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Review Article

The Imperatives in Mainstreaming Climate Change Mitigation, Adaptation and Transformation in Urban Management Practices: African Perspectives

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ABSTRACT

While urbanization provides significant development opportunities intertwined with challenges, a notable challenge portended by urbanization is global warming and climate change, leading to increased occurrences of drought oscillating with flood, heat waves, increased pest invasions, disease incidences and food insecurity. In the global south, this is likely to lead to population displacement with the hosts being urban centres already experiencing plethora of infrastructure inadequacies. Experience from the global south corroborate that mitigation, adaptation and transformation of climate change is a challenge at the urban level due to socioeconomic conditions accentuated by insufficient regional and national assistance to urban authorities. This paper therefore annunciates the African urban climate change mitigation, adaptation and transformation scenarios and further discuss the challenges the nations and cities in the global south face in mainstreaming climate change in the national urbanization agenda. To anchor the profound arguments, concise review of literature and policy documents on climate change as informed by the urban management practices in the global south is undertaken. Finally, the paper reflects on observations regarding the challenges posed by the mitigation strategies and propose way forward on mainstreaming climate change in the urban sustainability agenda.

Keywords: Urbanisation; Development; Climate change; Mitigation adaptation; Environment

INTRODUCTION

The 2030 Agenda for Sustainable Development and its dedicated goal on cities (Sustainable Development Goals-11) seeks to make cities inclusive, safe, resilient and sustainable [1]. In addition, under the New Urban Agenda, 2016, there is a renewed dedication among the development community to ensure the expansion of cities are sustainable to mitigate the impact of climate change. According to UN-Habitat [2], over 50% of the world's population are living in urban areas by the year 2020. This is projected at 68% by the year 2050. However, urbanization is relatively higher in Africa, where most countries are urbanizing at above 3.5% per annum. While cities should be centres of economic growth, opportunity and innovation, Africa which is expected to attain urban population of up to 1.3 billion by the year 2050 has continued to experience deteriorating urban services, growing informalities and climate change [3].

With a 27% urban population and urbanization rate of 4.3% a year, about half of the Kenyan population will be living in cities by 2050 [4]. The anticipated growth will take place in the existing urban centres, increasing levels of urban poverty, unemployment, proliferation of informal settlements, environmental risks and increased exposure to disasters with adverse impacts on the urban poor. Notwithstanding the above, Kenyan cities and urban areas like elsewhere in Africa are yet to mainstream climate change in urban resilience development plans, policies and regulations as prioritized in Kenya's long-term development plan [4].

LITERATURE REVIEW

The nexus of urbanization and climate change

Cities are development hubs as corroborated by the agglomeration of land uses within them. The agglomeration leads to both urban sprawl and internal densification to accommodate the

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increasing population and competition among land uses for strategic sites. However, the urban sprawl and re-densification mostly compromise the urban sustainability which is a measure of the urban condition as presented by air, water and thermal quality and the potential effects such conditions may have on human health, urban ecosystem and biodiversity. The effect of urbanisation on global warming and climate change has raised challenges to urbanization theory and efforts have been made to postulate models explaining the correlation between the two. Despite various postulations on the relationship existing between the urban morphological variables and the urban air quality, majority of the models offering an explanation on the same are descriptive rather than quantitative. However, it is quantitative models as facilitated by the geospatial techniques which have a niche in validating the correlation and aiding in the formulation of air quality policies for the mitigation of global warming and climate change.

Climate change is the long-term shifts in temperatures and weather patterns induced by either anthropogenic activities or natural factors notably; sun spot activities and volcanic eruptions. However, since the 1800s, anthropogenic activities occasioned by agricultural development, deforestation and combustion of fossil fuel to support industrialization and transportation have been the main driver of climate change. The combustion of fossil fuel generates Greenhouse Gas (GHGs) notably; carbon dioxide, Sulphur dioxide, nitrogen dioxide and the Suspended Particulate Matter (SPM). Other GHGs, which act as blanket wrapped around the Earth, trapping the heat emitted by the earth from escaping to the atmosphere and subsequently causing global warming are water-vapour, methane and ozone gases. Further postulation is put forward by Oke [5] that for every increment of 100,000 urban population, there is a corresponding 1°C temperature increase in the city. Climatologists have proved that while the average temperature of the earth's surface is now about 1.1°C warmer than it was in the late 1800s (before the industrial revolution), the last decade (2011-2020) was the warmest on record, with each successive decade being warmer than the preceding decade since 1850.

Air quality is a spatially variable phenomenon of concern in densely populated cities of the tropics where urban infrastructure, morphology, topography and climate interact to produce uncomfortable thermal and hazardous effects. This is because cities influence GHG emissions and sinks both directly and indirectly [6]. For instance, carbon dioxide which is a major component of the GHGs is a by-product of urban anthropogenic activities such as industrial and transportation activities. Clearance of land for urban expansion and infrastructure development are drivers of regional land cover changes which reduces the global carbon sinks.

