another thought says that compact city is based on the process of intensification within city boundaries to increased density, centralization and mixed land uses while limiting development beyond the city boundaries (Churchman, 1999; Hussain *et al*. 2017). Furthermore, urban elements such as compactness, density, ecological design, sustainable transportation, variety, passive solar design and mixed land use are also used to assess the sustainability of urban forms, (Jabareen, 2006). These have been summarized by Rogatka, *et al.,* 2015 as shown in Figure 2

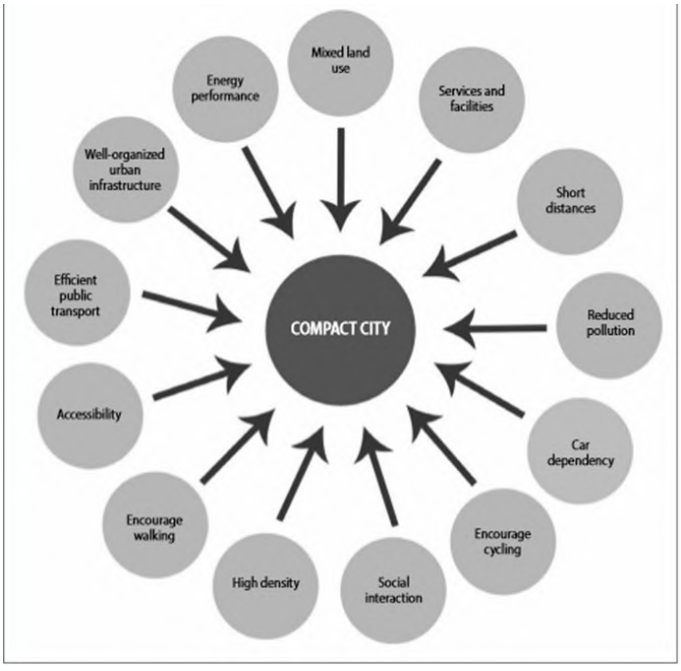

Figure 2. The main elements of a compact city (*Source: Rogatka & Ramos Ribeiro, 2015*).

According to Burton (2002), Mahriyara & Rhob (2014), there are 3 indicators for measuring urban compactness namely: density, mixed land use and intensification. These indicators are further divided into 12 variables. The density indicator include population density, built-up density and residential density variables and footprint. The mixed use indicator consists of the availability level of elementary school services , secondary schools, health facilities services, the number of medical power (medical doctors, dentists, and nurses), percentage of offices or working areas in land use, and percentage of recreational or free or green spaces in land use variables. The last is the intensification indicator which covers population growth rate and migration rate variables (Mahriyara *et al*, 2014). Further, UN-Habitat has recommended five principles of compactness including high density (at least 15,000 inhabitants per square kilometers), mixed land-use, social mix, limited land -use specialization, and an efficient street network, (UN-Habitat 2014). Based on their study of Lahore in Pakistan, (Hussain *et al.* 2017) put forth a framework of urban form characteristics and indicators to measure urban compactness or otherwise as shown in Table 1.These authors have also suggested that the development model of the compact city is a conceivable solution for a sustainable urban form.

Table 1: Framework for urban form characteristics and indicators

Urban Form Characteristics	Indicators	Calculation Formula
Density	• Gross population density • Average Town density • Density profile	$Gross\ Population\ Density = \frac{Estimated\ Population}{Area}$ $Average\ Town\ Density = \frac{Town\ Population}{Area}$
Transportation & Accessibility	• Average trip length • Road network density • Public transport accessibility	$Road\ Network\ Density = \frac{Road\ Length\ (meters)}{Population}$
Mixed Use Land Consumption	• Land use split up • Average land consumption per person • Ratio of residential to non-residential use • Ratio of built up to open area	$Ratio\ of\ Res.\ to\ Non-Res. = \frac{Residential\ Area}{Non-Residential\ Area}$ $Avg.\ Land\ Cons.\ Per\ Person = \frac{Town\ Population}{Average\ Land\ Consumption\ Area\ (Sq.m)}$ $Ratio\ of\ Built-up\ to\ Open\ Area = \frac{Built-up\ Area}{Open\ Area}$

Source: Hussain et al. 2017.

