Valorization of Sand Barrier-Lagoon Ecological Assets in Lagos Smart City Conceptualization

Olatunji T. **ADEJUMO** PhD
Landscape Architect/Associate Professor
Department of Architecture,
University of Lagos, Lagos. Nigeria
Email: tadejumo@unilag.edu.ng.
Tel: +234 803 443 1439

Abstract

Urban designers looked through diverse technological windows including engagement of mobile applications to manage urban infrastructures; interactive monitoring; real-time data collection and display; urban mapping and analysis. But the success of a smart city is not solely measured on these technological infusions. Rather a successful smart city place emphasis on achieving high quality of life especially ability to manage the supporting landscapes that carry the ecological processes. This is particularly important in Lagos Sand Barrier-Lagoon bioregion confronted by environmental crises including flooding, storm water pollution and increasing air pollution. Recent climate change impacts, especially flooding, triggered loss of properties, structural failure of infrastructures and increase in sick building syndrome in metropolitan Lagos. This paper disserts how to valorize sand barrier-lagoon natural assets in the quest to conceptualize ecologically resilient Lagos Smart City. The study is underpinned by productive green infrastructure principles and geomorphic urban drainage system. The paper submits that valorization of hydrological system that supports diverse habitats including low land rain forests, freshwater swamps; lowland coastal grasslands; and swamp mangroves forests should underpin livable and environmentally sustainable Lagos smart city. Valorization process consider strategic environmental assessment, urban green infrastructure, pragmatic flood risk management principles and green buildings and energy conservation. The paper recommended four policy statements in line with the four developmental processes.

Keywords: Smart city, sand barrier-lagoon, green infrastructure, valorization, ecological asset

1 Introduction

Four decades ago 'Techno-Politics' ideology crept into urban arena to shape the basic pattern and layers of human settlements (Rasmussen, 2007; Kurban et al, 2016). Technology was seen as an all pervading innovation that would redefine the culture of the city. Techno-politics ideology gave life to Smart City concept to infuse new technology to the holistic planning and management of human settlements. But the quest for cities to be smart is not solely on information and communication technology (Giffinger, 2007). The question is what makes a city to be a Smart City? The answer resides in the diverse definition of smart city movement in the last thirty years. This corroborates Crnčević1 et al (2017) submission that there is no agreement on what definition to give Smart City since there are many urban layers to be synchronized to make available desired livability standard for city people. Initial attempt to define smart city focused on information technology especially free internet services and computer aided design applications. Monzon (2017) definition sees smart city as attempt to efficiently "achieve sustainable and resilient development and a high quality of life addressing urban challenges on the basis of a multi stakeholder and municipality based partnership." This definition emphasis improvement and efficiency of cities as human system; environmental resiliency; and the importance of quality of life. The working definition holistically address smart city as an integrated system in which human, natural and social capital interact using technology-based solutions. In addition to information and communications (ICT), Giffinger (2007) summarized what makes a city smart to include smart resident, smart mobility, smart economy, smart housing, smart governance and smart environment. The latter is about enhancement of quality of life, sustainable living and provision of services that support people's livelihood.

Lagos State Government subscribed to the techno political ideology through the recent partnership with City of Dubai to establish Lagos Smart City Initiative (Lagos State Ministry of Physical Planning and Urban Development, 2016)). Developmental prospects of digital age on city scale, benefits of globally connected knowledge-based hub, center for innovation, wellness and green tourism destination were some of the stated benefits. Little was mentioned on the prime position of environmental decency as the base plane of smart cities. Not even Adamu et al (2017) amplification of economic benefits of Lagos Smart City initiatives including a "12-lane road, hotel resorts, world-class technological education facilities and a rail metro line". Cities

irrespective of modern driving philosophy is dependent on ecological services of contextual landscapes. Lagos Smart City Initiative cannot be an exception bearing in mind the environmental crisis facing Lagos sand barrier-lagoon bioregion in recent years especially tidal flooding. This paper disserts valorization of Lagos sand barrier-lagoon ecological values as base plane on which information and communication technology driven smart resident, smart mobility, smart economy, smart housing and smart governance would be grafted. The paper is underpinned by ecological planning theories.