Land uses, the distribution of development densities and building configuration which define a city's form have profound influence on transportation mode used in the city as well as the city's energy consumption and GHG emissions. This is because proximity of homes and concentration of services coupled with provision of efficient public transportation accentuated by compact (high density) urban development encourages walking, cycling and use of mass transportation as opposed to private motor vehicles. This consequently leads to decline in fossil fuel consumption per capita [7]. However, this is complicated by the fact that urban centres are industrial hubs and GHG emissions coming from industries outstrip those from the transportation sector. Overall, empirical evidence shows that cities which constitutes 2% of the earth surface are responsible for 75% of global energy consumption and 80% of GHG emissions [8]. Compact developments induce usage of less energy for heating. For example, households in the United States of America living in single-family detached housing consume 35% more energy for heating and 21% more energy for cooling as compared to households living in other forms of housing due to urban heat island effect [9]. This corroborates that urban density as an aspect of urban morphology affects household energy consumption.

Density is the best tool for shaping urban morphology, yet agreements on whether to adopt low or high development density is emotive. Based on the lessons learnt from the European and North American cities, it is imperative to find a middle ground between the two models. High density development is viewed as anti-suburbanisation and an indicative of claustrophobic squalor, poverty and deprivation. On the other hand, low-density urbanism is equated with selfish gated communities and the environmentally disastrous car-orientated suburbs. However, it grants individuals freedom to spacious living areas and can be presented as a model of freedom and sturdy individual choice [10]. Views on the impacts of urban development densities have tended to be polarising as noted by the works of Howard [11] and Jacobs [12]. Howard [11] argues that it is universally agreed by men of all parties that it is deeply deploring that people are still streaming in already overcrowded cities. On the other hand, Jacobs [12] whose work, The Death and Life of Great American Cities is taken as a mantra for new urbanism movement (those opposed to the suburban sprawl and restrictive residential enclaves) is passionate in the defence of high development densities. According to Burton [13], a study of medium-sized English cities suggests that while high urban development densities lead to reduced living spaces, it has the ability to improve public transportation, reduce social segregation and enhance access to utilities and amenities.

Low development densities are viewed as the main causes of urban sprawl and its subsequent effects of global warming and climate change. However, the definition and the effects of urban sprawl on environmental quality are widely debated. Frenkel and Ashkenazi states five parameters for detecting urban sprawl as growth rates, development density, spatial geometry, accessibility and aesthetics. Urban sprawl is often associated with problems such as social isolation, obesity and asthma, global warming, climate change, the demise of farmlands and extinction of wildlife. However, some scholars argue that urban sprawl is inevitable for it is an outcome of free-market mechanism [7]. In low and middle-income countries, peri-urbanization is increasingly taking place and the boundaries between urban and rural areas are continually being re-negotiated. The interfaces between the two are often afflicted by slums, inadequate urban services and degradation of farmlands. This is because planning regulations are inadequately enforced in the peri-urban neighbourhoods for such neighbourhoods are outside the legal and administrative boundaries of the cities [14].

High rates of urbanisation have exacerbated increased development densities in the cities. This is beneficial for the conservation

of open spaces and natural resources, enhancement of social relationships and enabling urban authorities to deliver more housing stock, services and employment stations within walking distances. However, high development densities exacerbate overcrowding and noise [15]. Equally, changes associated with urban developments have profound effects on urban surface temperatures and air quality which consequently have effect of inducing global warming and climate change. New surface materials associated with urban buildings, roads and other urban infrastructure alters the natural surface which consequently alters energy balance, water exchanges and airflow. These surfaces have high thermal properties due to their ability to store more solar energy and convert the same to sensible heat. The removal of the vegetation cover due to urbanisation reduces evapotranspiration and shading effects of the ecosystem [16]. Further, urban topographical features such as the surface roughness, building configuration and anthropogenic activities contribute to higher urban surface temperature values by generating and attenuating outgoing long wave radiation. The skyscrapers provide multiple surfaces for the reflection and absorption of terrestrial energy. This consequently hinders sensible heat loss and distribution of the same with increased urban surface temperature values [17]. The heat dynamics and building configuration further attenuates wind velocity and cause turbulences which restrict the air pollutants to building canyons leading to the accumulation of air pollutants in the city. The dynamics equally lead to the alteration of the precipitation pattern in the urban metropolis as well as the frequencies of urban flood disasters and changes in urban biodiversity [18]. The above combined with heat, carbon dioxide and other GHGs emitted by anthropogenic activities result in distinct urban climates. One of the known effects of such development is urban warming of which globally cities are warmer than the surrounding rural areas but with internal urban spatiotemporal variations [19]. On average, urban temperatures may be 10°C to 3°C warmer than rural environs, but in calm and cloudless nights, air temperatures can be more than 10°C warmer than surrounding rural environments [20]. Therefore, development density and building configuration adversely affect the urban air and thermal quality.