Resilient City

Resilience refers to future proofing cities and their built fabric to be better able to deliver basic functions in the face of future shocks, extreme events and stresses from natural and man-made hazards including climate change. Future

proofing is an on-going process rather than a definite end result. This is undertaken as the need arises for instance where there is a natural disaster like flooding, earthquake and extreme weather events. Resilience is also a city's capacity to absorb future shocks and stresses to its social, economic and technical systems as well as infrastructure. The hundred resilience city (100RC Network) programmes have been encouraging cities to join and learn from each other, (100RC programme). To determine a city's resilience requires appreciation of the threats, risk sources, locations and their vulnerabilities to articulate appropriate avoidance, adaptation and mitigation or risk reduction measures. A framework for such assessment requires a set of criteria of indicators, an example of which has been advanced and summarized by Sharifi & Yamagata (2014). Some of the major themes or indicators in these criteria include infrastructure, environment, economy, security, institutions and social/demographics. Sub-themes or sub-indicators under infrastructure for instance include spatial location and configuration and location, sheltering, building and design, defence structures (for instance a coastal or flooding defence), ecosystem, technology and information as well as planning and governance.

According to Asian Disaster Preparedness Centre – ADPC (2015), building a resilient city requires a holistic approach to city management and community engagement. To this effect and based on their experience, they identified five themes as the basis of the Resilient Cities Framework: risk and vulnerability reduction, inclusiveness, adaptive capacity, natural capital and knowledge management. These are illustrated in Figure 4 below.

