2019/2020
November-January
coou African Journal of Environmental Research *Vol 2, No. 1, 2019. pp 41-53*

FOSTERING URBAN ENVIRONMENT ADAPTATION TO CLIMATE CHANGE IN NIGERIA

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Abstract

Climate change has become one of the most pressing issues of the 21st century and against the background of rising concerns over its pernicious effects, this paper evaluates the realities of climate change challenge in the Nigerian urban environment with a view to proffering adaptation strategies towards urban climate change fitness. Using content analysis and relying solely on secondary data obtained from existing literature, the paper explores the salient conceptual and theoretical issues related to climate change as well as the intricacies of the threats it poses to the built environment. Urban greenness was identified as a veritable strategy for strengthening adaptability to the vagaries of climate change in Nigerian cities and innovative approaches expedient towards this end were discussed. Finally, the paper highlights the need for mainstreaming climate change issues into urban planning in Nigeria and recommends practical steps for the furtherance of the same in the interest of sustainable development.

Keywords: adaptability, climate change fitness, greenhouse gas emissions, green infrastructure, urban heat island

INTRODUCTION

Climate change, over time, has become a prominent subject of concern around the world. This phenomenon, commonly used to describe the rise in average surface temperatures on earth, has amassed an increasing amount of literature the last few decades. And although still a polarizing issue, its evidence and implications on lifestyle, ecosystems, the built environment and sustainability are widely accepted. Moreover, climate change concerns are a peculiarly insidious environmental problem. Their characteristics seem to be that they are slow to develop and, therefore, may not become apparent until their effects have become dangerously advanced. Hence global climate changes resulting from human influence have been described as "creeping crises" (Henderson-Sellers, 1995).

An overwhelming scientific consensus maintains that climate change is due primarily to human forces- as the natural factors, while also responsible for yearly variations in average global temperatures cannot explain the long-term warming trend over the past 60 years (National Research Council, 2012). Such human factors include burning of fossil fuels, cement manufacture, deforestation, among others. Yet, are they avoidable? Most of these activities are aimed primarily at overcoming man's challenges in the environment, and their cumulative results are expressed in the built environment. For instance, clearance of vast areas of vegetation around the world for farming, urban or infrastructure development is only expedient. Nonetheless, the opposite remains true, for with such action, stored carbon is released back in multiple ways into the atmosphere as CO_2, a greenhouse gas contributing to global warming. Thus, activities aimed at the betterment of life are indirectly instigating climate change and reducing sustainability.

The reality of this paradox brings to the fore the need to adapt the urban dynamics to make people less vulnerable to climatic change. As Sir Winston Churchill once affirmed, "We shape our buildings; thereafter they shape us". Urban settlements play an important role in this problematic. They contain virtually half of the world's population (United Nations, 2004; Cohen, 2006 and UNCHS, 2007), produce the most greenhouse gas emissions and are more exposed and vulnerable to the impacts of climate change (Pinto, 2014). With the challenges of climate change embedded in the process of urbanization, the possibilities and feasibilities of integrating climate change adaptation concepts into spatial planning are increasingly becoming the paradigm.

Although recent literatures continue to affirm the importance of spatial planning in sustainable development and for managing climate change (Davoudi, 2009), there is an evident lack of initiative in integrating climate change issues with local development priorities at the community level (Houghton, 2005). This is particularly true of cities of developing countries like Nigeria. Yet, the scientific evidence is clear: climate change is likely to have negative impacts on efforts to achieve Nigeria's development objectives, including the targets set out in Nigeria Vision 20:2020 and the Millennium Development Goals (BNRCC, 2011). In view of this, this paper explicates the climate change challenge and the applicable adaptation strategies for further improving climate change fitness in the Nigeria urban environment.

URBAN CLIMATE CHANGE PROBLEM: CONCEPTUAL AND THEORETICAL ISSUES

Climate change is a term used diversely both in public and scientific discourse. It is the most uttered environmental term of present time, used to refer to the change in modern climate brought predominantly by human beings (Rahman, 2012). The Inter-governmental Panel on Climate Change defines it as any significant change in climate over time whether due to natural variability or as a result of human activity (IPCC, 2007). Often, climate change and global warming are used interchangeably. Global warming however describes the general warming up of our planet due to the effect of human activities, particularly due to burning of fossil fuel and large-scale deforestation, that result in large 'greenhouse gas' emissions into the atmosphere (Houghton, 2005). It is the main component of climate change (Grover, 2010; IPCC, 2013) and receives the most attention due to its link with post-industrialization anthropogenic activities.

