Low Carbon and Smart Cities for Achieving SDG 2030: Resilient Dynamism Trends in Nigeria

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Abstract

The advent of the 21st century has witnessed an unprecedented surge in urbanization, transforming cities into epicenters of economic dynamism, innovation, and societal evolution. Yet, this rapid urban growth, coupled with environmental degradation, has presented multifaceted challenges, necessitating a paradigm shift towards resilient, eco-friendly smart cities to meet the Sustainable Development Goal (SDG) 2030 objectives. This paper focuses on the context of Nigeria, a nation undergoing rapid urbanization, and explores the transition towards sustainable urban development. The research elucidates how resilient, low-carbon smart cities play a crucial role in addressing the intertwined issues of urbanization, climate change, and sustainable development. Emphasizing the importance of comprehensive planning and strong governance frameworks, the paper advocates leveraging cutting-edge technologies like Internet of Things (IoT), artificial intelligence, and big data analytics to bolster urban resilience and mitigate carbon emissions. Ultimately, the paper calls for a paradigm shift towards resilient, low-carbon smart cities as a linchpin for attaining SDG 2030 in Nigeria, stressing the necessity of collaborative efforts among policymakers, urban planners, academia, civil society, and the private sector to forge a path towards inclusive, equitable, and environmentally sustainable urban development.

Keywords: Low-carbon Smart cities, SDGs, Urban planning, Climate change, Nigeria

Introduction

Presently, the world is experiencing an unprecedented surge in urbanization, a demographic trend alongside population growth, aging, and international migration. According to the World Bank's estimation in 2020, based on data from the UN People division, approximately 4.3 billion individuals reside in cities, constituting 55% of the global population and that by 2050, the figure will escalate to 7 billion, equivalent to 75% of the populace (UN Habitat, 2020; World Bank, 2021). Additionally, many middle-income countries spanning Eastern Europe, East Asia, Africa, and South America, urban dwellers already account for between 50% and 80% of the population, with figures exceeding 80% in most high-income countries across Australia, Japan, the Americas, the Middle East, and Western Europe (Ritchie & Roser, 2019; UN, 2019). As reported in December 2020 article by Forbes, the global smart city industry's market size is poised to double, surging from $410.8 billion in 2020 to $820.7 billion by 2025. The 17 objectives outlined in the 2030 Agenda for Sustainable Development, adopted by 193 United Nations member states in 2015, underscored the pivotal role of cities as focal points of economic, social, and cultural activity capable of concurrently addressing numerous sustainability goals and offer faster and more pragmatic responses to associated challenges (UN, 2016; Kaika, 2017). At the core of this agenda lies SDG 11, which seeks to develop sustainable cities, bolster urban resilience, foster inclusive urbanization, and curtail carbon emissions (UN, 2016).

Globally, policy makers are confronted with the daunting task of curbing with increase of urbanization, likened to wildfire (Eremia, Toma & Sandulec, 2017; Pašalić, Ćukušić & Jadrić, 2021). A myriad of environmental and socio-economic issues, including but not limited to pollution, unemployment, and poverty, are attributed to heightened levels of urbanization (Bodo, 2019; Kolandaisami, 2020; Chigara, 2020). Nigeria has been specifically identified by Opoko and Oluwatayo (2014) and Bodo (2019) as one African nation grappling with a surge in urbanization and its associated challenges, exacerbating susceptibilities to the impacts of climate change and environmental hazards. Consequently, an urgent transition to a sustainable built environment is imperative, particularly in regions where a significant portion of current urban expansion is occurring, and where cities are characterized by low institutional capacity and the commodification of urban land, thereby giving rise to intricate urban challenges such as ecosystem degradation, environmental pollution, and heightened vulnerability to natural disasters (IEA, 2011; UN, 2017a; UN-Habitat, 2018).

According to Dameri (2013), cities are moving towards more friendly urban environments, employing advanced technologies to tackle various challenges of urban life. The rise of technology, particularly the Internet of Things (IoT), has catalyzed the concept of smart cities (Albany et al., 2022). Proponents of the smart cities postulate that smart cities offer solutions to many of the problems associated with urbanization and serve as a strategy to mitigate the effects of climate change (Chourabi et al., 2012). Smart cities represent the fusion of technology, sustainability, and human-centered design aimed at addressing the multifaceted challenges encountered by urban areas globally (Jiogap & Abdryashitova, 2020; Oke et al., 2020). These cities utilize cutting-edge advancements in digital infrastructure, data analysis, and connectivity to enhance residents' quality of life, optimize resource allocation, and stimulate economic development (Aliyu & Amadu, 2017; Odefadehan, 2021). According to Silva et al. (2018), a smart city is one that integrates human and cyberspace, emphasizing connectivity and interaction. Therefore, effectively addressing the intricate interplay of

urbanization, climate change, and sustainable development necessitates a comprehensive approach that encompasses policy interventions, technological innovations, community involvement, and collaboration among stakeholders. This paper therefore assessed the transition towards resilient and low carbon smart cities in Nigeria, with a keen focus on achieving SDG 2030 targets. It seeks to unravel the intricacies of urbanization dynamics, climate change impacts, and sustainable development imperatives within the Nigerian context.