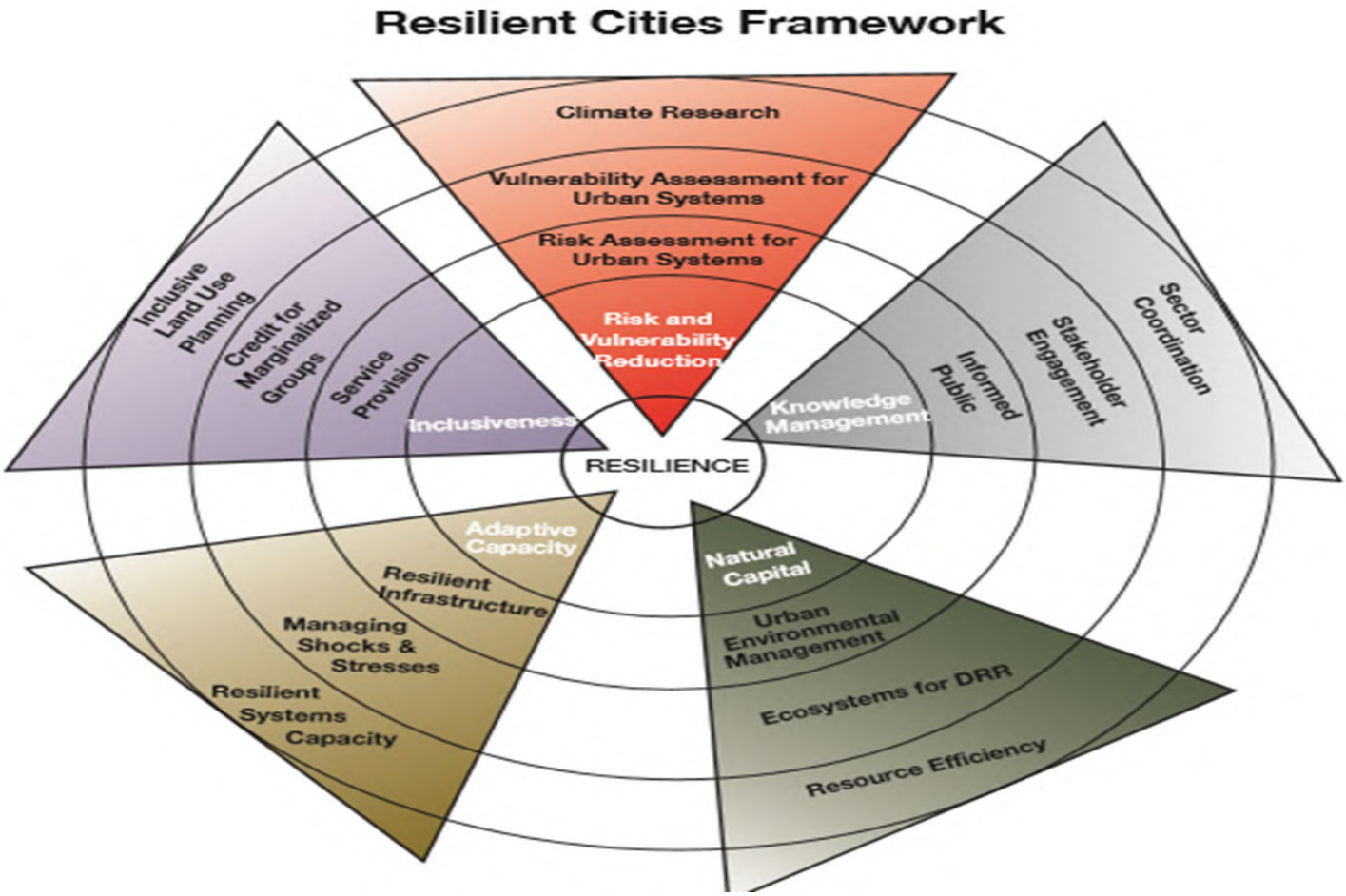

Figure 4: Resilient City Framework (Source: ADPC, 2015).

1.1.3 Sustainable City

Sustainable city pertains to a city which developed along the theory of using resources in a way not to endanger future generations' use of the same resources. The United Nations City Summit Habitat Agenda of 1996 proposed a built world 'in which economic development, social development and environmental protection are interdependent and mutually reinforcing components of sustainable development', ISC. This emphasizes that a country, region or city when using any resources should be aware of the effect of their consumption on others and so be considerate in their usage. Sustainable city is designed with consideration for social, economic, environmental impacts and resilient habitat for existing population without compromising the ability of future generations to experience the same, (Lachman, nd). It means that a sustainable city should be able to feed itself, power itself with renewal energy, and reduce ecological footprint, lower pollution and wastes. That means sustainable city should be equitable, diverse, connected and democratic and provide good quality life, (Bagherian, nd). Sustainable city principles can be summarized thus as shown in the Table 2below.

Table 2 Sustainable City principles

More Sustainable	Less Sustainable
Compact forms of residential Development.	Low-density, spread-out residential development.
Mixed land use; homes, jobs and shopping in close proximity/ TD.	Segregation of land uses: homes, jobs and shopping separated into uniform tracts or concentrations.
Employment based primarily on education and skills.	Employment based primarily on environment polluting or non-renewable resource based industry.
Movement on foot and by bicycle and transit.	Heavy dependence on private cars.
Wind and solar energy.	Thermal and nuclear energy.
Tertiary treatment of sewage; use of natural means of sewage treatment.	Discharge of sewage into water bodies or water-courses untreated or with low level of treatment.
Protection and use of natural hydrologic systems.	Hard surfaces preventing infiltration; channelling to natural water-courses.
Natural open space; protection of wetlands, woodlands, stream valleys, habitat, etc.; use of manure, compost, integrated pest management, etc.	Destruction of natural landscape; "manicured" parkland with exotic species; heavy use of chemical fertilizers, herbicides, pesticides.
Reduction of waste; recovery, re-use and recycling of waste materials.	Landfills, incinerators.

Source: Nigel Richardson. Prepared by the Ontario Round Table on Environment and Economy, sustainable community resource package.

From Table 2 above it can be said that sustainable city should have a development path where progress is not at the expense of future generation such as bad planning, having huge debts and exporting present problems to the future.

In their review of the literature on sustainable development of smart cities, Trindade *et al*. (2017) interrogated the relationship between the concepts of sustainable urban development and smart cities. They suggested that these concepts are not contradictory but partially overlapping. To study cities in terms of sustainability, they advocated, it is necessary to understand the meaning of sustainable urban development. To illuminate this, they put forth Hiremath et al. (2013) definition of sustainable urban development as that which achieves a balance between the development of the urban areas and protection of the environment with an eye on equity in income, employment, shelter, basic services, social infrastructure and transportation. To expand on this, Dhingra and Chattopadhyay (2016) indicate that there are four attributes of the smart and sustainable cities, namely: (a) sustainability; (b) quality of life; (c) urban aspects, and; (d) intelligence. According to Kondepudi, 2014) and Trindade et al. (2017), these are analysed under four main themes including: (a) society; (b) economy; (c) environment, and; (d) governance. Equally, Yigitcanlar and Lee (2014) contended that a similar concept, smart-eco city, proposes that the city should be ecologically healthy, using advanced technologies with economically productive and environmentally efficient industries, have a responsible and harmonious systematic culture, a physically aesthetic and functionally living landscape.