Over the years, scholars have had differing stands for and against climate change, its causes and extent. A number of theories have been provided to explain the phenomenon. Two however enjoy considerable support within the scientific community. The first, anthropogenic global warming (AGW) is the most prominent theory of climate change. It simply contends that human emissions of greenhouse gases, principally carbon dioxide (CO_2), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures through the mechanism called the enhanced greenhouse effect. Backers of the AGW theory contend the 0.7°C warming of the past century-and-a-half and 0.5°C of the past 30 years is mostly or entirely attributable to man-made greenhouse gases (Bast, 2010). According to this theory, nothing less than large and rapid reductions in human emissions will save the planet from its detrimental effects.

Apart from the AGW theory, Bast (2010) identifies "Human forces besides greenhouse gases" as another vital theory of climate change. This theory holds that mankind's greatest influence on climate is not its greenhouse gas emissions, but its transformation of Earth's surface by clearing forests, irrigating deserts, and building cities. Prominent among these manmade forces other than greenhouse gases is the urban heat islands. Cities have greater concentrations of energy-producing machines and vehicles and large amounts of concrete, asphalt, and other building and road materials that absorb solar energy and then re-emit thermal energy, a situation called urban heat islands (UHI) which makes them to be warmer than their surrounding hinterland. Evidence shows that the climate system in cities is warming faster than the rural areas which have the buffer of vegetation, water bodies and less built-up areas. Centres of megacities may be typically 7-10^{o}C warmer than rural areas, that of medium-sized cities, typically 4-6^{o}C warmer than rural areas and centres of small cities typically 1-3^{o}C warmer than rural areas (Chan, 2017). Advocates of the AGW theory falsely attribute higher temperatures caused by urban heat islands to rising atmospheric CO_2 levels (Bast, 2010).

This second theory further underscores the necessity of fostering climate change adaptability in the built environment, a fact that has been recognised within the United Nations Framework Convention on Climate Change. As posited by ICPC (2000) "the adverse impacts of climate change will severely undermine the goal of sustainable development in many parts of the world, with developing countries, and the poor in developing countries, being most vulnerable. However, it should be noted that some of these projected adverse effects can, to some degree, be reduced through proactive adaptation measures". However, adaptability (adaptive capacity) is a concept often confused with mitigation. It is the degree to which adjustments are possible in practices, processes or structures of systems to projected or actual changes of climate (Watson et al., 1996) while mitigation refers to an activity that limits or reduces the degree, extent, magnitude or duration of adverse impacts (Rundcrantz & Skarback, 2003).

The difference between the two has been clarified by the UNFCC (2000) with climate change adaptation meaning the adjustment in natural or human systems in response to actual or expected climate change effects, which moderates harm or exploits beneficial opportunities while mitigation is intervention or policies to reduce the emissions or enhance the sinks of greenhouse gases (GHGs) which contribute to climate change. In other words, the causes of climate change are to be addressed through a drastic reduction in greenhouse gas emissions (mitigation) and its consequences through an equal emphasis on investment in climate resilience (adaptation). It is however noteworthy that while the mitigation approaches might be a formidable challenge at the local scale, at least for developing countries like Nigeria, those relating to adaptation are much more attainable. Hence, mainstreaming adaptation strategies into spatial planning becomes more imperative. The capacity of spatial planning systems to adapt spatial development and existing spatial structures to climate change impacts is what is called *climate change fitness* (Pütz and Kruse, 2013). Explicating the means of improving the climate change fitness of the Nigerian built environment is the object of this paper. However the apparent climate change challenges in the said built environment will first be highlighted after which these will be examined.

The Climate Change Challenge in the Built Environment:

The impact of climate change on Nigerian settlements is already an accepted fact and these impacts are expected to increase in the future. In fact, a report by the Building Nigeria's Response to Climate Change (BNRCC) Project for Federal Ministry of Environment suggest that, in the absence of adaptation, climate change could result in a loss of between 2% and 11% of Nigeria's GDP by 2020, rising to between 6% and 30% by the year 2050 (BNRCC, 2011). These effects are felt in several ways in the urban built environment hence it's imperative to identity the drivers of climate change and the challenges posed in the built environment.