Overview of Sustainable Development Goals (SDGs)

The first major milestone in establishing the importance of the environment on a global scale was the 1972 UN Environment Summit in Stockholm (UNGA,1983). This Summit, alongside the adoption of the Policy Declaration and Action Plan, resulted in the establishment of the UN Environment Program. Fifteen years subsequent to the Stockholm Summit, in 1987, the Norway Minister of Environment, Mrs. Brundtland set up the eponymous special committee to look at the issue of development and its impact on the environment (Brundtland, 1987). The resulting Brundtland Report, titled "Our Common Future," introduced the concept of sustainable development for the first time, defining it as development that fulfills the needs of the present generation without compromising the ability of future generations to meet their own needs. This report pioneered the linkage between environmental protection and economic development, social welfare, and prosperity, marking the inception of the consolidation of sustainable development principles.

In 1992, two decades following the Stockholm Summit, the United Nations convened its World Conference on Environment and Development in Rio de Janeiro, Brazil (UN, 1993; Drexhage & Murphy, 2012). The principal outcome of this gathering was the preparation of a document known as "Agenda 21," outlining the responsibilities and objectives of the international community in pursuit of a better quality of life and sustainable goals for the 21st century. Agenda 21 comprised 40 chapters addressing various aspects concerning the interconnection of the economy, society, and environment, ranging from poverty alleviation to issues of development cooperation and the necessity for the establishment of appropriate institutions. Subsequent to the Rio Conference in 1992, leaders from 189 nations convened at the United Nations Headquarters in September 2000 and adopted the momentous Millennium Declaration, committing to the achievement of a set of 8 goals, 18 targets, and 48 indicators (UN, 2000, 2001; UNDP, 2020). These Millennium Development Goals (MDGs) spanned from 2000 to 2015, primarily focusing on the needs for developing countries to commit to halving extreme poverty and hunger, promoting gender equality, reducing child mortality, and ensuring sustainable utilization of natural resources by the specified deadline of 2015 (UNDP, 2012).

Drawing upon the lessons learned from the Millennium Development Goals (MDGs) era, the UN General Assembly's Open Working Group (OWG) proposed a 15-year Sustainable Development Agenda comprising seventeen goals (17) for the approval of the General Assembly in July 2014 (UN Foundation, 2019). This agenda was adopted at the 70th General Assembly in New York in September 2015, with the participation of delegates representing 193 United Nations member countries, under the theme: "Transforming Our World: The 2030 Agenda for Sustainable Development" (UN, 2015). Agenda 2030 represents the most ambitious global agreement ever reached by the UN, serving as an action plan to achieve social inclusion, economic growth, and environmental sustainability spanning the years 2015 to 2030 (Allen, Metternicht, & Wiedmann, 2018; UN, 2020a). The Sustainable Development Goals

(SDGs) are interconnected and multifaceted, designed such that the accomplishment of specific goals would, in various ways, contribute to achieving others. SDG 11 of the United Nations Agenda 2030 calls for national governments to facilitate transformative change in cities and communities, aiming to create settlements that are safe, resilient, inclusive, and sustainable for their inhabitants (Chidinma, Ogochukwu, & Chinwe, 2020). SDG 11 emphasizes the provision of access to safe, affordable, and sustainable housing and basic amenities, as well as the promotion of sustainable urbanism and the sustainable planning and management of human settlements (UN, 2018).

To ensure the effective implementation of development strategies and the tracking of progress towards the 17 Sustainable Development Goals (SDGs) by United Nations member countries, the United Nations established a comprehensive Global Indicator Framework (GIF), comprising 232 indicators (Fukuda-Parr, 2014; UN, 2019; Miola & Schiltz, 2019; UN, 2020b). These indicators serve as the practical means through which national governments can monitor achievement and report progress on each of the 169 targets outlined in the 2030 agenda. On the other hand, developed nations typically rank high in SDG performance, while Nigeria, with an underdeveloped economy, ranked 160th in the SDG Index 2021, achieving an overall score of 48.93 (Miola & Schiltz, 2019; Sachs et al., 2021).

Researchers have begun exploring the connection between Nigeria's struggle to achieve sustainable urbanization and the legacies inherited from colonial rule (Craggs & Neate, 2017; Sachs et al., 2021). The issue of inadequate sustainable urban development, manifested through substandard housing, the proliferation of informal settlements, insufficient access to energy, water, and sanitation services, and ineffective land use and urban planning, has been a concern for both the government and, more recently, the private sector (Arudi, 2017; Bello, 2019). For attaining SDG 11, technology has presented opportunities for developing tools and strategies for addressing significant global developmental challenges highlighted in the SDGs. Therefore, advanced technology, information dissemination, and suitable infrastructure are encouraged (Omobolade, 2018).

Smart City Concept

Different paradigms and concepts have emerged to address urban complexities throughout different historical periods. One contemporary approach gaining increasing popularity is the Smart City concept, often portrayed within a neoliberal context and presented as a utopian vision for sustainable development (Grossi & Pianezzi, 2017). The term "Smart City" emerged in the early 1990s, sparking a rapid expansion in its application (Yin et al., 2015; Anthopoulos, Janssen & Weerakkody, 2016; Allam & Newman, 2018). In 2008, the International Business Machines Corporation (IBM) in Armonk, NY, USA, proposed the concept of the "smart city" as part of its "smart earth" strategy (Qian, 2023). Smart cities aim to integrate intelligent sensors into the Internet of Things systems governing public resources such as power grids, hospitals, oil and gas pipelines, highways, subways, and buildings, enabling real-time monitoring of key information within core urban systems. This approach is widely employed to address urban complexity and challenges, enhance quality of life, and foster the development of sustainable cities (Monfaredzadeh & Berardi, 2015). However, within theoretical discourse in urban planning and social science, there lacks a specific definition and framework for Smart City concepts (Vanolo, 2016).