1.2 Urban Design Approaches for Smart, Compact, Resilient and Sustainable Cities in the Developed Countries.

Urban design is a process of planning an urban area with respect to the use of resources and the comfort of the people, (Fadamiro, Ajenifujah & Adelowo, 2005). It is a creative, collaborative, place-making process which involves creating three-dimensional urban forms and spaces to enhance the experience and functions of towns and cities as habitats for human life (Wall & Waterman, 2010). The main purpose of urban design is functionality, safety, aesthetics, health and others. Urban design is based on three issues; structures, open spaces and nature. Structure includes buildings, streets, highways, parking areas, public utility and others. Open spaces include parks, playgrounds, green ways, right of ways (ROWs'), nature reserves, watersheds and riparian corridors while nature comprises ground forms, rocks, plants, water resources (Emenike, 2014). Nature is always working for man. We eat from nature; we build on nature and leave our waste (sink) on nature. All these are better done in their natural setting, (McHarg, 1992).

Urban design is the architecture of the city design which talks about commodities, firmness and delight. Commodity describes usefulness, suitability and value; while firmness is a state of being firm, stable or hard and delight gives pleasure or a joy to behold. An aspect of commodities is sustainability. Urban design thrives on making a city sustainable, which is to be able to sustain its physical, social and economic structure, (Okedele, 2005).

Beckley (1979) viewed urban design as focusing on the form of urban settlements and the cultural processes affecting them. It is the urban form and its peoples' reaction to it, occurring in two levels: the physical and the psychological. These help to shape and influence the growth of the city. In the design of urban centre, the issues at stake are the urban form, then the economic and the socio/cultural aspects or sense of place. These invariably affect the social milieu. Sustainability hinges on environmental quality and social equality.

For new towns and settlements in most developed urban centres, their urban design strategies are very distinct and well planned ahead of any human habitation, projecting into the future well ahead of these developments. Any other unforeseen occurrence is taken care of as it arises. In this, some specific principles such as sustainable city approach, compact, resilient city and /or smart city approach are deployed.

Sustainable city approach is to develop a path of progress that is not at the expenses of future generation and there

should be equilibrium between different issues **(ISC**, nd).Resilient city uses integrated approach in promoting social, economic and spatial inclusion. It encourages public participation (100RC). Smart city approach employs digital technology to improve municipal, management, governance and long–range design and planning (Townsend, 2017).The issues addressed in these various city planning and management are as listed in table 3 below.

Table 3: Issues in city planning & management ranked in order of priority

Economy	**Land use**	**Society**	**Input/output**
Economic transition to market economy	Transportation (roads, trains)	Jobs	Energy (renewable/non-renewable)
Energy efficiency	Green areas	Housing	Sewage
Public transport vs. cars	Ecological footprint	Social welfare	Solid waste
Waste prevention & reduction	Industrial sites	Civil society/public participation in decision making	Air pollutants
Legislation/ enforcement	Buildings	Law & order	Raw materials (mining, agriculture, recycling)
Financial institutions/ instruments	Urban sprawl	Education	Water
Pollution paid for by the polluter	Landfills	Immigration	Food
Abandoned industrial sites	Zoning/planning	Health	Fresh air
		Access to Information	Noise
		Crime	
		Competence/ capability/ cooperation of stakeholders	
		Poverty	
		Aesthetic value of a city	
		Population (population size, demographic trends)	
		Culture	
		Environmental awareness	
		Ethnic/social Segregation	
		Historic preservation	

Source: Regional Environmental Center for Central and Eastern Europehttp://www.rec.org/

1.2.1 Examples of these Concepts from around the Developed World

Adelaide a city in Australia developed an urban forest to improve air and water quality, beautify and cool the city, making the city more liveable, reduce greenhouse gases and conserve wild life habitats in the city. Also it developed solar power, wind power and energy from waste recycling to reduce reliance on conventional power sources and hydropower, (100RC).

Rotterdam developed innovative approach to water management, (100RC) as the problem of the world is water crisis, (droughts, floods, and sea level rise), too much or too little water in most cities of the world, (Zanuso, 2016).

Rio de Janerio, Brazil's aspiration for a more resilient city is focused on evolving a relationship with water, its built infrastructure and citizens. It started by adapting to the realities of extreme weather events and formed a climate change panel. With this they expected to create climate risk maps and expand access to green space and strengthen their built and human infrastructure. They also expected to change to 75% LED bulbs, a part of smart grid with sensors to identify traffic conditions, neighbourhood micro climates, saturation of road infrastructure and track crimi-

nal activities in city's trouble spots (Baxter, 2012).