The rising heat waves experienced in cities is a major climate change challenge. Different patterns of settlement, spatial configuration of cities, land use allocation, lifestyle and consumption behaviours, all influence the combined effect of climate change and urban heat island (Kim & Ryu, 2015; Dugord et al., 2014). Already in Nigeria, there is evidence between 1941 and 2000, of long-term temperature increase with the most significant increases recorded in the extreme northeast, northwest and southwest where average temperatures rose by 1.4-1.9^{o}C. Projections reveal a temperature increase of 0.04^{o}C per year until the 2065 period, rising to 0.08^{o}C per year after 2050 (BNRCC, 2011). Even though detection of climate driven trends at the scale of individual cities is problematic due to the high inter-annual variability of local weather and factors such as land-use change or urbanization effects, it has long been recognized that built areas can have an urban heat island (UHI) that may be up to 5 – 6^{o}C warmer than surrounding countryside (Oke, 1982).

Elevated temperatures are experienced in developed areas compared to more rural surroundings owing to a number of reasons. Tall buildings slow the rate at which cities cool off at night, high absorption of heat by hardscapes such as dark, non-reflective pavements and buildings and its radiation to surrounding areas, reduced air flow from tall buildings and narrow streets exacerbates the effects (Building and Construction Authority, 2010). The effects are not far-fetched. High temperatures, apart from the apparent health implications, also speed up deterioration of housing stock and bitumen roads, and increase energy demands through increased use of air conditioning/other cooling systems (BNRCC, 2011).

Urban drainage and flood risk is another problem. Climate change increases the frequency and intensity of heavy rainfall events, thereby increasing the risk of urban flooding. Moreover, runoff from impervious surfaces can have dramatic effects on downstream risks of flooding and erosion (Hollis, 1988). As the amount of impervious surfaces increase, lesser rainwater can be absorbed on site and this leads to increase in storm water generation and runoff into drains and receiving water bodies. This can harm water quality and stresses existing drainage capacities. Furthermore, the Intergovernmental Panel on Climate Change estimates that global sea levels rose by about

2mm per year during the 20th century, with the fastest average rates (4mm per year) recorded in the 1990s. Flooding caused by a rise in sea level is already affecting beaches, monuments, industries, ports and human settlements. Large areas of cities may become uninhabitable as a result of flooding or water-logging (IPCC, 2007). Coupled with such factors like poor drainage networks, dumping of refuse in drainage, flooding already is pertinacious in the Nigerian urban scene.

Transportation is another aspect that cannot be ignored. Vehicle emissions contribute to climate change, smog, acid rain and other air quality problems. Besides, areas to accommodate vehicles like the parking areas, roads, loading areas and so on, typically add impervious surfaces on site which contribute to heat island effects and storm water runoff. Imperviousness increases the risk of flooding, generates water deficits, contributes to global warming and affects biodiversity (European Union, 2012). Essentially, the physical constituents of built areas and human activities within urban centres interact with and accentuate other climate drivers.

APPROACHES FOR STRENGTHENING BUILT ENVIRONMENT ADAPTATION TO CLIMATE CHANGE

A major strategy identified in existing literature towards strengthening adaptability of urban areas to the vagaries of climate change is urban greenness. It has been shown to have a proven proclivity for making amenable urban forms to climate change. Two basic approaches for operationalizing this in urban built environment are considered here.

Green Infrastructure:
Green infrastructure (GI) is an important tool for fostering climate change adaptation in urban environments. Its integration in spatial planning has emerged as one of the most appropriate and effective ways to improve microclimate and tackle the impacts of climate change especially the Urban Heat Island (UHI) effect (Salata & Yiannakou, 2016). Green Infrastructure according to Norton et al. (2015) is the network of planned and unplanned green spaces, spanning both the public and private realms, and managed as an integrated system to provide a range of benefits. Its major components are depicted in Figure 1. Assets forming the network includes street trees, green roofs and walls, private gardens, pedestrian and cycle routes, road and railway networks, pocket parks, city parks, regional or national parks, churchyards, school grounds, institutional open spaces, play areas, local nature reserves, sports pitches, allotments, agricultural land, ponds/lakes, rivers and floodplains and urban-municipal plazas (Norton et al., 2015).