Several definitions have been suggested for the concept of a smart city, with some variations in terminology such as substituting "smart" with terms like "intelligent" or "digital."

Additionally, instead of referring to a city, certain definitions extend to encompass a "community" (Albino, Berardi & Dangelico, 2015). Furthermore, Albino, Berardi, and Dangelico (2015) and Dinca et al. (2022) assert that the smart city concept was initially delineated as the application of information and communications technologies and was characterized as a sustainable urban model. The smart city represents a novel urban development paradigm that combines the internet and modern information technology with urbanization to foster development driven by factors, investments, and innovation (Clarke, Kuipers & Roos, 2019; Qian, 2023). According to the British Standards Institute, smart cities are defined as the seamless integration of physical, digital, and human systems within the built environment, aimed at fostering a sustainable, prosperous, and inclusive future for their inhabitants (BSI, 2014). Mariano-Hernández et al. (2020) and Qian (2023) assert that smart cities leverage digital and next-generation information technology to catalyze green transformation across various domains, instigate shifts towards eco-friendly lifestyles, enhance urban governance capabilities, forge paths towards low-carbon sustainable development, and infuse vigor into ecological civilization construction.

Researchers have identified six dimensions that collectively characterize a smart city as one that integrates various modern information and communication technologies. These dimensions encompass smart economy, safety and security, smart governance, mobility, smart environment, and living, all aimed at comprehensively optimizing urban functions (Gobbo, Souza & Gobbo, 2016; Patel & Bhagat, 2019; Camero & Alba, 2019). Rooted in theories of regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and citizen participation in city governance (Lombardi et al., 2012), these dimensions underscore that city development hinges not only on hard infrastructure (physical capital) but also on the availability and quality of intangible capital (human and social capital). Key indicators encompass aspects such as economy, education, energy, climate change, finance, governance, health, housing, wastewater, and water quality (Czupich, 2019). In the transportation sector for instance, the advent of smart travel modes like shared electric vehicles and bicycles has not only mitigated traffic congestion but also to some extent reduced carbon emissions produced by traditional transportation means (Vaidya, 2020). In the same vein, data mining and sensing techniques are employed to acquire real-time data for managing traffic light duration, monitoring traffic congestion, and responding to accidents promptly (Giest, 2017; Odefadehan, 2021; Qian, 2023).

In Nigeria, the establishment of the Smart City Initiative (NSCI) aims to convert major urban centers from traditional, dysfunctional cities into modern, efficient, and environmentally responsive ones capable of meeting the housing needs of both current and future generations of Nigerians. Darma (2023) stated that the prioritization of short-term financial gains, limited awareness and understanding, uncertain regulatory and policy frameworks, inadequate financial instruments and mechanisms, and insufficient funding for environmental sustainability initiatives pose significant obstacles to achieving sustainable development goals, particularly in the context of smart cities. The implementation of carbon-responsive smart housing concepts could offer a more effective solution to the housing and urbanization challenges faced by Nigerian cities. Smart City initiatives have the potential to promote shared mobility options including carpooling, motorcycle sharing, and bicycle-sharing programs, as depicted in Figure 1.

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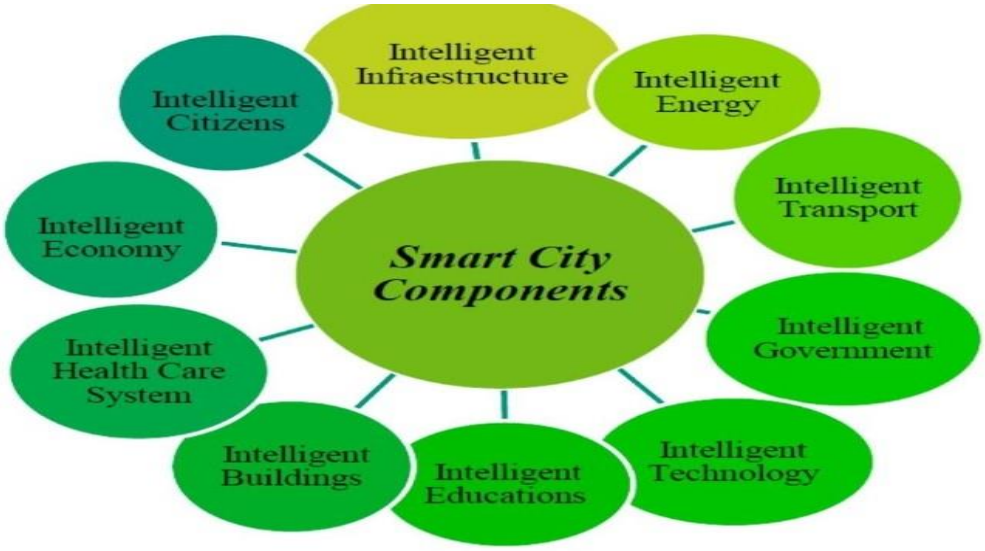