From the above, it is evident that the spatiotemporal variations in urban temperatures is accentuated by the neighbourhoods' attributes such as the amount of vegetation on site, development density and the nature of the construction materials used in the neighbourhood. This manifests in form of urban heat island which is further accentuated by anthropogenic activities such as vehicular traffic, industrialisation and domestic buildings which produce heat, sulphur dioxide, nitrous oxide, suspended particulate matter and carbon dioxide, gases known to contribute to global warming and climate change [21]. These gases interact with the city's compact mass to affect energy exchange and levels of thermal conductivity. However, factors such as topography in relation to the sun's angle and aspect are as influential as the surface type in controlling the amount of radiation received and absorbed. Thus, a low-vegetated area incidence to direct solar radiation is much warmer as compared to vegetated areas [22].

A study of GHG emission in Toronto city concludes that low density suburban developments consumes between 2.0 to 2.5 times more energy annually than densely developed neighbourhoods. This is because high development density encourages low car ownership and requires less energy for heating, cooling and to power the buildings [23]. A study of 16 variables in 45 Chinese cities concludes that there is a positive relationship existing between urban development density and air quality up to a certain level as other variables such as income levels, urban spatial structure, transportation network, surface temperatures and population size explains why cities in Southern Asia which are densely settled than cities in North America yet they generate less levels of GHGs than the North American counterparts [24].

In as much as high urban development density encourages compact urban form which reduces GHG emissions, high development densities cause urban heat-island effects as well as increased outdoor and indoor air pollution [25]. As noted by Neumann [26], compact urban form is not singly sufficient for the improvement of air quality and urban sustainability. Therefore, other strategies such as enactment of policies related to public transportation, building regulations and reduction of household energy consumptions must be entrenched in the urban development agenda if sustainability has to be realised [27]. For urban sustainability to be achieved, Jabareen [28] identifies seven pillars that must be considered as urban form, public transportation, development density, mixed land uses, diversity, passive solar design and greening. He used the concepts to compose a sustainable urban form matrix and concludes that compact city model is the most sustainable, followed by the eco-city, neo-traditional development and urban containment. Indeed, doubling a neighbourhood's density combined with green buildings and smart-growth technologies decreases automobile usage by 30%, thus decline in gasoline consumption and GHG emissions [29].

The urban spatial structure equally influences the GHG emissions. This is demonstrated by energy usage differentials in four urban spatial structures notably mono-centric, poly-centric, composite (multiple-nuclei) and urban village models. In the mono-centric cities, most economic activities and amenities are concentrated in the Central Business District (CBD). In this scenario, the authorities focus on promoting public transportation as the most convenient mode of transportation, for most commuters travel from the suburbs to the CBD while in the poly-centric cities, few jobs and amenities are located in the centre and most trips are from suburb to suburb. In this regard, a large number of possible travel routes exists, but with few passengers per route. Therefore, public transportation is difficult and expensive to operate and private means of transportation becomes convenient option for users.

The composite (multiple-nuclei) model is the most common type of urban spatial structure. This model manifests a dominant centre with a large number of jobs located in the suburb's minor centres. Under the composite model, most trips from the suburbs to the CBD are made using public transportation, while trips from suburb to suburb are made using private means of transportation. This necessitates the need for both public and private modes of transportation. The urban village model is utopian and is a construct of the urban master plans. In this model, urban areas contain many business centres, commuters travel only to the centre which is closest to their residence and have more opportunities to walk or cycle to work. This model is ideal for it requires less motorised modes of transportation due

to the reduced distances travelled to work. This lowers the energy usage and the GHG emissions. The more the urban spatial structure encourages public transportation, the more it lowers the emission of GHGs, air pollutants and climate change.

Alterations of urban land uses and land cover indirectly modify the urban climate. For example, in America, surface temperature increases have been observed where extensive forests and other natural vegetations have been cleared. Accordingly, Kalnay and Cai [30] estimates that over the past fifty years in the United States of America, land-cover changes have resulted in 0.27°C mean annual surface warming. Narisma and Pitman [31] having observed the impacts of land cover change on temperatures in Australia, supported the postulations of Kalnay and Cai [30]. Other studies such as Sailor and Fan [32] and Unger et al. [33] concludes that for large urban areas, depletion of vegetation cover increases surface temperatures by between 1.67°C to 2.22°C during summer and by 5.6°C during winter.

The primacy of vegetation in the nexus of urbanisation and climate change is profound for vegetation mitigates the heating and polluting effects generated by the urban developments through a combination of photosynthesis, evapotranspiration and shading effects. Vegetation through photosynthesis sequences carbon dioxide gas in the atmosphere, thereby mitigating the GHG effects [34-36]. Vegetation facilitates urban cooling through evapotranspiration which converts solar radiation into latent heat of vaporisation. The latent heat of vaporisation then escapes with the sensible heat to the atmosphere [37]. Therefore, vegetation density differentials within urban neighbourhoods explain the surface temperature variations among the same. Vegetation also has effect on wind velocity and precipitation regime of urban areas which in turn affects the urban air quality [38]. Further in mitigating climatic parameters, vegetation also impacts on urban storm water management. For example, in Baltimore, it was determined that neighbourhoods with 40% tree cover reduce surface runoff by 60% more than neighbourhoods without trees.