1.1 Lagos Sand Barrier-Lagoon Landscapes

Lagos State thrives on sand barrier-lagoon landscapes. This coastal tip of south western Nigeria geopolitical zone is underlined by folded gneisses schist and quartzite. The profile of sedimentary formations highlighted two strata including Recent Coastal Deposits and Coastal Plain Sands. The Coastal Plain Sands were deposited in Oligocene-Pleistocene times. Hydromorphic soils on lagoon sediments cover low lying areas of Lagos lagoon. On the other hand, hydromorphic soils on alluvium deposits are on the flood plains of various rivers that drains into the lagoon systems especially Yelwa, Ogun, Owuru, Aye and Osun rivers. Lagos State bioregion is made up of ten lagoon systems including Lekki, Lagos, Apese, Ologe, Badagry and Port Novo. The lagoon formation run parallel to Atlantic coast line. This geomorphology is responsible for the highly productive Lagos lagoon systems supporting diverse habitats including freshwater swamps; lowland coastal grasslands and swamp mangroves forests skirting the various lagoons and creeks. They constitute Lagos sand barrier-lagoon ecological goods and services to be valorized in the planning process towards Lagos Smart City initiative.

2.Smart Environment in Smart City

The notion that the city is a place of human and ecological interaction should be taken seriously in urban policies generation. City fabric is a product of well blended ecological processes and human cultural processes. The two processes must fit like a jigsaw to avert urban environmental crisis. In smart city, natural assets and developmental knowledge are sustainably managed towards better quality life. Therefore, the thrust smart city is to valorize contextual natural capital with the singular goal of redefining them as developmental tools (Mauritius Ministry of Environment, Sustainable Development and Disaster and Beach Management, 2015). Reinwald

et al (2014) citing GD (IP 2014) streamlined smart environment to include sustainable resource planning and management; information and technology based energy grid and renewal energy; ecological resilient planning and pollution free cityscape; green buildings; and generous urban green infrastructure provision. They collectively provide an insight into the planning demands of smart city. Therefore, environmental perspective of planning and design of smart cities aims at achieving cleaner, greener, flood and ecologically resilient urban landscapes. Unfortunately, urban planning process in Nigeria pitch environmental conservationists against developers amplifying conflicting interest rather than symbiotic relationship towards sustainability. Environmental conservation in smart city development is expected to promote a very efficient growth pattern that accommodate restoration of degraded landscapes.

While developmental activities are desired to enhance inclusive prosperity, appropriate environment assessment is required to keep the urban ecosystem working and to achieve sustainable resource planning and management in smart city conceptualization. This is better achieved in pre development phase of city building process via strategic environmental assessment (Dalal-Clayton and Sadler, 1999). Strategic Environmental Assessment provides a good platform for the emergence of healthy urban green infrastructure needed for flood control, ecological resiliency, recreational spaces creation and amelioration of urban heat island. Urban green infrastructure is strategically planned network of parks, greenways, generously vegetated streetscapes, conservation easements that maintain urban ecological processes. Planned green infrastructure include parks, public open spaces, forests, wetlands, fringe farmlands and public facility outdoor areas. These are organically connected by links including pedestrian paths, green streets, water streams, and eco-corridors. Wetlands and wood lands constitute natural green wedges that contain each city. They represent the remaining fragments of contextual city ecosystem vulnerable to intensive anthropogenic activities. Urban green infrastructure positively impacts water quality in city ecological system, create livable urban environment, ameliorates urban heat island, meets city food security and serve as urban lung mopping up pollutants from urban air, water and soil layers. Landscape architects looked through diverse technological windows including engagement of mobile apps with capacity to influence planning and management of urban infrastructures; interactive monitoring; real-time data collection and display; urban mapping and analysis and even narrative public art installations to conceptualize

smart cities. Integration of diverse layers of urban development with the natural processes to make technological infusion meaningful is one of the very important process in the conceptualization of smart city. This is needed in Lagos sand barrier-lagoon landscapes prone to climatic anomalies especially incessant flooding.