It is noteworthy that the different components are not mutually exclusive and there are no limits to the intricacies of their possibilities when combined. As observed by Givoni (1991), green infrastructure may be incorporated in a variety of ways, including the creation of parks, tree planting along streets, and green roofs. It has a significant role in improving the urban microclimate and hence tackling UHI, whilst also helping to reduce the risk of natural disasters. Eco-friendly sidewalks are a viable alternative choice to concrete pavements (European Union, 2012), given that imperviousness from transport infrastructure contributes to global warming. A vital element of this in cities is the bicycle lanes, which promote sustainable urban mobility and is common in many European cities around the world. Open green spaces such as parks and fields are a reliable source of carbon reduction.

The greenery absorbs heat and cools the urban area through evapotranspiration. Urban forests constitute an important component of urban infrastructure. They are the areas with natural, semi-natural or planted forests situated in the cities or on the outskirts (Tirla et al., 2014). Trees unlike grasses and other herbaceous plants effectively store carbon in woody tissue for decades, keeping enough CO_2 out of atmospheric circulation over a sufficient time frame to reduce the rate of climate change. As noted by Ezeabasili (2013), urban forest, provides the ecosystem service of reducing a city's carbon footprint in two major ways, directly by carbon uptake from the atmosphere and long-term storage in wood, and indirectly by reducing a city's energy use

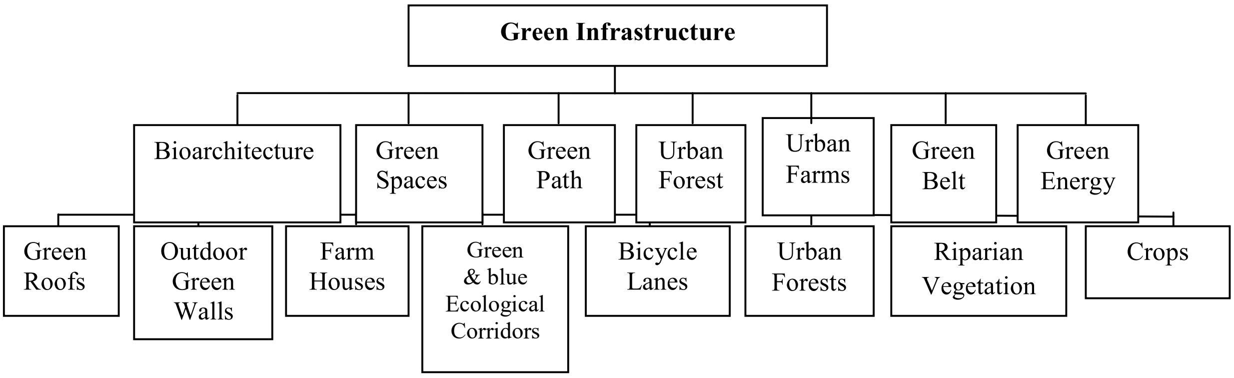

Figure 1: Basic Elements of Green Infrastructure

Source: (Adapted from Tirla et al., 2014)

GI assets can reduce the negative impact of urbanization in a sustainable manner, preventing urban sprawl, reducing the demand for transport (reducing congestion, noise, air pollution), promoting a land use mix and a more compact city structure, ensuring a sustainable and efficient use of resources and enhancing biodiversity (Salata & Yiannakou, 2016). The onus of adapting this strategy in the Nigerian built environment rests mainly on the planners. There is no one-solution-fits-all technique to the use of green infrastructure as different cities have their peculiar configuration. However, an empirical evaluation of GI assets is usually suggested in individual densely built-up areas, and their potential for reducing a compact's area vulnerability to UHI will inform appropriate approach. Yiannakou and Salata (2017) explicated a comprehensive approach of GI in the City of Thessaloniki. The methodology adopted comprises:

i. Highlighting the vulnerability of the area to UHI, by using the urban structure data, which include the inherent characteristics of the area, in order to map the parts of the built-up area which are likely to be more vulnerable.
ii. Analytical mapping of the available GI assets, followed by an assessment of the cooling effect of these assets, in order to define which parts of the area studied do not benefit from the cooling effects of GI assets and are, therefore, more vulnerable to UHI.
iii. Designation of potential planning interventions which maximize the positive effect of available GI assets on climate change adaptation.