Figure 1. Basic components of smart city. **Source:** Azizalrahman and Hasyimi (2019)

Trends of Low Carbon and Resilient Smart City Practices

Amidst the pressing global imperative to address climate change, incorporating low-carbon practices into the development of smart cities has emerged as a fundamental strategy to advance sustainability. Urban areas, characterized by human activities and heavy industries reliant on energy and natural resources, play a pivotal role in carbon reduction efforts. Despite the adverse effects of rising carbon dioxide levels on air quality and ground temperatures, the adoption of low-carbon measures at the urban development level was not significantly pursued until 2003 when the United Kingdom government released The Energy White Paper, aiming to foster the growth of a low-carbon economy (De Jong et al., 2015). It's noteworthy that urban systems consume up to 75 percent of the world's energy (UN, 2022).

Urban challenges encompass two main approaches: "mitigation," which entails reducing greenhouse gas emissions and transitioning to low-carbon development, and "resilience," which involves planning and constructing responses to inevitable climate change impacts, known as "adaptation" (Harford & Raftis, 2018). The concept of "resilience" has its origins in the early work of ecological scholars, including MacArthur (1955), Lawton, and Brown (1994), who initially examined environmental stability with a focus on biodiversity. Formally introduced as an ecological concept in 1973, resilience was defined by Crawford Stanley Holling as the capacity to absorb instability and adapt to changes (Holling, 1973). Holling emphasized the necessity for persistence inherent in ecological resilience, extending the concept beyond mere stability. From the 1980s onward, Holling expanded the notion of resilience to encompass engineering and management perspectives. Concurrently, the study of resilience gained popularity due to growing public concerns about the environment and natural hazards. A growing number of scholars have engaged in multidisciplinary research on resilience, aiming to develop an integrated approach for the sustainable transformation of cities (Beigi, 2015).

Researchers suggested the concept of "low carbon resilience," which offers a more effective and efficient approach compared to addressing issues separately (Harford & Raftis, 2018). In addition to the spontaneity of nations and cities independently, international conventions have played pivotal roles in driving the development of low-carbon cities. The

Kyoto Protocol of 1997 as the first international treaty addressing low-carbon initiatives, was adopted by over 150 countries during the United Nations Framework Convention on Climate Change (UNFCCC) Conference and entered into force in February 2005, with total participants rose to 192 in 2013 (Yuan et al., 2011). Two years later, the Paris Agreement replaced the Kyoto Protocol due to perceived limitations in its effectiveness (Smith, 2013). The Paris Agreement obligates participating nations to target efforts towards mitigating global warming and emphasizes the need to bolster implementation efforts. As the concept of low-carbon cities and resilient cities gains traction and popularity in the urban context, it is observed that "low carbon" and "resilience" often coexist in both international agreements and government mandates. Notably, within the Paris Agreement, four articles addressing low-carbon targets also discuss resilience (Smith, 2013).

In terms of strategic planning for resilient cities, the integration of low-carbon practices tends to be seen as a complementary concept due to the negative impact of carbon emissions on climate change vulnerability and urban areas. Consequently, organizations began merging these two concepts in the late 2000s. For instance, the Australian Government introduced "A Low Carbon and Resilient Urban Future" in 2001. Since 2009, nine least developed countries have announced their plans for developing low-carbon cities (Fisher, 2013). In 2013, the World Economic Forum meeting centered discussions on "Resilient Dynamism" (West, 2013). That same year, the Rockefeller Foundation established the 100 Resilient Cities program aimed at guiding member cities toward resilience goals to address physical, economic, and societal challenges both financially and logistically (Martín et al., 2018). This program has been recognized as a significant milestone in the operational roadmap for resilient cities, with approximately 97 cities worldwide being selected for the 100 Resilient Cities project with over 2600 initiatives been launched, with more than 3 billion dollars invested in funding resilient-oriented initiatives (Martín et al., 2018). In essence, the concept of low carbon represents a form of mitigation, while resilience embodies the notion of adaptation. The majority of carbon emissions stemming from residential, commercial, and public sectors are heavily influenced by energy consumption (Azizalrahman & Hasyimi, 2019). As illustrated in Figure 2, merging these two concepts together has significant potential for enhancing the efficiency and efficacy of climate action initiatives.

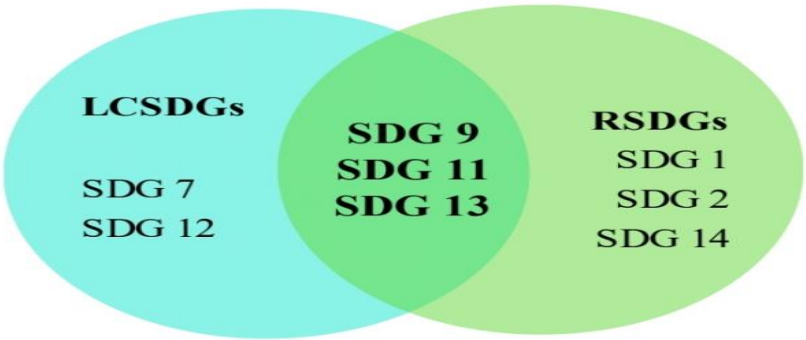

Fig. 2: Low carbon and resilience interaction **Source:** He (2022).