The above annunciations corroborate the correlation existing between urbanisation through its resultant morphological parameters of urban spatial structure, the development densities and the urban configuration notably the building heights and the GHGs emissions, air quality, urban surface temperatures and climate change. However, the relationship is moderated by the amount of vegetation within the urban landscape which act as carbon sinks. According to Klaus et al [39], stale and polluted air accumulates in the highly built up areas due to convergence of air into the areas during the day for they are warm and acts as urban heat islands. These areas thus experiences warm rising air during the day but this may be replaced at night by cool fresh air from adjacent cold neighbourhoods. It is therefore evident that the urban air quality and surface temperature values are determined by both anthropogenic and physical process for as anthropogenic activities continues to alter the natural ecology of cities through urban development processes; the long-term energy exchanges taking place within the boundary layer are affected. This is because the surface properties influence the atmospheric energy budget and by altering the surface conditions, man has inadvertently affected the atmospheric properties which influences local, regional and global climate through the cascading linkages of the atmospheric, terrestrial and hydrological systems [40]. Therefore, global warming and climate change may not be attributed to the effects of the GHGs alone but also to the effects of heat islands occasioned by urbanization [41].

The effects of climate change to sustainable development in Africa

Even though Africa's climate has warmed more than the global average since pre-industrial times (1850-1900), continued global GHG emissions accentuating global warming and climate change is likely to heighten the prevalence of devastating disasters hitting the most vulnerable hardest and contributing to food insecurity, population displacement and stress on water resources. Some of the effects of climate change include increased temperatures and drought frequencies, retreating mountain glaciers, sea level rise, occurrence of extreme weather exemplified by extreme heat, wildfire and dust storms especially in Tunisia, Algeria, Morocco and Libya, high rainfalls leading to severe floods leading to elevated water levels of lakes and rivers. Drought also causes dwindling water stress, food insecurity and population displacement. Perhaps no region in the world has been affected as much as the Africa, which is experiencing rapid population growth of 2.8% per annum, in an environment of shrinking natural resources [42]. The continent has experienced frequent floods, an invasion of desert locusts and droughts aggravated by the COVID-19 pandemic, yet the continent accounts for about 2% to 3% of global GHG emissions. The decadal predictions, covering the years from 2020 to 2024, shows continued warming and decreasing rainfall especially over North and Southern Africa and increased rainfall over the Sahel. Much of Africa has already warmed by more than 1°C since 1901 and it is projected that extensive parts of the continent will exceed 2°C of warming above pre-industrial levels by the last two decades of the 21st century [43]. The ravages of climate change will be borne by the urban centers where the displaced population will congregate as climate refugee, heightening urbanization of poverty.

At global warming mean temperature of 2°C, significant climatological changes will occur in all sub-Saharan regions. According to the IPCC (Intergovernmental Panel on Climate Change) [43], Western Sahel region will experience increased length of dry spells. Similarly, Central Africa will witness decreased length of rainy seasons but with a slight increase in the amount of rainfall. West Africa which is a climate change hotspot is likely to experience decline in crop production leading to food insecurity. Southern Africa will also be affected as the western part of Southern Africa is set to become drier, with increasing drought frequency and heat waves toward the end of the 21st Century. At 1.5°C of warming, less rain would fall over the Limpopo and Zambezi basins as well as parts of Western Cape in South Africa. This will cause reductions of between 5% to 10% in the volume of the Zambezi River. At 2°C of warming, Southern Africa is projected to face a decrease in precipitation of about 20% and increases in the number of consecutive dry days in Namibia, Botswana, northern Zimbabwe and southern Zambia [42].

Climate change induced by GHG emissions and global warming is likely to increase the intensity of natural hazards such as storms, cyclones, tsunamis, flooding and erosion in the coastal cities [44]. According to IPCC [45], a rise in global average

temperatures by 2°C or more will exacerbate coastal flooding while temperature rises of more than 3°C may result in loss of about 30% of global coastal wetlands and agricultural land as occasioned by water logging and salt stress. Other likely effects of temperature rise are inadequate freshwater supplies, destruction of property, loss of human lives and increased prevalence of environmental, malnutrition and cardio-respiratory diseases. Further to temperature variations associated with global warming and climate change inducing frequent and intense heat waves, it also results in additional cost of environmental control within buildings as well as increased concentration of air pollutants in the urban canyons [46].

Drought, floods, increased pests and diseases associated with global warming and climate change have resulted in food insecurity and loss of livelihoods at the regional, national and individual household levels. By the middle of the 21st century, major cereal crops grown in Africa will be adversely impacted albeit with regional variability and differences among crops. Under the worst-case climate change scenario, a reduction in mean yield of maize is projected at 13% in West and Central Africa, 11% in North Africa and 8% in East and Southern Africa. Millet and sorghum have been found to be the most promising crops, with a yield loss of 5% and 8%, respectively by the year 2050 due to their greater resilience to heat-stress conditions, while rice and wheat are expected to be the most affected crops with a yield loss of 12% and 21%, respectively. The impact of this is already manifesting in the number of undernourished people who have since increased by 45.6% since the year 2012 in the drought-prone sub-Saharan African countries [42]. Drought, desertification and scarcity of resources has further heightened conflicts between crop farmers and pastoralists. In concert with prevalence of armed conflict and military operations in the region, millions of people have been displaced and require humanitarian assistance.