Davis (1994) described barrier island as a sandy island that developed from a broadened barrier beach usually above high tide and parallel to the shore. A barrier system has dunes, vegetated zones, and swampy terrains that extend lagoon wards from the beach. The Coastal Barrier Resources Act (CBRA) of 1982 delineated a coastal barrier as all related aquatic habitats, including swamplands, marshes, estuaries, inlets and near shore waters. Sand barrier-lagoon coast have dynamic ecosystems dominated and subsidized by physical energies (Carrada and Fresi, 1988). Lagoons are highly productive coastal features that provide a range of natural services to meet societal values. Their setting within the coastal landscape leaves them especially vulnerable to profound physical, ecological and associated societal disturbances. Expected shifts in physical and ecological characteristics range from changes in flushing regime, freshwater inputs and water chemistry to complete storm surge driven inundation. This demands conscious planning that respects sand barrier-lagoon ecological assets.

2.1 Lagos Sand Barrier-Lagoon Ecological values

Ecological goods and services connotes a bank of natural capital on which the livelihood of local people depends. Assets include stocks of natural goods in the landscape and environmental services provided by contextual ecological systems. While the latter is made up of soil, water, air, genetic resources; hydrological and mineral filtration cycles form the core of natural services. Sand Barrier-Lagoon landscapes on this platform are considered as social ecological systems- a manifestation of community and local ecosystems symbiotic relationship. The core ecological goods in Lagos State sand barrier-lagoon landscapes include fishery and other aquatic fauna; fresh water, coastal grassland and mangrove forests; hydrological system including Atlantic Ocean, the ten lagoons, creeks and upland rivers; sub urban arable agricultural land; and 180 kilometers golden sand beaches. These goods influence the prevailing livelihood including artisan fishing; peasant farming, small scale sand mining, craftsmanship, informal trading and tourism**.** Services include soft engineering against flood and coastal erosion control mechanism,

wetland water filtration, religious interactions and water transportation. Services as link between human and ecological systems are opened to both internal and external influences. This resonates the fact that the two systems are in a feedback loop in which culture (human design and planning) changes landscapes and landscapes (natural design and planning) influence culture. But twentieth century urban infrastructure developmental approaches were blind to environmental limits, ignore human behavioral impacts and often aim to overcome and disconnect from nature (Louv, 2010). It is unfortunate that ongoing urban infrastructure conceptualization focus on dominating nature rather than accepting its prime position as the environmental base plane that will generationally support dynamic human culture. This anthropocentric position negatively impacts cityscapes and human wellbeing. Louv (2010) referred to this scenario as 'Nature Deficit Disorder'.

Anthropocentric developmental posture in Lagos sand barrier-lagoon landscapes manifests in frequent tidal flooding. It ignores the consciousness that the volume of water in the lagoon is influenced by rate of evaporation, precipitation, groundwater input, surface runoff. Determinants of the flushing rate that is, exchange with the ocean) include the size and shape of the lagoon, the level of connectivity with the ocean, tidal range, and freshwater flow. The ten Lagos lagoon system have low flushing rates because of the single exchange with the ocean at Commodore Channel, low tidal range and seasonality of freshwater inputs from the six major rivers. This is responsible for the productive Lagos lagoon systems supporting diverse habitats including low land rain forests on northern ridges that dissects Ikorodo and Epe sub regions; freshwater swamps; lowland coastal grasslands; and swamp mangroves forests skirting the various lagoons and creeks. Unfortunately, the productive lagoon bioregion is threatened by unsustainable developmental principles especially reactive planning strategy, piecemeal approach to urban infrastructure delivery, uncoordinated reclamation of fragile wetland ecosystems, urban pollution and severity of urban heat islands in heavily built up areas of the metropolis. This is compounded by recent climate change phenomenon driving tidal, pluvial and fluvial flooding.