Based on a survey conducted by IESE Business School Ranking utilizing the Cities in Motion Index, nine dimensions were evaluated, namely human capital, economy, governance, social cohesion, environment, mobility and transportation, urban planning, international projections, and technology. The study consisted of 174 cities from 80 countries (Índice IESE

Cities in Motion, 2020). Among the "TOP 10" smart cities, six European cities were featured, including London, Paris, Reykjavik, Copenhagen, Berlin, and Amsterdam (Índice IESE Cities in Motion, 2020), with London being declared as the smartest city globally in 2020. Ecological smart initiatives powered London City Hall to prominence, incorporating unconventional energy sources such as paving slabs that generate electricity, the Blackfriars solar bridge, and the London Array wind farm situated at the mouth of the Thames. Additionally, London has implemented measures such as a paid entry system to the city center (with exemptions for electric vehicles), tax incentives for purchasing electric cars, and the establishment of vehicle charging stations and Barclays Cycle Hire (Szymańska & Korolko, 2015). Similarly, Copenhagen has embarked on numerous environmental projects, with a goal of achieving carbon neutrality by 2025. This objective is pursued through initiatives like green construction, low-emission heating, and energy generation from water and wind farms, exemplified by projects such as the Middelgrunden project (Szymańska & Korolko, 2015; Larsen et al., 2005). In Canada, the Adaptation to Climate Change Team (ACT) was built to explore opportunities and strategies for low-carbon resilience in 2016. The low-carbon resilience report by ACT is the most systematic among the strategic paperwork formulated by the ACT. The team develops an "integrated climate action approach," combining adaptation and mitigation, visualizing the idea through a conceptual process model and matrix (Harford & Raftis, 2018).

According to Rana et al., (2019), governance issues pose significant challenges to smart city development across many countries. Nam and Pardo (2011) and Monzon (2015) posited that achieving an all-encompassing smart city is practically unattainable in an environment lacking cooperation between the city's network, including public institutions, the private sector, voluntary organizations, and citizens. Similarly, Ruhlandt (2018) stated that in situations where governance is ineffective and trust between the government and its citizens is lacking, the development of smart cities becomes unachievable. In order to understand the historical background and seek the conceptual roots of urban planning towards sustainable development, the trajectory of the international movement toward low-carbon resilient cities is demonstrated in Figure 3.

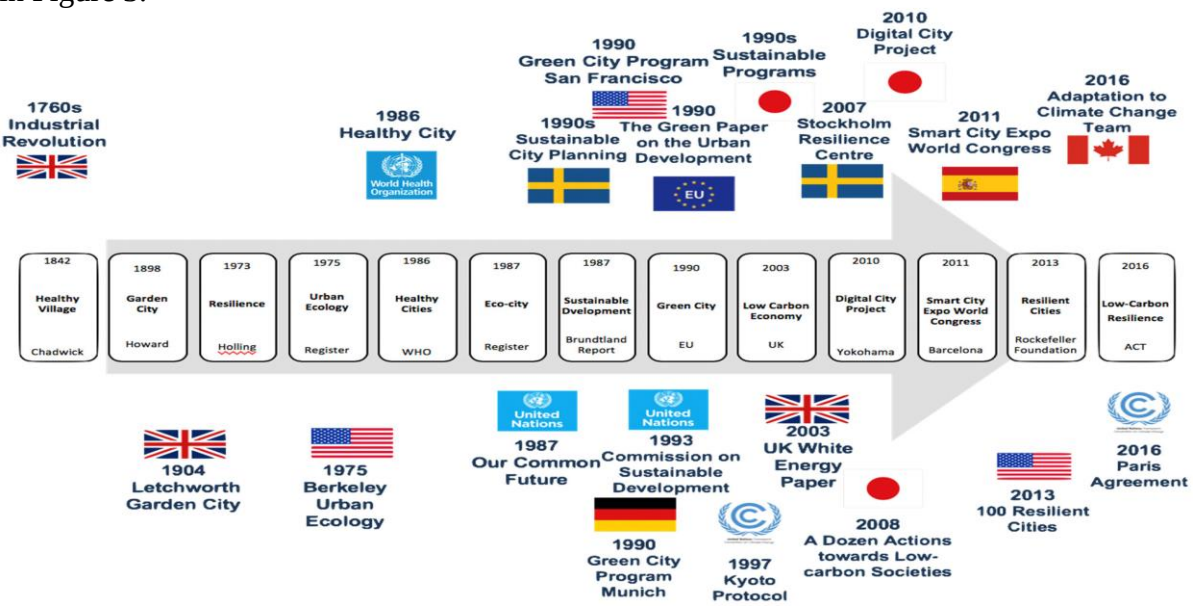

Fig. 3. Timeline of international movement towards low-carbon resilient cities (He, 2020)