Temperature increase, heat waves, extensive floods, tropical cyclones, prolonged droughts and sea level rise resulting in loss of lives, property damage and population displacement is undermining Africa's ability to achieve the targets of the United Nations Sustainable Development Goals (SDGs) and the African Union Agenda 2063, which outlines Africa's path for attaining inclusive and sustainable economic growth and development. Water stress in Africa occasioned by frequent droughts, receding lake and river volumes, disappearing glaciers and devastating floods, rising water demand combined with limited and unpredictable supplies threatens to aggravate water-based conflict, displacements, undermine human health and safety, food security and other socio-economic development parameters, making urban communities, economies and ecosystems increasingly vulnerable. High water stress is estimated to affect about 250 million people in Africa [43].

Marked regional variability in sea-level rise is witnessed in Africa. Whereas sea-level increase reached 5 mm per annum in several oceanic areas surrounding the continent, it exceeded 5 mm per year in the south-western Indian Ocean from Madagascar eastward towards and beyond Mauritius. This is more than the average global sea-level rise of 3 mm to 4 mm per year. This has exacerbated coastal flooding, erosion and salinity. This is expected to worsen in the future with implications on coastal towns, notwithstanding the impact the phenomenon have on agriculture sector, ecosystem and biodiversity. The prospects here have been worsening with other extreme events such as cyclones of which Tropical Cyclone Idai is cited as among the most destructive tropical cyclones ever recorded in the southern hemisphere and which resulted in hundreds of casualties and thousands of displacements [43].

Adverse consequences of climate change are concentrated in regions with relatively hot climates, where disproportionately large number of low-income countries are located. Africa is therefore an exposure and vulnerability hot spot for climate variability and change impacts [47]. The continent is therefore destined to significantly experience declining Gross Domestic Product (GDP) occasioned by global temperature increase. For scenarios ranging from a 1°C to 4°C increase in global temperatures relative to pre-industrial levels, the continent's overall GDP is expected to decrease by 2.25% to 12.12% with West, Central and East Africa exhibiting higher adverse impact than Southern and North Africa as shown in Table 1 [48].

Table 1: Long-term impacts of climate change on Africa's GDP (% change/year) according to four global temperature increase scenarios for the five subregions and for the whole of Africa.

Subregions	GDP (% Change/Year)			
	1°C	2°C	3°C	4°C
North (n=7)	-0.76 ± 0.16	-1.63 ± 0.36	-2.72 ± 0.61	-4.11 ± 0.97
West (n=15)	-4.46 ± 0.63	-9.79 ± 1.35	-15.62 ± 2.08	-22.09 ± 2.78
Central (n=9)	-1.17 ± 0.45	-2.82 ± 1.10	-5.53 ± 1.56	-9.13 ± 2.16
East (n=14)	-2.01 ± 0.20	-4.51 ± 0.34	-7.55 ± 0.63	-11.16 ± 0.85
Southern (n=10)	-1.18 ± 0.64	-2.68 ± 1.54	-4.40 ± 2.56	-6.49 ± 3.75
Whole of Africa (n=55)	-2.25 ± 1.52	-5.01 ± 3.30	-8.28 ± 5.12	-12.12 ± 7.04

Note: Adapted from Economic growth, development and climate change in Africa, published by the African Climate Policy Centre (ACPC) of the United Nations Economic Commission for Africa (UNECA).

Increase in temperature and changes in rainfall patterns significantly affect population health across Africa. Warmer temperatures and higher rainfall increase provides conducive habitat for pathogens, insects and the transmission of vector-borne diseases such as dengue fever, malaria and yellow fever. In addition, new diseases are emerging in regions where they were previously not present. In 2017, an estimated 93% of global malaria deaths occurred in Africa. Similarly, warming in the East African highlands is allowing malaria-carrying mosquitoes to survive at higher altitudes.

International and national agenda for the mitigation, adaptation and transformation to global warming and climate change

Combating climate change and its impacts was key in the enactment of 17 Sustainable Development Goals (SDGs). In its 13th goal on climate action, the agenda endeavours to combat climate change and its impacts by limiting global warming to between 1.5°C to 2°C. Recognizing that the years from 2015 to 2021 were the warmest accompanied by devastating climatic

impacts, many countries came together in the year 2015 in what is known as the Paris Agreement. The Paris Agreement was adopted by all the 196 Parties in Paris on 12th December 2015 into the United Nations Framework Convention on Climate Change (COP21), a development which is significant for the reduction of GHG emissions and building of climate resilience cities. All the African nations, except Angola, Eritrea and South Sudan are signatory to the agreement.