2.2. Lagos Sand Barrier-Lagoon Environmental Crisis

Success story of smart cities is hinged on ability to create and maintain high quality of life for its inhabitants. Kim and Yoo (2015) submission is that such cities already have in place and strictly

adhere to planning system that respects inherent natural resources in the conceptualization of value driven public realm for daily economic, social, cultural and educational benefits of the people. This scenario is missing in various cities and littoral communities that constitute Lagos State. The negative news of urban pollution in Nigerian cities including Lagos metropolis, point to the abundance of pm10 particles (Dirtied by success? Nigeria is home to city with worst PM10 levels**,** 2016). These are particulate matters that are less than or equal to 10 micrometers in diameter. Reliance on solid fuels for household cooking, solid waste burning and traffic congestion were observed as the source of pm10 particulates in the air space of these cities. More important than particulates are increase in atmospheric abundance of greenhouse gases. Air quality of Lagos metropolis is a reflection of the high 20,000 people per square kilometer density (Olowoporoku, 2007). This is compounded by long hours of traffic congestion, decades of promotion and reliance on hydrocarbon based transportation mode and reliance on hordes of generators to power homes and industrial estates (Loricamp, 2007).

Change in land use intensity triggered by population upsurge is redefining land use/land cover ratio in regional Lagos. Large scale lagoon sand filling and reclamation of fragile mangrove wetland ecosystems as new locations for residential and industrial estates are major threats to fragile sand barrier dynamics. These large scale reclamation projects are not coordinated and synchronized to respect fragile lagoon wetlands values. Stream order in Lagos State is composed of rivulets, swales, canals, wetlands, natural detention ponds, creeks and lagoon systems The order has for ages managed annual flood regimes of the bio region. Urbanization in the bioregion has totally ignored this order. The policy alternative favor rickety open surface concrete primary, secondary and tertiary drainage channels that are inadequately designed to carry overland flow from one point to the other. The result is destructive flooding; aquatic and terrestrial resources depletion; and degradation of surface water quality. This is in addition to informal settlements on fragile waterfronts enhanced by rural –urban migration; dumping of untreated sewage in precious lagoon wetlands; illegal surface mining activities and poorly managed 'slash and burn' farming process in rural Lagos. So also are natural phenomena including climatic anomalies – major force behind devastating tidal, pluvial and fluvial floods in regional Lagos. As a consequence, some of the sand dune systems are already irreversibly altered and lost. Frequency of ocean surge and erratic rainfall pattern manifest in different types of flooding experienced in Lagos State in recent decades. Climate change driven flooding is indeed a national affair and is

the most potent natural disaster in Lagos sand- barrier. Flood hazard has damaging physical, socioeconomic and mental impacts. Recent climate change impacts especially flooding triggered loss of properties, structural failure of infrastructures and increase in sick building syndrome in metropolitan Lagos.

Upper economic class Ikoyi township conceptualized on 1901 Ebenezer Howard ideology (Lord Luggard Cantonment Proclamation, 1904) is now flooded. Victoria Island reclaimed and sub divided on tropical modernism ideology is constantly submerged in recent years. Parts of FESTAC Town planned on Messer Dioxiades Ekistic philosophy was also flooded. Dolphin Estate, Isheri LSDPC, Parkview Estate and Banana Island subdivided on some form of tropical modernism is not spared of flooding. Isale Eko that organically grew on Yoruba city dictum came under poorly managed storm water system. Various planned units' developments on reclaimed coastal grassland and mangrove wetlands of Lekki peninsular are annually inundated by tidal flooding. Environmental disaster is no respecter of planning philosophy but a respected of harmonious relationship between human design and natural design. If all these urban developments based on different planning and design principles were not spared, Smart city as an urban techno-political ideology will equally be submerged in flood water if physical developmental short comings that disrespect sand barrier-lagoon ecological values are not considered. That is, if Smart City is one where ICT driven developmental knowledge enhance sustainable management of ecological goods and services towards better quality of human lives, then the thrust of Lagos Smart City should be valorization of contextual landscape resources during planning and developmental processes.

Contrary to the developmental status quo that urbanization in Lagos can minimize contextual ecological values, the paper argues in favor of prime position of smart environmental constituents in the delivery of desired urban livability level expected of smart cities. This is rooted in the application of planning strategies in literature to mitigate documented environmental crises in Lagos that will at the same time valorize prime ecological assets in proposed Lagos Smart City.