San Francisco in USA launched an Open Data initiative in 2009 which supports smart cities initiative aimed at reducing greenhouse gases, improve and increase public transportation services. San Francisco was declared the greenest city in USA in 2011, (NLC, 2016).

Charlotte, North Carolina USA had in 2011 established a Public/Private Collaboration (PPC) known as Envision Charlotte. It helped the city to sustain its accelerating population growth as well as work on ways to reduce energy use in commercial buildings through behavioural changes, (NLC, 2016).

London, United Kingdom is a practical example of a Compact City principle application. The Strategic Plan for London or the London Plan of 2004, revised in 2011 and 2014 was rooted in this strategy. Fuelled by challenges of population growth coupled with the need to protect existing open spaces and impact less on the environment, the key objective of this plan was to cater for population growth within the existing Greater London Area (GLA) boundary at the time. By focussing residential and employment growth within a limited area it was envisaged, travel distances would be curtailed thereby reducing transport infrastructure costs and containing environmental pollution (Bowie, 2017). This was the impetus for the subsequent development of existing commercial areas such as Canary Wharf.

1.3 Current design, planning and management approaches to modern cities in Nigeria.

Abuja the capital city Nigeria is used as a case study. Most Nigerian cities grew from their traditional setting with some form of master plan or piecemeal planned sections being added or juxtaposed with the existing structure later on. This often makes it very difficult to characterize the structure of Nigerian cities in terms of modern city forms. In reality, only few Nigerian cities have had city-wide land use plans or master plans. With the exception of Abuja which took off with a prepared master plan (which has seen no revision since inception), Lagos had a plan document (Land use Plan 1977 – 2000) with unrealized revisions and Owerri had a twin-city approach as master plan at inception of the state, most other Nigerian cities and towns lack master plans which can be located in the public domain. They therefore largely grew and sprawled from their traditional settings. Indeed Barrow (1995) as cited in Tindade et al. (2017) had opined that long travel distances, health, congestion and fuel emissions, inequity, pollution and degrading environment, loss of land such as agricultural and natural assets, are major issues seen in developing world cities due to an impact of a physical urban form.

This was not largely the case with Abuja which was planned on a virgin land without encumbrances except for the natural environment that was utilized. Abuja city was conceived as a symbol of national unity, with mini-cities of a population of 150,000 to 250,000 people. These mini-cities were organized around a community core occupied by local businesses and employment centres and connected to other parts of the city by exclusive transit ways. Abuja city as was planned by International Planning Associates (IPA) was to be built in phases.

Phase 1 comprised the city's inner district made up of Central Area, Maitama, Asokoro, Wuse and Gariki, all spreading out from the foot of Aso Rock separated by expressways. The city is integrated to the federal road network through A2 highway which transverses Abuja to Kaduna (north bound) and Lokoja (south bound). Abuja Central District (CD) is located between the foot of the Aso Rock and into the 3Arms Zone to the southern base of the ring road. The CD divides the city into northern sector (Maitama and Wuse) and the southern sector (Gariki and Asokoro). Each district is clearly defined with commercial and residential areas, (FCDA nd).

Abuja city as conceived and planned should have been a model of a beautiful sustainable city but for one thing. Population overwhelmed the city and there seemed to be an obvious lack of political will and a lot of self interest which militated against strict adherence to the master plan. This led to a lot of sharp practises and illegalities going on unabated resulting in frequent demolition of illegal structures.

1.4 Towards a Future Smart and Sustainable City in Nigeria

In our movement to the future, we need to make some radical changes in the way things are done. First, there should be a total overhaul of our planning laws, regulations and codes in line with the current paradigms. The most current planning law in Nigeria is Cap of 1992 known widely as urban and regional planning law of 1992. But it is still not operative in most states in Nigeria. These states are still using the old 1946 planning law which was modelled after UK's 1932 law. The 1992 law really pointed a way forward but enforcement has always been the major problem in Nigeria. Any new strategy, we need to emphasise enforcement procedures and penalties for non-compliance. This is very necessary because this is where the task of our moving forward is hinged.

Secondly, various geopolitical zones in the country have different ecological issues such as floods, prolonged droughts, deforestation, erosion and lately climate change, some of which can be tackled through approaches embedded in some of the concepts discussed herein, while backed with requisite data and data bases. To build resilience and hence risk reduction, for instance our existing and future cities, require requisite topographic mapping with current aerial techniques at appropriate scales to properly identify vulnerabilities and environmental hazards.