The twenty second session of the United Nations Framework Convention on Climate Change (COP 22) took place in Marrakesh, Morocco on 7th to 18th November 2016. This marked the beginning of the preparations for the entry into force of the Paris Agreement and implementation of actions for addressing climate change. Further, the United Nations Framework Convention on Climate Change (COP23) which took place in Bonn, Germany, from 6th to 18th November 2017 and which brought together leaders of national governments, cities, states, businesses, investors, NGOs and civil society further accentuated the resolves of COP22.

The United Nations Framework Convention on Climate Change (COP24) which took place on 2nd to 14th December 2018 in Katowice, Poland was instrumental in finalizing the rules and work plan for the implementation of the Paris Agreement. The convention also called for increased financial support from developed countries in assisting climate action efforts of developing countries. Since the year 2015, the Nationally Determined Contributions (NDCs) to the Paris Agreement have become the main instrument for guiding policy responses to climate change. Towards this end, fifty-two African countries have submitted their first NDCs.

The United Nations Framework Convention on Climate Change (COP25) which took place from 2nd to 16th December 2019 in Madrid, Spain came at a time when emerging data evidenced worsening impact of climate change. This was authenticated by COP26 which took place from 13th October to 13th November 2021 in Glasgow, the United Kingdom. The COP26 brought together 120 world leaders and over 40,000 registered participants, including 22,274 party delegates, 14,124 observers and 3,886 media representatives. For two weeks, the world was riveted on all facets of climate change; the science, the solutions, the political good-will and areas of action.

Evidently, the United Nations has continued to encourage all stakeholders to take action towards reducing the impacts of climate change. This is corroborated by COP27 which was held in Egypt's coastal city of Sharm el-Sheikh from 6th to 18th November, 2022. In attendance were the Heads of State, Ministers and Negotiators, along with Climate Activists, Mayors, Civil Society Representatives and Chief Executive Officers of various companies. The convention built on the outcomes of COP26 on delivery of issues critical to tackling the climate emergency notably; the need in urgently reducing GHG emissions, building climate resilience, climate change adaption and delivering on the commitments to finance climate action in developing countries. In concert with United Nations conventions, the Africa's Agenda 2063, which was concluded in 2013 has also recognized climate change as a major challenge to the continent's socioeconomic development and has called for invigorating efforts towards the mitigation of the same. This is demonstrated by ratification of the Paris Agreement by over 90% of the African nations with commitments to transition to green energy and agriculture within a relatively short time frame as prioritized in over 70% of the African NDCs.

Other initiatives for mainstreaming climate change mitigation and adaptation into urban development agenda is the urban resilience initiatives, which have been adopted by many global cities participating in the 100 Resilient Cities (100RC) Network, pioneered by the Rockefeller Foundation to build cities' capacity in becoming resilience to the environmental, physical, social and economic challenges, of which climate change is part of. Apart from climate change, the 100 Resilient Cities Network supports cities in building resilience capacity to mitigate, adapt and transform to shocks such as floods, fires, riots and stresses such as urban poverty, unemployment and aging population among others.

The realization that real action for climate change mitigation, adaptation and transformation should involve collaboration between national and county governments, business community, the civil society and communities in reducing GHG emissions, initiatives at building climate resilience in Kenya include but not limited to the following:

- Article 42 of the Constitution of Kenya 2010 guarantees the citizens clean and healthy environment. This empowers persons to seek legal redress in the courts of law when their right to a healthy and clean environment has been violated or infringed on. The courts are empowered to issue orders that prevent, stop or discontinue acts that are injurious to the environment and provide compensation to an offended party
- Climate Change Act of 2023-The Act is paramount for the development, management, implementation of mechanisms to enhance climate change resilience and low carbon development in Kenya. It is a precursor for the Kenya National Action Plan on climate change which aims at strengthening the countries pathways to sustainable, climate resilient development.
- Environmental Management and Coordination Act (EMCA) of 1999-A comprehensive environmental law that provides the legal framework for environmental management in Kenya. It covers various environmental issues including air pollution and empowers regulatory authorities to enforce compliance and take necessary actions to protect the environment.
- Urban Areas and Cities Act which is an Act of Parliament giving effect to Article 184 of the Constitution; to provide for the, classification, governance and management of urban areas and cities. One of the fundamental issues of governance considered in the Act is environmental management
- Physical planning and land use 2019 is an Act of Parliament regulating development of land and for connected purposes for sustainability of which environmental consideration is part of.
- National Climate Change Response Strategy
- National Policy for Disaster Management
- Development of Kenya County Climate Risk Profile Series

- Development of Urban Resilience Strategies for five cities in Kenya, namely Nairobi, Mombasa, Kisumu, Nakuru and Eldoret since the year 2021
- Nairobi Climate Action Plan 2020-2050
- Mombasa County Climate Change Action Plan
- Mombasa-Climate-Change-Policy, 2021
- Kisumu Sustainable Mobility Plan 2021
- The Kisumu County Disaster and Emergency Management Act, 2015

DISCUSSION

Mainstreaming climate change mitigation, adaptation and transformation in urban management policies