Transition Towards Low Carbon Smart Cities for Achieving SDG 2030 in Nigeria

Nigeria is the largest nation and economy in Africa and the seventh largest globally, with a population exceeding 203 million people, with approximately half residing in urban areas (Abubakar & Aina, 2019; Awe et al., 2019; Echendu & Georgeou, 2021). Like many colonized countries, Nigeria's planning model traces its roots back to the British system, as it adopted the planning framework of its colonizers (Kimari & Ernston, 2020). Formal urban development policies and strategies have been in existence in Nigeria since the colonial era (Lamond et al., 2015). Notable among these are the 1863 town improvement ordinance, the Cantonment Proclamation of 1904, the 1917 Township Ordinance, and the 1946 Town and Country Planning Ordinance, all aimed at guiding physical planning and regulating the issuance of building permits (Fatusin, 2015). Subsequently, the Nigerian Urban and Regional Planning Act (Amendment) Decree No. 18 of 1992 was enacted to replace the British colonial government's 1946 Town Planning Ordinance (Dan-Jumbo et al., 2018). The Urban and Regional Planning Act delineates the responsibilities of the federal, state, and local governments concerning policy matters such as land zoning and physical planning. These three tiers of government in Nigeria are engaged in urban planning in varying capacities, as shown in Figure 4.

At the federal level, responsibilities include formulating national policies regarding urban and regional development and planning, developing and executing National Physical Development and Regional Plans, providing financial and technical aid to states for plan formulation and implementation, and promoting planner education and training. The state government is tasked with formulating its state policy for planning within the stipulations of the national policy. The state also prepares and implements its Regional, Sub-regional, and Urban Plans as well as Subject Plans. Furthermore, states offer technical support and aid to local governments in plan implementation. At the local level, oversight is provided for Town Plan, Rural Plan, Local Plan, and Subject Plan initiatives. Decree 88, 1992 requires that a National Urban and Regional Planning Commission, comprising professionals from diverse urban planning fields with relevant experience is constituted at the federal level. The various government parastatals and ministries involved in planning in different capacities each have representatives on the national commission. The commission is in charge of carrying out planning functions at the national level. At the state level, a board is also constituted and charged with state planning activities. The local planning authority is tasked with planning at the local level. The members must all be planning professionals.

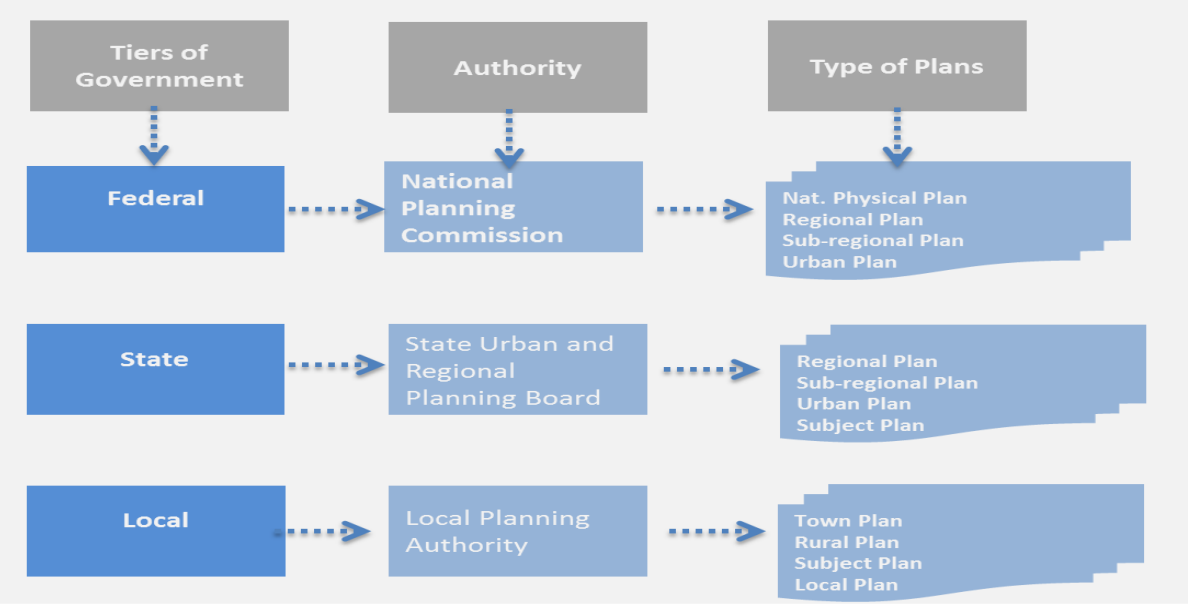

Figure 4: The planning system in Nigeria Source: Lamond et al. (2015)

Prior to the preparation of the National Plans, the National Commission is mandated to solicit inputs from all pertinent governmental and non-governmental entities, as well as the public, whose contributions are to be taken into account during the draft preparation phase. This process aims to foster integration across all levels of Physical Development Plans and encourage community involvement. The draft plan undergoes public presentation, where objections are welcomed and addressed before the final plan is submitted to the legislature for approval. The legislature may approve the plan in its entirety, in part, or request amendments. Once approved, the plan becomes the operational National Physical Development Plan, subject to review every five years to align with evolving needs and circumstances. The review process mirrors the original plan's procedure and stages. Similarly, at the state level, the preparation of Regional, Sub-regional, and Urban/Master Plans follows the same procedure. This holds true for Town Plans, Rural Plans, Local Plans, and Subject Plans, which must also synchronize with the state plan. Each level of government establishes a Development Control Board responsible for overseeing all developments within its jurisdiction. Every developer, whether governmental or private, must submit plans (including relevant information such as drawings and designs) for approval from the appropriate control board before commencing any physical constructions or development. Plans may be rejected on various grounds, such as if the proposed development poses significant environmental, social, or infrastructural impacts.