3. Sand Barrier-Lagoon Natural Assets Valorization in Lagos Smart city

Environmental perspective of planning and design of smart cities focus on achieving cleaner, greener and ecologically resilient urban landscapes. This perspective will be viewed within the

context of Mauritius (2015) and Reinwald et al (2014) synopsis of what constitute smart environment in smart city including land use planning; sustainable resource planning and management; ecological resilient planning and pollution free cityscape; green buildings and energy conservation; and urban green infrastructure provision. Strategies towards this achievement should not depreciate the ecological values of Lagos sand barrier –lagoon bioregion and should possess in built capacity to mitigate the prevailing environmental crises especially land cover degradation, flooding, urban heat island, pollution and food insecurity. Table 1 summarizes strategies relative to smart environment constituents and environmental mitigation perspective.

Table 1: Smart Environment Attributes Relative to Valorized Sand Barrier-Lagoon Assets

S/N	Smart Environment Attributes	Planning Strategies	Environmental Crisis	Valorized Assets
1	Land use planning	Strategic Environmental Assessment	Reactive planning principles, Unsustainable reclamation, Urban sprawl	Hydrological System Aquatic habitats Sandy Beaches Livelihoods
2	Sustainable resource planning	Strategic Environmental Assessment	Land cover removal, loss of biodiversity, illegal sand mining, poor sand filling schemes.	Terrestrial habitats Aquatic habitats Sandy Beaches Livelihoods
3	Ecological resilient planning	Flood Risk Management	Ocean surge aggravated incessant flooding, forest fragmentation	Properties Human lives, Sand dunes, Livelihoods
4	Pollution free cityscape	Urban Green Infrastructure	No street trees, no urban forest projects	Terrestrial habitats Hydrological System
5	Green Buildings and Energy Conservation	Urban Green Infrastructure	Inadequate public parks and open spaces, no street streets	Terrestrial habitats Hydrological System
6	Green infrastructure provision	Urban Green Infrastructure	Inadequate public parks and open spaces, no street streets	Terrestrial habitats Hydrological System

Table 1 modified from Mauritius Ministry of Environment, Sustainable Development and Disaster and Beach Management (2015).

3.1 Strategic Environmental Assessment of Conceptualized Smart City Land uses

Land use planning in the sand barrier Smart City planning should be underpinned by sustainable concepts that have local meaning. The local perspective provides ample room to accommodate most suitable sites for infrastructure and developmental activities siting; protection of environmentally sensitive habitats; and conservation of natural assets that enhance community livelihood. Therefore, conceptualized land use should be subjected to the process of strategic

environmental assessment. Strategic Environmental Assessment (SEA) of smart city looks at conceptualized land use relative to inherent biophysical features. SEA is the process of predicting and evaluating the impact of a strategic action on the environment and using that information in decision making (Dalal-Clayton and Sadler, 1999). The purpose of SEA is therefore to help understand the development context of Smart City; to appropriately identify problems and potentials; address key trends, and to assess environmental and sustainable viable options that will achieve strategic goals. Landscape architects engage geo-design approach in real-time biophysical data collection and display; urban mapping and analysis using geographic information system and contemporary computer aided soft wares to define environmentally vulnerable areas of proposed smart city. Guiding environmental decision-making then line the environmental status quo against stated smart city vision and mission statements towards the identification of development constraints zones. Development constraints addresses the incompatibility of biophysical features with envisaged land use. For example, a very high development constraint zone of proposed Smart City may include flood prone areas, lagoon shore line, Atlantic Ocean coastline, creeks and tributaries of rivers; and various categories of productive wetlands and terrestrial habitats. Developmental interests driven by the magnetic pull of ocean and lagoon should then inculcate the principles of urbanization that respect ecological functioning of sand barrier lagoon system.