As acknowledged by global frameworks and agreements such as the Sustainable Development Goals, the United Nations Framework Convention on Climate Change and the Paris Agreement, mitigating and adaptation to climate change needs implementation of multiple strategies and techniques which are known to work within the standard practice of urban environmental planning and management. Such strategies include promotion of green infrastructure, innovative urban design and conservation, tightening up legislations on protection of urban ecosystems such as the green belts, gardens and trees, urban river restoration and implementation of sustainable drainage and transportation networks. Other measures include cutting GHG emissions, adapting to climate impacts and financing required adjustments. Some noble actions such as reducing the utility of fossil fuels such as coal, oil and gas and switching to renewable energy such as solar will reduce the GHG emissions driving climate change. Indeed, the policy approach should promote investment in sustainable solutions such as ending subsidies on fossil fuel and polluters must pay for their pollutions. Other measures include popularization the use of public transportation, reduction of household energy consumptions, investment in green transition which accelerate the decarbonization of all aspects of the economy, creation of green economy, jobs and inclusive growth as well as strengthening transboundary collaboration and corporation for climate resilience in realization that no country can succeed alone in climate change mitigation, adaptation and transformation.

Additional measures for building resilience to climate change include strengthening early warning systems, data exchange and knowledge sharing. Climate change mitigation, adaptation and transformation further requires a new environmental contract encompassing civil society, public and private sector participations as well as reorientation of legal, institutions and development infrastructure towards delivering urban environmental quality. This should build on the strengths of planning and other environmental management strategies which give more scope and encouragement to local action, behavioural change and innovation. Therefore, building climate resilience cities should be anchored on proactive policies focussed on socioeconomic development strategies and institutional capacity building for planning, both at the community, city, county and national government levels.

Inadequate consideration of climate change in national, county and city plans lead to potential increase in vulnerability, risks and a reduction in coping capacities of urban communities and socioecological systems, yet development policies, urban plans and climate programs are examples of immediate adaptation interventions at the city level. Therefore, there is need to change the way current development and climate policies are positioned and prepared across cities in Africa and to change the capacity of urban plans and planning practices to respond to climate risk. Climate change awareness, analysis and action need to be improved together with a dynamic, comprehensive risk assessment and enactment of flexible climate adaptation strategies.

Enhancement of vegetation cover within the city through adoption of sustainable urban growth policies is imperative in the climate change mitigation, adaptation and transformation. Recent studies show that nature-based solutions can contribute up to 37% reduction on GHG emissions required to keep global warming below 2°C [43]. This is occasioned by the vegetation's ability to sequestrate carbon dioxide, decreasing the amount of carbon in the atmosphere and subsequently reducing the GHG effects and ultimately leading to the mitigation of global warming. Further, vegetation moderates surface temperatures making vegetation density the most significant urban morphological variable influencing urban thermal values. However, this may be negated by urban sprawl characterizing many cities of the south. Therefore, measures such as the design and implementation of appropriate, innovative and dynamic development policies geared towards increasing the vegetation cover should be prioritised. Such policies should entail implementation of programmes such as development of urban forests, arboretum, open parks, playgrounds and/or village squares, picnic sites and walkways in the residential, commercial and industrial neighbourhoods as well as tightening up legislations protecting urban ecosystems such as the green belts, gardens and urban river restoration among others. The above can be achieved through implementation of development policies which minimises land fragmentations and urban sprawl such as up-scaling of sky lines through increments of plot coverages, ratios and minimum lot sizes for various developments.

Hindrances to the enhancement of the vegetation cover in the cities are ad-hoc enactments of the development control policies and regulations, inadequate implementation of the development plans and land speculations which accentuate proliferation of illegal developments leading to undesirable land use and land cover conversions. To rectify this, the cities should regularly update the existing development plans and enforce strict adherence to the development control standards. This should also include shortening the time period in plan approval process to minimise illegal developments. The evolved development plans should spell out the number of trees to be planted per acreage of a developed plot. In accordance with the provisions of Environmental Impact Assessment Regulations of 2003, all the proposed developments within the cities which are likely to generate significant GHGs should be subjected to Environmental Impact Assessment and enforced by National Environment Management Authority in conjunction with the city authorities.

Privatisation and restitution concepts which have found niche in the management of public affairs have altered the urban

housing market. The concepts empower the private sector to be the main providers of the urban housing, yet the sector is more interested in providing housing for the middle and high-income groups. This has made housing unaffordable to the urban poor who move to the urban periphery and/or open lands to establish informal settlements, consequently leading to rapid land use and land cover changes as well as environmental degradation. Therefore, the government should roll-out sustainable urban low-income housing development programmes if the environmental degradation and encroachments into the fragile ecosystems which are carbon sinks has to be managed.

Creation of air quality monitoring stations in the cities to facilitate enactment of appropriate environmental management, transportation and industrial development policies should be prioritised. Industries and motor vehicles emits GHGs, sulphur dioxide and suspended particulate matter which are major contributors of global warming and climate change. Therefore, the cities should formulate policies and enact legislations and standards for the reduction of air pollution in the cities. The policies should include popularisation of public transportation, none-motorised modes of transportation as well as limiting the number of vehicles coming into the city. Other transportation policy measures that should be favoured include the development of arterials which supports rapid vehicular flow for it has since been established that vehicles emit more GHGs, sulphur dioxide and suspended particulate matter when their speeds are low. However, for the above to be undertaken, there is need for frequent air quality monitoring which can be achieved through the establishment of adequate network of stationary air quality monitoring stations as well as undertaking mobile air quality monitoring along road transects and in the industrial plants.