Thirdly, from this review: the definitions of these concepts explored are not contradictory but partially overlapping and even complimentary to each other. A resilient city can be made smart through the infusion of technology and digital tools to generate smart urbanism, smart living/mobility/ governance and so on, in addition to sustainable urban development. These are technologies for city-wide geo-data collection and management; those for public participation and technologies for sectorial applications such as rapid transit, energy infrastructure and others (Stratigea et al. 2015; Angelidou, 2017). In the similar manner, a few authors have advocated the compact city concept and strategy as a conceivable solution for a sustainable city and sustainable urban form as

exemplified by the London Plan (Burton, 2002; UN- Habitat, 2014; Liaqat et al. 2017; Bowie, 2017).

In consequence, much as Nigerian towns and cities are growing and sprawling in piece-meal fashion without comprehensive plans, opportunities abound to key into these concepts and strategies towards smart, compact, resilient and sustainable cities. The planning/design strategy to achieve these could lie within a twin city approach as deployed in the Owerri Capital city master plan. In this scenario, traditional and old cities could undergo urban regeneration with the application of both compact and resilient city concepts to recreate nucleated, pedestrian communities and districts linked by rapid transit and embedded smart technologies. The new cities and expansions can equally be planned afresh under a comprehensive master plan with compact, resilient and smart city strategies to limit ecological footprint and achieve sustainable development. Under our current energy and infrastructure challenges, the application of smart technologies to the management of our cities for efficiency and sustainability can only witness limited progress until significant improvements in the quantum of energy delivered for living, working and operating cities from diversified energy mix appreciates. Smart technologies depend on steady energy supply, whether active or passive.

There is need to enhance the quality of life on our urban centres by improving on urban sustainability. To do this we should make use of our current urban fabric, work on generating urban data base and then open up avenues for application of smart technologies and solutions in our urban planning and management (Beurden et al. 2017).

2. Conclusion

The world is evolving so fast that we in Nigeria should not be left behind. There is a need to realign our priorities so as to key into the current urban paradigms. We need smart, resilient and sustainable cities in Nigeria. They do not just happen; we have to work towards that.

This paper reviewed the literature to illuminate briefly some of the prevailing definitions of urban concepts. Part of this was to ascertain their compatibility or otherwise, draw examples internationally and ideate briefly on their application to Nigerian cities. It was established that the definitions of these concepts are overlapping and complimentary to each other and are applicable to our cities and towns in certain circumstances identified. Although some frameworks were identified, no cook-book or systematic, methodological pathways for the application of these concepts to the planning/ design of cities generally were encountered in the literature surveyed. Two scenarios for their application in the Nigerian cities were briefly advanced. Some suggestions on the way forward for our cities were also made. It is further recommended that public research be funded by appropriate authorities and agencies of government to develop tools for collection, storage and analyses of urban data, to develop strategies for digital infrastructure alongside other infrastructure.

Reference

Albino, Vito, Umberto Berardi and Rosa Maria Dang (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology*, 2015, 1-19 http://dx.doi.org/10.1080/10630732.2014.942092.

Angelidou, M. (2017): The Role of Smart City Characteristics in the Plans of Fifteen Cities, Journal of Urban Technology, 1-28. DOI: 10.1080/10630732.2017.1348880.

Anthopoulos, L. G. (2017) Understanding Smart Cities: Tool for Smart Government or an IndustrialTrick. http:/ www.springer.com/9783319570143.

Asian Disaster Preparedness Center –ADPC, Department of Resilient Cities & Urban Management (2015).Resilient Cities Framework. Accessed online on 30/10/18 at https://www.adpc.net

Bagherian, B. Baharash Architecture. https:// www.baharash.com/what-is-a-sustainable-city/

Barrow, C. J. (1995). "Sustainable development: concept, value and practice." *Third World Planning Review* 17 (4): 369.

Baxter, S. (2012).'Modest gains in first six months of Santa Cruz' predictive police program' Accessed at: http:/www.santacruzsentinel.com/general-news/20120226/modest-gains-in-first six-months-of-sant -cruz-predictive-police-program.

Beckley, R. M. (1979) Urban Design. In A. J. Catanese& J. Snyder (ed)(1979).Introduction to urban planning.

Beurden, J. B, Kallaos, J., Gindroz, B., Riegler, J., Noll, M., Costa, S. And Maio, R, (2017). Smart City Guidance Package for Integrated Planning and Management.Norwegian University of Science and Technology.