3.2 Flood Risk Management towards Ecological Resilient Smart City Planning

Sustainable planning and management of cities, towns on Lagos sand barrier-lagoon bioregion demands a framework that is conscious of degradation of ecological goods and services, sand replenishment, shoreline instability and proactive adaptive and mitigation measures to checkmate both tidal, pluvial and fluvial flooding associated with recent climatic anomalies. Flooding is the major disaster in Lagos State. Its disruptive impacts can be brought to manageable level through increase preparedness and proactive managerial flood risks awareness. This is in line with SDG Goal 11; target 5 that focuses on ecologically resilient cities to bring to minimal level climate change induced urban disaster (UN, 2016). The drive for healthy smart city ecosystem should look through Flood Risk Management Plan, Sustainable Drainage Systems in urban storm water management and generous green infrastructure windows to create livable public and private realms.

3.3 Urban Green Infrastructure

Urban green infrastructure encompasses all green spaces within the limit of city system. These spaces are either natural or planned. Natural green infrastructure hubs and links are urban gene bank that encourage biodiversity conservation It also constitute less expensive ecological engineering alternative to sea walls, retaining wall and levees to reduce the threats from ocean surges. Green infrastructure is then a 'soft' engineering approach, where natural ecosystems or enriched planted degraded wetlands are used as buffers against many flood related hazards. Planned green infrastructure includes public open spaces that are legally designated areas designed and developed for community use. Public urban open spaces came into global reckoning through the year 2000 Millennium Development Goals. It is the core of city greening movement that epitomizes the incorporation of socio-cultural values in environmentally organized human settlements. How these values are symbiotically entrenched in contextual urban landscape announce the people and define their place on civilization ladder. The 2015 Sustainable Development Goal number 11 "*Make Cities and Human Settlements inclusive, safe, resilient and sustainable*" is particularly relevant to Lagos urban centers facing dearth of public open spaces. The New Urban Agenda (2016) further confirms the contemporary position of public urban open spaces as major land use in 21st century cities. The broad goal of sand barrier smart city should consider the provision of safe, inclusive, accessible, high quality public recreational areas and open space system in appropriate locations to meet the needs of all age and user groups. Flood free and properly furnished public parks, plazas, city malls, coffee shops and other well-articulated green interstitial spaces are socio cultural hubs that should be enhanced by innovative information and communication technologies towards improve quality of life and efficient urban services.

3.4 Green Buildings and Energy Conservation

Urban green infrastructure in all its ramifications serve as city lung system mopping up pollutants; sequestering carbon dioxide; conserving biodiversity; reducing urban heat island; and driving visually desired aesthetics. Therefore, it plays dominant role in decreasing carbon dioxide emissions in urban airspace. This should be appreciated from the back drop of buildings role in high urban greenhouse gases. Hardy et al (1996) identified buildings and poorly managed industrial estates and reliance on fossil fuel based automobile transportation mode as the major

sources of greenhouse in third world nations. Buildings of all types have indeed been responsible for 30-40 percent of total energy use worldwide (UNEP, 2007 and WBCSD, 2007). Rendering building energy efficient require that whole energy chain, made up of energy input and output, be considered as a unit. That is, local environmental conditions, community issues, transportation systems and other grey infrastructures must be seen as one single energy efficient unit. The building is then assessed within the context of city energy flow and city energy flow viewed within the bioregion. City at this level becomes a developmental entity within the ecosystem (Adejumo, 2010).

Passive solar housing design, with-out active mechanical cooling system, is very important in Lagos State hot and humid tropical climatic belt. The consciousness that the environmental condition of an area and its buildings are affected by microclimatic variables and site features is necessary in the process of sustainable planning and design. In all projects, climatic analysis is necessary to consider site's biogeographic factors especially topography, vegetation, water bodies and structures including existing buildings. Urban design consideration in the zone should explore building form, low albedo material and beneficial values of shading against high solar radiation. Global temperature changes traceable to climate change bring to the forefront the effect of urban heat island. Rehan (2016) consideration of cool city principles to ameliorate urban heat island is relevant in hot and humid tropical Lagos barrier island. His antidote to urban heat island is application of urban heat management principles which is the very core of cool city concept. Cool city concept is the application of passive solar cooling on urban planning and design platform. Cool city principles explore green infrastructure strategies. These strategies improve urban air quality through carbon sequestration, lower gas emission, reduce urban energy use and creates communal socialization hubs as parks and planned open spaces with inbuilt capacity to accommodate hotspots.