Any developer intending to develop land parcels of three hectares or more, as well as recreational and commercial buildings of specified sizes, must submit a comprehensive Environmental Impact Assessment. Despite Nigeria's rapid population growth, sustainable housing and urbanization have not been adequately addressed in the country's 2021-2025 Development plan. In the SDG11 section, concerning the dashboard and trends, the report highlighted persistent challenges and a declining score in the performance indicator related to the percentage of the urban population. Nigeria's SDG Index score, released in June 2020, stood at 49.30, positioning the country 160th globally out of 166 countries assessed, with Norway securing the top position globally, and Algeria leading in Africa with a score of 72.30 at the 56th position out of 166. Nigeria, alongside India and China, is projected to account for up to

35% of the world's population by 2050. In the same vein, it is anticipated that by 2025, over 60% of Nigerians will reside in urban areas (Taiwo & Gbolabo 2020). In adherence to the commitments made by the Federal government of Nigeria to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, several policy documents have been instituted, establishing institutions in various states to promote the sustainable utilization of available energy resources in alignment with low carbon development (Azeez, 2020).

According to Azeez (2020), the National Electric Power Policy of 2001 aimed to extend power coverage to all local government areas. Additionally, recognizing the necessity to diversify the nation's electricity supply, the government, through the formulation of the Rural Electrification Policy, established Rural Electrification Boards tasked with extending power to all 774 local government areas across the nation (Azeez, 2020). Efforts toward low-carbon development in Nigeria included expanding renewable energy supply and the utilization of natural gas for power generation, along with proposed joint expansions in electricity and natural gas capacity (Eleri, Onuvae & Ugwu, 2013). Building on the recommendations of the National Electric Power Policy, the Electric Power Sector Reform Act of 2005 was enacted, emphasizing the role of renewable electricity, particularly in expanding access to rural and remote regions (Azeez, 2020). However, despite these initiatives, the Agency established for this purpose was dissolved in 2009 after achieving minimal progress. Azeez (2020), stated that the establishment of the Rural Electrification Agency (REA) led to the establishment of the Nigeria Electricity Regulatory Commission (NERC), while the Energy Commission of Nigeria (ECN) developed the National Energy Policy in 2003.

The National Energy Policy aimed at optimizing the utilization of both conventional and renewable energy resources in the nation. However, since its inception, no government agency has actively pursued the implementation of this policy (Azeez, 2020). Other policies geared towards promoting low carbon development in Nigeria include the National Oil and Gas Policy, formulated by the Bureau for Public Enterprises in 2004. This policy advocated for the establishment of a National Gas Grid and encouraged the use of gas for industrial processes and power generation. Additionally, it proposed fiscal incentives and investments in non-fossil fuel-based energy sources like solar, hydro, and biomass, among others (Azeez, 2020). Despite the provisions for research and development within the policy, the extent to which subsequent governments have acted upon its directives remains uncertain (Azeez, 2020). However, despite efforts from the Energy Commission, supported by the UNDP, the Renewable Energy Master Plan (REMP) was drafted in 2005 to address the challenges associated with renewable energy exploitation in Nigeria (Azeez, 2020). Regrettably, the REMP did not receive endorsement from the Federal Executive Council, nor was it passed into law by the National Assembly, thus failing to guide governmental actions (Azeez, 2020). Furthermore, the Federal Government introduced the National Biofuels Policy in 2007 with the aim of establishing a thriving bio-fuel industry and enhancing the quality of automotive fossil-based fuels in Nigeria (Azeez, 2020).

However, despite considerable investments and funding of pilot projects, this policy has not yielded substantial results (Eleri, Onuvae & Ugwu, 2013). Similarly, the Petroleum Industry Bill (PIB) was presented to the National Assembly in 2012, intending to safeguard health, enforce safety standards, and ensure environmental quality management systems in oil and gas exploration, in line with international standards (Azeez, 2020). Nonetheless, the bill faced challenges due to disagreements between the government and labor unions over fuel pricing deregulation (Azeez, 2020). While the Federal Government has formulated several

policy documents and strategies to enhance Nigeria's energy sector in alignment with the country's economic growth blueprint and the goal of low carbon development, a comprehensive national policy or strategies specifically targeting low carbon energy development have yet to be established (Eleri, Ugwu & Onuvae, 2011). The implementation of government policies aimed at low carbon development has often been hindered by political instability, discontinuity in administration, and ineffective execution (Alumona & Onwuanabile 2019; Echendu 2020a,b; Echendu 2021a). Given the projected urban growth, urgent attention is needed for Nigeria's urban planning and management to sustainably accommodate such projected growth (Echendu 2022; Taiwo & Gbolabo 2020; Yiran et al. 2020) toward a typical Smart city pathway as illustrated in Figure 5.