Embarking on such an endeavour will require comprehensive data and these fall under three categories: the climatic conditions/environmental data, which includes temperature, humidity, wind, rising sea levels, air pollutants; demographic data, which includes population change, demographic and socio-economic structure; and urban form data, which include the layout plan, building characteristics, land uses, densities, open spaces/ green infrastructure (Yiannakou & Salata, 2017).

Green Buildings:

Buildings, though considered as elements, are significant enough to be considered distinctly. Building design is known to have urban-scale impacts. For instance, higher building density can increase local urban heat island effects and urban flooding, but green building strategies can ameliorate such issues (Ezeabasili, 2013). Passive design features like the aspects of the building form and envelope that will reduce energy consumption, as well as the adoption of energy efficient strategies such as natural ventilation, building greenery and the use of renewable energy have the double benefit of countering increasing temperatures without undermining mitigation efforts. Optimizing passive design strategies is the first step towards reducing the energy demand of buildings and fostering green buildings. The more developed and impervious a site is planned to be, the greater the heat island effects and surface runoff will be. The way out of this is to minimize building footprint, either by designing taller buildings with a smaller footprint as opposed to shorter buildings with a larger footprint or by consciously reducing area of impervious surfaces or hardscape.

In addition, external shading of vulnerable building surfaces and strategic siting of deciduous vegetation are effective strategies. External ground greenery is the most effective strategy to protect against heat build-up and control ambient temperatures (Building and Construction Authority, 2010). External landscaping at ground level may be in the form of trees. Studies have shown that shade plays a major role in determining the cooling effect of green sites in urban areas. Empirical analysis in the suburbs of Sacramento, United States in areas where greenery are found, showed that the air temperature under tree foliage was 1.7 - 3.3^{o}C lower compared with areas where there are no trees (Taha et al., 1998). A study of urban green areas with trees in Israel also revealed after analysis that about 80% of the cooling effect in the warm season is contributed by tree shading (Shashua-bar & Hoffman, 2000).

Other innovations include vertical greening, green roof and roof design technology. The element of novelty here is the introduction of vegetation (adjacent green) to the arrangement of a green building: green roofs and terraces, green walls and green hedges made of trees or shrubs (Anderson, 2008; Blanc, 2012). In this way, a green building increases the comfort by bringing the benefits of urban green spaces closer to the user (Tirla et al., 2014). Growing plants on the external walls especially for tall building also reduces heat transmission into the building, especially if installed on the east and west façades. This is a familiar sight in the United States and is well practised in places like Chicago where there are hundreds of residential blocks and other buildings, including the Town Hall, which have landscaped terraces and gardens (Dunn, 2010).

Furthermore, green roof systems are especially becoming widely adopted and connote living vegetation installed on the roofs. They could range from a spontaneously occurring moss and lichen covered roof to a full-scale roof garden that includes trees, shrubs and hard landscaping features and are known to contribute positively to the mitigation of urban heat island and enhancement of building thermal and environmental performance (Beattie, 2004; Kumar & Kaushik, 2005). The cooling effects of green roofs on buildings have been affirmed in studies with evidence of lower air temperatures above green sections (Wong et al., 2003). They provide thermal insulation to interior spaces below, afford a habitable space for people and animals thereby promoting biodiversity, increase comfort by bringing the benefits of urban green spaces closer to the residents and also slow storm water runoff (Menten, et al., 2006; BCA, 2010; Tirla et al., 2014).