Blowers, A. (ed) Planning for a sustainable environment; a report of the Town and Country planning association.

Bowie, Duncan (2017). Beyond the compact city: a London case study – spatial impacts, social polarisation, sustainable development and social justice. *Reflections*, Issue 19: 1- 30.University of Westminster.

Burton, E. (2002). Measuring urban compactness in UK towns and cities.*Environment and Planning B: Planning and Design* 29 (2): 219-250.

Correia, L. M. &Wunstel, K. (2011) Smart Cities Application and Requirements. (white paper) from Net!work European Technology Platform.

Caragliu, A., C. Del Bo, & P. Nijkamp (2011).Smart Cities in Europe.*Journal of Urban Technology,* 18: 2 (2011), 65–82.

Churchman, A. (1999).Disentangling the concept of density.*Journal of Planning Literature* 13(4): 389-411

Deakin, M. (2013) From Intelligent to Smart City.In M. Deakin. Smart Cities: Governing, Modelling and Analysing the Transition. Taylor and Francis.

Dhingra, M., &Chattopadhyay, S. (2016). Advancing smartness of traditional settlements-case analysis of Indian and Arab old cities. *International Journal of Sustainable Built Environment*, 5(2), 549– 563.

Emenike, (2014) Evaluation of Environmental and Landscape Qualities of Public Open Spaces in Enugu Metropolis. Unpublished Doctoral thesis, ESUT, Enugu.

European Commission.Digital Agenda for Europe.https://ec.europa.eu/digital-agenda/

Ewing, R. H. (2008). Characteristics, Causes, and Effects of Sprawl: A Literature Review. *Urban Ecology: An International Perspective on the Interaction between Humans and Nature.*In J. M. Marzluff, E. Shulenberger, W. Endlicher et al. Boston, MA, Springer US: 519 - 535.

Fadamiro, J. A, Ajenifujah&Adelowo, W, (2005) Urbanisation in an emerging Nigerian city:
the need for sustainable development. In A compilation of congress seminar papers.Abuja, pp.122-135.

Gallion, A. B. & Eisner, S. (2004) The Urban Patterns: City Planning and Design. New Delhi,
CBS Publishers.

Giffinger, R., C. Fertner, H. Kramar, R. Kalasek, N. Pichler-Milanovic& E. Meijers (2007). Smart Cities: Ranking of European Medium-sized Cities (Vienna: Centre of Regional Science, 2007).

Hiremath, R. B., Balachandra, P., Kumar, B., Bansode, S. S., &Murali, J. (2013). Indicator-based urban sustainability: A review. *Energy for Sustainable Development*, 17(6), 555–563.

HussainLiaqat, Abdul Waheed, NaeemAsghar Malik and Imtiaz Ahmed Vohra (2017). Measuring Urban Sustainability through Compact City Approach: A Case Study of Lahore. *Journal of Sustainable Development Studies,* Volume 10, Number 2, 2017, 61-81. ISSN 2201-4268.

http://www.ida.gov.sg/~/media/Files/Infocomm%20LandscapeiN2015Reportsrealisingthevisionin2015.pdf.

InstituteforSustainableComwww.learningsustainability.com/sustainable-cities.htm/

Jabareen, Y. R. (2006). Sustainable urban forms, their typologies, models, and concepts.*Journal of planning education and research* 26 (1): 38-52).

Jong, M., Joss, S., Schraven, D., Zhan, C., &Weijnen, M. (2015). Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. *Journal of Cleaner Production*, 109, 25 – 38.

Kondepudi, S. N. (2014). Smart sustainable cities analysis of definitions. The ITU-T focus Group for Smart Sustainable Cities, United Nations, Washington.

Lara, A., Costa, E., Furlani, T., &Yigitcanlar, T. (2016). Smartness that matters: Comprehensive and human-centred characterisation of smart cities. *Journal of Open Innovation*, 2(8), 1–13.

Lazaroiu, G. C., &Roscia, M. (2012).Definition methodology for the smart cities model. Energy, 47(1), 326–332.

Lee, J. H., Hancock, M. G., & Hu, M. C. (2014). Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. *Technological Forecasting and Social Change*, 89, 80 –99.

Lombardi, P., S. Giordano, H. Farouh, & W. Yousef (2012) Modelling the Smart City Performance.
Innovation: The European Journal of Social Science Research 25: 2 (2012) 137–149.