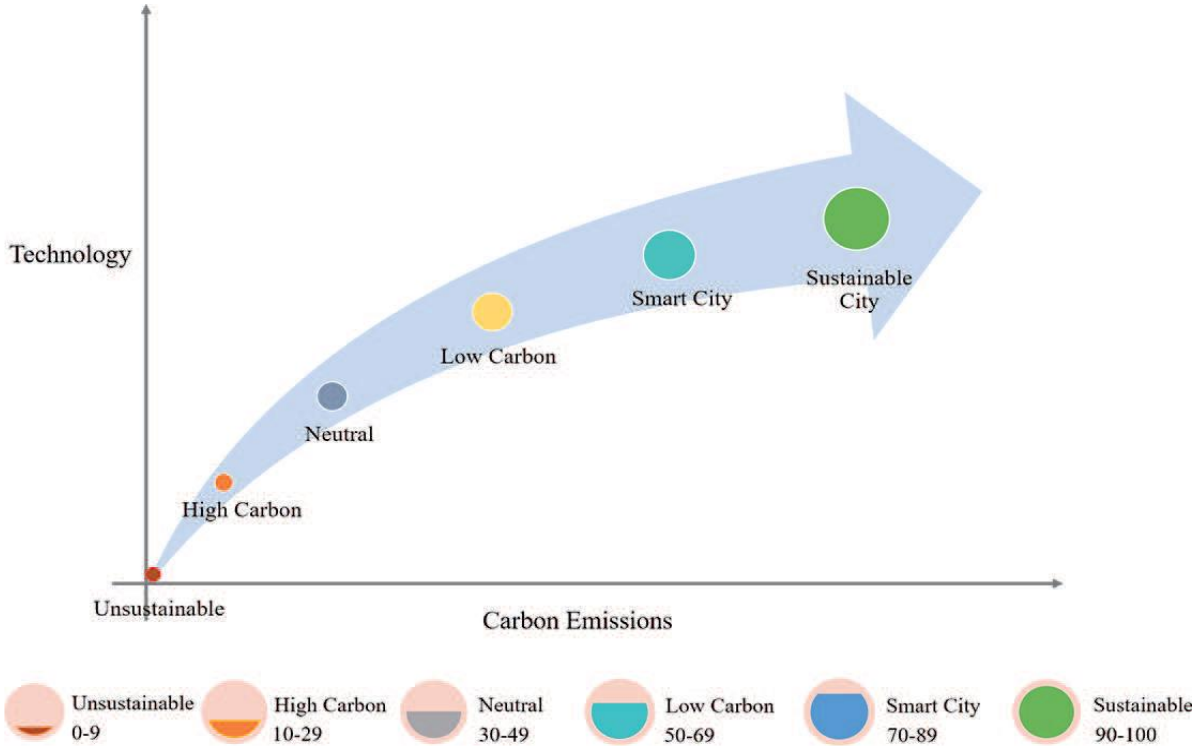

Figure 5. Smart city pathway to sustainability
Source: Azizalrahman and Hasyimi (2019)

Optimization Strategies for Low Carbon Smart Cities to Achieve SDG 2030 in Nigeria

Based on the findings of this study, the researchers recommended that government, policymakers, urban planners, academia, civil society, and private sector stakeholders should adopt the following strategies to enhance low carbon and resilient smart cities to achieve SDG 2030 in Nigeria:

1. Develop comprehensive urban planning frameworks that seamlessly integrate principles of resilience, sustainability, and smart city concepts across all facets of urban development.
2. Invest in capacity building initiatives aimed at enhancing the technical expertise of government agencies, local authorities, and urban planners in sustainable urban development practices.

3. Establish and enforce policies and regulations that provide incentives for sustainable urban development, such as implementing building codes that promote energy efficiency, mandating the use of renewable energy, and endorsing green building certifications.
4. Introduce fiscal incentives, such as tax incentives, subsidies, and grants, to encourage private sector investment in low-carbon technologies, renewable energy projects, and sustainable infrastructure.
5. Launch awareness and education campaigns to garner public support for sustainable urban development objectives, emphasizing the advantages of resilience, energy efficiency, and environmental sustainability.
6. Conduct regular assessments and evaluations of urban projects to assess their performance, identify challenges, and pinpoint areas for improvement, thereby facilitating adaptive management and evidence-based decision-making.
7. Foster transparency and accountability in the implementation of sustainable urban initiatives by making data and information readily accessible to the public and relevant stakeholders.

Conclusion

The significance of resilient and low-carbon smart cities in Nigeria to achieve the Sustainable Development Goals (SDGs) by 2030 cannot be emphasized enough. This researchers have conducted a thorough examination of the challenges and opportunities involved in transitioning toward sustainable urban development in Nigeria. Moving towards sustainable urban development in Nigeria requires a fundamental shift in urban planning approaches, governance structures, and stakeholder engagement methods. While the obstacles to this transition are numerous, there are ample opportunities for transformative progress. By embracing innovation, collaboration, and sustainability as guiding principles, Nigeria can harness the potential of its cities to drive economic growth, social advancement, and environmental stewardship. Implementing integrated approaches that bridge traditional divides in urban planning, environmental management, and economic development will be essential for navigating the complexities of urban sustainability. This endeavor demands sustained dedication from policymakers, urban planners, academia, civil society, and private sector stakeholders to translate aspirations into tangible actions.

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