Green roofs are increasingly being used especially in advanced countries. An extravagant project promoting the green values is the "Vertical Forest" (Bosco Verticale) of Milan, Italy – a complex of multilevel residential buildings with tree and shrub vegetation growing on the roof and on a number of asymmetric terraces (Tirla et al., 2014). The building's functionality is not a barrier when it comes to implementing green architecture and technologies. From individual residential buildings, the trend has spread to business premises and multifunctional centres such as the Commerzbank in Frankfurt, Taipei and Green Gate in Bucharest (Tirla et al., 2014). In Hong Kong, Hui (2006) noted that the existing applications are still few though the development potential is large because the city has many buildings with exposed roof areas. The experience in Singapore indicated that greenery on buildings in the forms of rooftop garden, podium garden, balcony planting, greenery on façades and multi-storey car parks would be useful for tropical cities (Wong et al., 2003). All these innovative techniques are needed in Nigerian urban centres and will go a long way in improving the resilience of the built environment to climate change.

MAINSTREAMING URBAN GREENNESS INTO SPATIAL PLANNING IN NIGERIA

From the forgoing, it is obvious that optimizing urban greenness requires not just the efforts of urban planners but collaboration with architects, engineers and other built environment professionals. Integration of efforts from these three main actors will be a step in the right direction towards effective use of urban greenness in Nigeria. The design of buildings- an indispensable component of the built environment is primarily the architect's responsibility. Engineers provides structural solutions for the buildings to withstand extremes of weather and heavy loads or create connective infrastructures, while planners shape the built environment and guide the use of land and development of resources in the interest of the community. Synergy between these professionals is essential if the habitability and asset value of existing and new buildings are to be preserved in the face of increasingly unpredictable and extreme climate change threats.

The federal government can drive the built environment professions to make necessary changes in their respective practices towards this end. Green building initiatives, organizations and general university courses on green urbanism could be introduced to bolster built environment professions so they can efficiently operationalize urban greenness. In addition, as green roofs, walls and buildings are yet to find their way into the Nigerian urban scene, researches into the tree, hedges, shrubs or plant species best suitable for these innovations and the appropriate methodologies of applying them in varying Nigerian climatic context can be sponsored by the government.

The major task however rests with planners. To this end, the fitting step will be to make the conscious effort of designating greenery as an imperative planning tool in Nigeria. Urban greenery, a medley of green spaces, green paths and green belts is the most accessible, affordable and flexible component of green infrastructure and optimizing it will prove effective for climate change adaptation. Various methodologies for achieving this exist around the world but a framework is put forward, tailored, in a context-specific way for the urban scene in Nigeria. This will help moderate the already identified potential consequences of climate change and take advantage of greenery opportunities, ultimately, improving climate change fitness of local environments. The approach will entail:

i. Introducing a separate "urban greening legislation" at state and local levels to form the basis for the establishment of an urban greening agency. An agency can then be charged with the cultivation and maintenance of local urban greenery. This body will conduct GIS based inventory of existing coverage of various green spaces within the built up area in its jurisdiction; map out the brown spots with potentials for an upturn and the areas likely to become vulnerable to greenery depletion; organize them to categories, then draw up appropriate strategies to renew canopy coverage in the former and maintain it in the later. Liaising with planning authorities, the agency can synthesize all these into a "local greening plan" for each local government area. Public enlightenment and strategic tree planting campaigns will also be primary responsibilities of the agency.

ii. Reinforcing urban greenery as a spatial planning tool by making building greenery considerations mandatory in the existing building proposal and environmental impact assessment modalities. Planning authorities should instil into development approval process, stringent regulations concerning greenery, specifically the ratio of green space to paved surfaces, the number and type of trees expected per plot area of land for residential, commercial, institutional and industrial developments. This would also be factored into the Control Department's checklist for periodic monitoring with provisions for sanctioning contraveners. Rather than being an optional landscape element, greenery specifications must be made as salient a feature, as others like plot coverage, parking and setback standards for building approval.

iii. Invigorating intra-urban transportation networks by the adoption of road designs that accommodate ornamental trees. Planning authorities must ensure that any road construction, expansion or dualization projects within neighbourhoods should incorporate central divides that will double as planting strips and sidewalk that accommodate street trees and hedges. The proposed urban greening agency can then ensure the maintenance of such road medians and sidewalks planted with green vegetation.

iv. Infusing urban climate mapping into relevant federal ministries of environment. A number of developed countries utilize this to guide planning practices. (Ren et al., 2011). Analysis of an urban setting from a climatic point of view provides important data for spatial planners on how best to deploy green infrastructure. To achieve this, urban planners and designers consult urban climate maps in order to better manage the urban form and land-uses at different spatial planning levels (Gedikli, 2018). Hence, urban climatology units can be created at environmental ministries and funded by the federal government. With this units in place, information on meteorological conditions and requirements of a city becomes more available to planners in local authorities as well as the proposed greening agencies and such maps like urban climate analysis map, among others, can be provided to guide urban planners in developing land-use decisions.