5. Conclusion

Urbanization wind in sub Saharan African nations is carrying with it the developmental ideology in global north including Smart City principles. In recent years ICT influence of Smart City has been made to accommodate improved quality of life, efficiency of urban operation and services, economic competitiveness and environmental sustainability (ITU-T, 2014). Environmental sustainability content is resonated by Sustainable Development Goal number 11and New Urban Agenda which highlighted the need for ecologically resiliency in cities undermined by

environmental disaster (UN, 2016 and UN Habitat, 2015). This is relevant in Lagos Sand barrier-lagoon cities and communities prone to climate change induced ocean surges and biophysical challenges. Strategies towards the realization of smart environment that characterize smart cities in Lagos sand barrier-lagoon bioregion should valorize hydrological system that supports diverse habitats including low land rain forests, freshwater swamps; lowland coastal grasslands; and swamp mangroves forests.

Strategic environmental assessment relative to smart city land use; urban green infrastructure; flood risk management principles; and green buildings and energy efficient communities are necessary to valorize Lagos sand barrier and its inherent ecological goods and services. The paper recommends that appropriate environmental policies and developmental strategies within these four sub headings should be crafted to create ecologically stable, green infrastructure conscious and livable low carbon Lagos Smart City. Suggested policy objectives include:

- Consideration of strategic environmental management plan with inbuilt capacity to address urban developmental anomalies aggravating climate change impacts relative to proposed land use.
- Protection, conservation, restoration and management of Lagos sand barrier-lagoon aquatic and terrestrial ecosystems as urban natural life sustaining system and productive base plane for smart people, smart building, smart transportation and smart governance.
- Adoption of proactive flood risk planning and management towards ecologically resilient Smart City where the safety of lives and properties are given priority and public infrastructure capacity is conscious of climatic anomalies.
- Provision of safe, inclusive, accessible, quality public recreational areas and open spaces system to meet the needs of all ages and user groups bearing in mind appropriate spatial distribution.

These policies will enhance geomorphic approach to conceptualizing flood free Lagos Smart City with inbuilt capacity for efficient functioning of its ecological services and sustainable of goods that support the livelihood of the people.

6. References

Adamu, A.A.,Wang, D. and Adam, A. (2017). Smart Cities: The Foundation for Future Citizen Service Delivery in Nigeria. *American Journal of Engineering Research*, Vol. 6, No-3, pp-161-167 www.ajer.org.

Adejumo O. T. (2010). *Eco-City Principles: Design Tool to Mitigate Climate Change Impacts in Lagos Metropolis.* In Architecture and National Development Agenda III. Architects Colloquium 2010. ARCON. Falomo- Lagos. Pp 94- 106

Ashiyanbi, J. (2006) *Review of the Lagos State Regional Plan (1980-2000)*. Regional Plan, Performance and Recommendation.

Carrada G.C, & Fresi E (1988). *Le lagune salmastre costiere, Alcune riflessioni sui problem esui metodi*. In carrada, cicogna, Fresi (eds), Coastal Lagoons: Research and Management, CLEM, Massa Lubrense (Napoli): 35-36.

Crnčević1, T., Tubić, L. and Bakić, O. (2017). *Green Infrastructure Planning for Climate Smart and "Green" Cities. SPATIUM* No. 38, pp. 35-41. https://doi.org/10.2298/SPAT1738035C

Dalal-Clayton, B and Sadler, B, (1999). Strategic Environmental Assessment: A Rapidly Evolving Approach. *Environmental Planning Issues No. 18. Environmental Planning Issues No. 18.* London

Dirtied by success? Nigeria is home to city with worst PM10 levels (2016). www.cnn.com/2016/05/31/africa/nigeria-cities-pollution/

Giffinger R. (2007): *Smart cities, Ranking of European medium-sized cities*. http://www.smart-cities.eu/press-ressources.html

Hardy J, Diana M, Scallerthwaite D (1996*). Environmental Problems in Third World Cities.* Earthscan. London.

ITU-T Report (2014) *"Smart sustainable cities: An analysis of definitions"*, https://www.itu.int/en/ITU-T/focusgroups/ssc/Documents/.../TR-Definitions.docx, accessed 10th July 2017.