Mahriyara, M. Z. and Jeong Hyun Rhob (2014).The Compact City Concept in Creating Resilient City and Transportation System in Surabaya. *Procedia - Social and Behavioral Sciences* 135 (2014) 41 – 49. Available online at www.sciencedirect.com.Accessed on 18/10/18.

McHarg, I. L. (1992).*Design with nature*. 2nd edition Canada; John Wiley and Sons, New York.

Nam, T. & T.A. Pardo (2011). Conceptualizing Smart City with Dimensions of Technology, People, and Institutions. *Proceedings of 12th Conference on Digital Government Research, College Park, MD*, June 1 2 – 15, 2011.

National League of Cities (NLC): Center for City Solutions and Applied Research (2016).

Trends in Smart City Development. NLC, Washington D. C. Accessed on 5/10.2018 at https://www.nlc.org. 44p.

New J., Castro D., & Beckwith M. (2017). How National Governments Can Help Smart Cities Succeed. Centre for Data Innovation

Nigel, R. Characteristics of Sustainable Cities. Archive.rec.org/REC/Programs/sustainable citieS characteristics.htm/

Nuissl, H., Haase, D., Lanzendorf, M. &Wittmer, H. (2009) Environmental impact assessment of urban land use transitions – a context-sensitive approach. *Land Use Policy* 26 (2), pp. 414 – 424. DOI: 10.1016/j.landusepol.2008.05.006.

Okedele, N. (2005). The concept of sustainable architecture of city building in African Urbanisation. In A compilation of congress seminar papers, Abuja, pp 161-185

Orka, J. W. (2018) Three Requirements for Successful 'Smart Cities' https://www.cowi.com/insights/three-requirements-for-successful-smart-cities

Rogatka, K. & R. R. Ramos Ribeiro (2015). A compact city and its social perception: A case study. *UrbaniIzziv,* Vol. 26, No. 1 (2015), pp. 121-131.

Sharifi, Ayyoob&Yoshiki Yamagata (2014). Resilient urban planning: Major principles and criteria. *Energy Procedia*61 (2014) 1491 – 1495 doi: 10.1016/j.egypro.2014.12.154

Smart Cities Council.http://smartcitiescouncil.com/smart-cities-information-center/definitions-and-overviews

Smart Cities Mission (2015) http://smartcities.gov.in/ Ministry of Urban Development,
Government of India.

Stratigea, A., C. A. Papadopoulou and M. Panagiotopoulou (2015).Tools and Technologies for Planning the Development of Smart Cities.*Journal of Urban Technology* 22: 2 (2015) 43 – 62.

Trindade, E.P., Marcus Phoebe FariasHinnig, Eduardo Moreira da Costa, Jamile Sabatini Marques, Rogério Cid Bastos and Tan Yigitcanlar (2017). Sustainable development of smart cities: a systematic review of the literature. *Journal of Open Innovation: Technology, Market, and Complexity* (2017) 3:11, 1-14. DOI 10.1186/s40852-017-0063-2.

Townsend, A. (2017) Smart Cities: What do we need to know to plan and design them better?
MediumHomepagehttps:medium.com@anthonymobile/smart-cities-what-do-we-need-to-know-plan-and-design-them-better-b6d05e736ea1

Townsend, A. (NA) Smart Cities: Big Data, Civic Hackers and the Quest for a New Utopia

UN-Habitat. (2014). A new strategy of sustainable neighbourhood planning: five principles. *Urban Planning Discussion Note 3*. Retrieved from https://unhabitat.org/wpcontent/uploads/2014/05/5- Principles_web.pdf).

Wall, E. and Tim Waterman (2010).*Basics Urban Design*. Ava Publishing SA, Lausanne, Switzzerland.184p.

Wikins M (NA) Smart Cities have significant economic benefits, https;/www.quora.com/what-is-the-concept-of-a-smart-city/

XuanThinh, N., Arlt, G., Heber, B., Hennersdorf, J. & Lehmann, I. (2002) Evaluation of urban
land-use structures with a view to sustainable development. *Environmental Impact Assessment Review,* 22(5), pp. 475– 492. DOI: 10.1016/S0195-9255(02)00023-9

Yigitcanlar, T., & Lee, S. H. (2014). Korean ubiquitous-eco-city: A smart-sustainable urban form or a branding hoax? *Technological Forecasting and Social Change*, 89, 100–114.

Zanuso, V. (2016) Water Management and Multi Benefit Solutions: The Rotterdam Exchange. http://100resiliencecities.org/water-management....