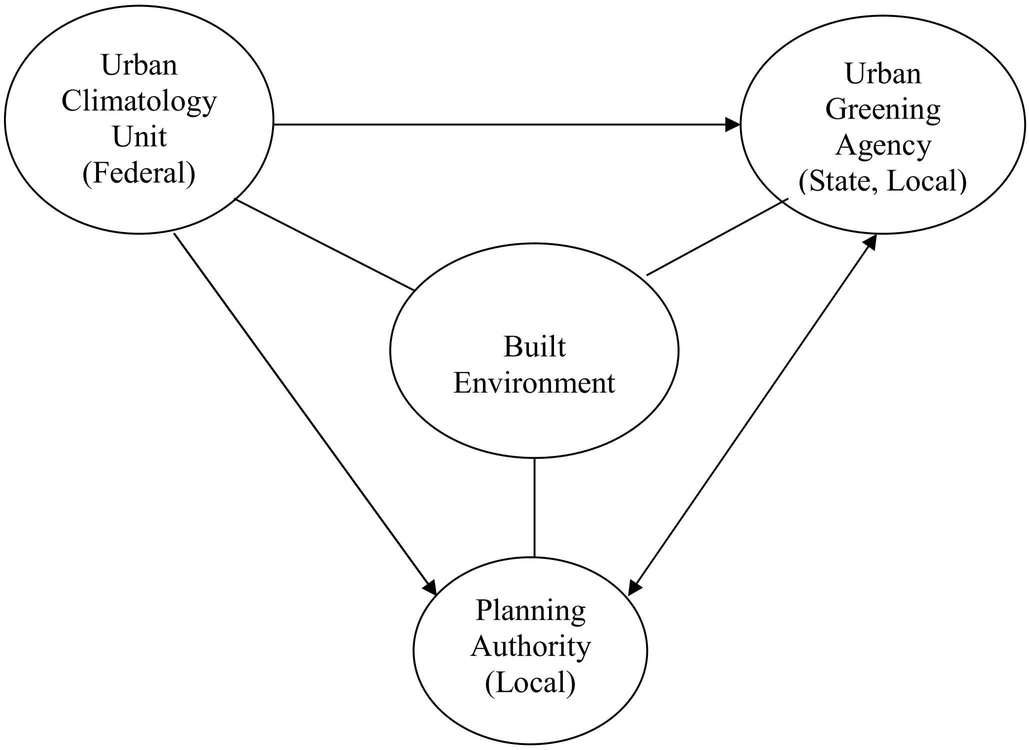

Figure 2: Conceptual framework for mainstreaming urban greenness in spatial planning
Source: (Authors' Conceptualization, 2020)

Finally, adoption of renewable energy practices is an important means of going green. Reducing energy consumption and adopting energy efficient strategies such as natural ventilation and use of renewable energy are integral elements of green buildings. Power is generated mainly from hydroelectricity within the county and its supply is often epileptic culminating in the preponderant use of fossil fuel generators, thus making buildings energy inefficient. Consequently, a shift towards environmental friendly energy sources by improving hydroelectricity and more importantly solar power is a crucial mitigation measure that will augment the already discussed measures towards climate change adaptation. This can be achieved by investing heavily in and improving accessibility to solar energy contrivances, the onus of which lies with the government. Solar power is a familiar technology in the country but its use is yet to be widespread in residential environments owing to affordability. As it emits no greenhouse gases, its widespread use, especially in residential homes will naturally enhance climate change mitigation in the built environment.

CONCLUSION

With the realities of climate change becoming more and more preponderant, urban greenness though not a new concept is increasingly recognized as a means for fostering climate change resilience in urban environments. Innovative approaches towards this end have been examined in the paper and practical measures towards its attainment in the Nigerian setting discussed. On the whole, it remains imperative that the government develop educational programmes, set up appropriate policies and embrace the needed renewable energy culture for the furtherance urban greenness in the interest of urban residents.

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