Science-based climate information is the foundation of climate change resilience building. However, the limited uptake and use of climate information services in development planning in Africa is partially due to the paucity of reliable and timely climate information for building green, sustainable and climate resilient cities. Despite climate action gaining momentum, only 40% of the African population have access to early warning systems to protect them against extreme weather and climate change impacts [43]. This necessitates prioritization of universal access to early warnings, revision of the national climate plans to upscale commitments to urban climate mitigation, adaptation and transformation. Additionally, there is need for increased investment in hydrometeorological data collection and improvement of climate services provision in Africa. Currently, 28 countries provide climate services from basic to essential level. While only 9 countries provide the services at full level, only 4 countries are providing end-to-end drought forecasting services at advanced capacity [43].

Consideration should be made to instituting Geospatial, Information and Communication Technologies in the urban planning and growth management in line with the SDGs' recommendations. In undertaking regular reviews of the development plans and standards as earlier proposed, cognisance should be taken of land use suitability. This is impetrative in protecting the fragile ecologies such as the forest and riparian reserves against encroachment by anthropogenic activities. The land use suitability analysis is also imperative in protecting human life and property against disasters such as floods. However, the above can efficiently and effectively be undertaken if the city authorities institute the utility of ICT and the geospatial techniques notably remote sensing and Geographical Information Systems as planning tools. This is also imperative in climate proofing urban planning strategies into short and long-term climate scenarios in order to identify areas for improvement and to promote evidence-based decision-making.

As occasioned by increased frequencies of sewer blockages and bursts, there are indications that developments in the African cities are surpassing the capacity of the existing infrastructure. Therefore, for the cities to continue supporting the current population through re-densification of the existing land uses (curtailing the urban sprawl), expansion and regular maintenance of the urban infrastructure such as water, sewer and roads should be prioritised. In order to finance such climate change mitigation projects, city authorities should actively seek out and utilize financial resources from international, national, own funding mechanisms, actively involve the private sector through public-private sector partnerships as well as establish capacity building programs and trainings to improve climate change awareness and analysis among urban planning practitioners, policy makers and the general public.

Adoption of multi-sector partnership approach to urban environmental planning and management is a sustainable approach to climate change mitigation, adaptation and transformation. Despite the constitutional stipulations on the involvement of the citizens in the development plan formulation and implementation, it is glaring that the current climate change mitigation, adaptation and transformation paradigms operational in the Kenyan cities are not people driven and various development agents feel left out in the process. Therefore, in the evolution and review of the climate action plans for the cities, the people and various development agents should be brought on board. This makes it easy for people and the development agents to understand the issues entailed in the plans and to take charge in implementing the same. Therefore, city authorities should reactivate policy on partnership building with citizens and other development agents as well as registering the neighbourhood associations and empowering the same to undertake self-driven development control and climate change compliance monitoring. It is equally imperative to explore broad based (in issues and stakeholders) and participatory institutional framework on which various strategies that are meant to enhance the cities' climate resilience can be implemented. Further to the above, the capacity of cities should also be strengthened to ensure effective implementation of climate change mitigation, adaptation and transformation policies and plans.

In Kenya like everywhere else in Africa, a promising approach to the reduction of climate risks and hazards posed by extreme weather-related events is the reduction of poverty through promotion of socioeconomic growth in the agricultural sector which employs 60% of the population. This should entail the utility of value-addition techniques using efficient and green energy sources in the agricultural production. For example, solar-powered, efficient micro-irrigation is increasing farm-level incomes by five to ten times, improving yields by up to 300%

and reducing water usage by up to 90% while at the same time offsetting carbon emissions by generating up to 250 kW of clean energy [47].

CONCLUSION

While strategizing mitigation, adaptation and transformation to climate change, cognizance should be taken to the correlation existing between urbanization, global warming and climate change. Therefore, with growing urbanization, global warming and climate change are likely to reach significant levels with varied consequences. However, urbanization is inevitable and cities shall continue being anchors to socioeconomic development as corroborated by the concentration of industries and being transportation hubs to their hinterlands. This will exacerbate the GHG emissions if sustainable strategies are not enacted to mitigate the same. Mitigation of climate change is possible with concerted partnership building efforts among various stakeholders at international, national and city levels. This is because GHGs responsible for climate change are transboundary and multisource phenomenon. Indeed, efforts should be geared towards data and knowledge sharing on the best practices. The primacy of public awareness and participation on the policies enacted to mitigate, adapt and transform climate change is imperative in achieving the objective. As much as high urban development density encourages compact urban form which reduces GHG emissions, it is not a panacea to the mitigation, adaptation and transformation of climate change. As such, other strategies popularizing public transportation and reduction of household energy consumptions must be entrenched in the urban development agenda.

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