Kim, J. and Yoo, U.S. (2015). *New Sustainable Urban Design Strategies for the Beijing Region's Most Extensive Green, Compact City: Case Study of Bohai Innovation City*. True Smart and Green City?In Proceedings of the 8th Conference of International Forum Urban.

Kurban,C., Peña-Lopez, I., Haberer, M. (2016).What is Techno-politics? A conceptual scheme for understanding politics in the digital age. *Building a European Digital Space*. Pp 499-519 http://ictlogy.net/presentations/20160707_can_kurban_ismael_pena-lopez_maria_haberer_-_what_is_technopolitics_conceptual_scheme.pdf

Lagos State Ministry of Physical Planning and Urban Development (2016). *Lagos Signs Historic Smart City Deal with Dubai*. https://physicalplanning.lg.gov.ng/index.php/2016/06/21/lagos-signs-historic-smart-city-deal-with-dubai/

Loricamp Engineers & Consultants (2007). *Traffic System management (TSM) Measures for Group F & H Junctions.* Being Consultancy Report for Lagos Metropolitan Area Transport Authority(LAMATA)

Louv, R, 2010 *Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder* (Algonquin Books).

Mauritius Ministry of Environment, Sustainable Development and Disaster and Beach Management (2015). *Environmental Guideline for Smart Cities*. Cleaner, Greener & Safer Mauritius. http//www

Ministry of the Environment, Lagos State (2010). *State of the Environment Report - Lagos, 2010. Published by* Ministry of the Environment, Lagos State / Beach Land Resources Limited. Alausa. Ikeja

Monzon, A. (2017). *Assessing smart city initiatives for the Mediterranean region.* Assessment Methodology for Smart City Projects: Application to the Mediterranean Region European Investment Bank. https://institute.eib.org/wp-content/uploads/2017/03/4-Ascimer.pdf

Olowoporoku, D. (2007). *Air Quality Management in Lagos*. Air Quality Management Resource Centre, UWE, Bristol.

Rasmussen, T (2007). *Techno-politics, Internet Governance and some challenges facing the Internet. Oxford Internet Institute*, Research Report 15. http://www.media.uio.no/prosjekter/internettiendring/downloads/RasmussenTechnopolitics.pdf

Rehan R.M. (2016). Cool City as A Sustainable Example of Heat Island Management Case Study of the Coolest City in The World. *Housing and Building National Research Center HBRC Journal Vol 12, pp191-204* http://ees.elsevier.com/hbrcj

Reinwald, F.,Damyanovic, D.,Brandenburg, C., Allex B., Gantner, B., Czachs,C. and Preiss, J. (2014). *Urban Green Infrastructure Planning as a Contribution to the Smart "Green" City* Proceeding of REAL CORP 2014. Editors: Manfred Schrenk, Vasily V. Popovich, Peter Zeile. Elisei, P. 21-23 May 2014, Vienna, Austria. http://www.corp.at

Toy,J.T and Hadley *R.F.(1989) Sediment and the Environment.* Proceedings of the Baltimore Symposium, May 1989. IAHS Publ. no. 184, 1989

UN Habitat (2015). *Towards A New Urban Agenda*. United Nations Conference on Housing and Sustainable Urban Development (HABITAT III). New York, November 2015

UN (2016). *The Sustainable Development Goals Report 2016*. United Nations New York, 2016. http//SDG/The-Sustainable-Development-Goals-Report-2016-Global.pdf.

UNEP, (2007). *Buildings and Climate Change: Status, Challenges and Opportunities.*
WBCSD, (2007). *Energy Efficiency in Buildings: Business Realities and Opportunities.* World Business Council for Sustainable Development.

Citation:
Adejumo, T.O (2019). *Valorization of Sand Barrier-Lagoon Ecological Assets in Lagos Smart City Conceptualization*. Chapter in the Book: African Smart City Agenda. Leke Oduwaiye, Taibat Lawanson and Victor Onifade (Ed). University of Lagos Press. Faculty of Environmental Sciences. University of Lagos, Lagos. Nigeria. Pp 140-159.