CHAPTER 1: The Influence of Urbanisation on Climate Change in Major African Cities

Abstract

Urbanisation is one of the key aspects that have led to the fragility of urban landscapes in many parts of the African continent. Over the years, the relationship between people and the environment has been seen as the catalyst to negative environmental changes such as climate change as people have exploited the resources provided by the environment and failed to safeguard them. In developing regions of Africa, most people migrate from rural to urban areas in search of greener pastures. This has caused peri-urban developments, urban sprawl and the growth of settlements on wetlands. Urbanisation has led to major urban problems leading to the destruction of infrastructure through traffic congestion that, in turn, contributes to urban decay and environmental pollution. Urban geographical processes have led to the alteration of seasons, rainfall patterns and the destruction of the ozone layer. This chapter discusses the link between urbanisation and the degradation of environmental quality on the African continent.

INTRODUCTION

Climate change and urbanisation have been one of the two most important issues that have led to policy-making in many regions of the world in the 21st century (Chapman *et al.,* 2017). The rise of the urban form as the dominant geographical context for life on earth and the emergence of climate change as a real and present threat to socio-ecological sustainability on the planet and a potent, if not dominant, force of urban change are components of the earth system that are detrimental to each other (Ziervogel *et al.,* 2014). This relationship has become an important element of policy-making as recent trends are showing that we are living in an era of unprecedented rapid urbanisation, with more than 50% of people in the world living in urban areas and, in particular, Africa, reaching a 50% share of the urban population by 2050 (While and Whitehead, 2013; Allen, 2015; Angelo, 2016; Van Noorloos and Kloosterboer, 2018). The growth of urban centres has led to several urban activities constituting over 80% of anthropogenic carbon dioxide emissions produced globally (While and Whitehead, 2013), with 65% of emissions coming from fossil fuel and industrial processes, 11% from

forestry and other land use. Urbanisation and human activities have become the greatest threats influencing the changing nature of the environment (Nyamadzawo *et al.,* 2015). This can be attributed to the alteration of the natural environment by deforestation for further building and an increase in paved surfaces. In 2021, Zambia cleared about 201 000 hectares of forest land, directly altering the environment (Moyo, 2022). Cities are thus seen to be the main drivers of global outcomes on climate change due to the high carbon footprint in cities which increases the destruction of the ozone layer, as well as due to the high volume of activities carried out in cities that also exacerbate climate change such as industrial activities. This has compromised urban sustainability since there is a gap between the demand of the natural environment and the provisions of land use (Rosenzweig *et al.,* 2018).

The relationship between climate change and urbanisation is thus seen to be a cause-effect relation as urbanisation has impacts on climate change and climate change also alters urban systems. Urban centres drive climate change, and are also amongst the most vulnerable geographical sites to the effects of global warming, whether it is through sea-level rise, changes in temperature, or more extreme and uncertain weather conditions that environmental and social changes codetermine each other, climate change would (Matenga, 2019). Human activities are changing the earth's climate in ways that increase the risk to cities. This conclusion is based on many different types of evidence including the earth's climate history, observations of changes in the recent historical climate record, emerging new patterns of climate extremes and global climate models (USAID, 2018). Cities and their citizens have begun to experience the effects of climate change (Rosenzweig *et al.,* 2015). On the other projections for future climate change as most often defined globally, it is becoming increasingly important to assess how the changing climate will impact cities. Efforts to understand climate change and its impacts and to design and implement adequate adaptation strategies and programmes will inevitably face difficulties related to different dimensions of the socio-ecological system-Earth (Bauer and Scholz, 2010). Anthropogenic climate change resulting from an intolerable accumulation of greenhouse gas emissions in the earth's atmosphere is but the best-known example of these planetary boundaries brought about by urbanisation. Climate change has also brewed centrifugal tendencies in rural areas as urban space perceivably became lucrative for better livelihood options (Kupika *et al.,* 2019). Climate change globally and regionally can influence water

resources, agriculture, environmental health, industry, economy and consequently urbanisation.

In September 2015, the United Nations endorsed the new Sustainable Development Goal (SDG) 11, which is to "Make cities and human settlements inclusive, safe, resilient and sustainable." This new sustainability goal cannot be met without explicitly recognising climate change as a key component (Rosenzweig *et al.,* 2018). Therefore, this chapter aims at assessing the dynamic relationship between climate change and urbanisation to assist policy-making to promote the growth of environmental; friendly and sustainable cities according to the SDG 11. The chapter assesses the degree to which urbanisation has degraded the environmental quality, and secondly, to assess the impact of urban areas and how urbanisation has had an impact on climate change in other neighbouring areas such as the rural areas through deforestation, creation of more buildings and infrastructure, and the growing population into peri-urban areas.

Background Of Urbanisation And Climate Change In Developing Regions

The impact of urbanisation on near-surface temperatures has been investigated since the1980s (Bryceson and MacKinnon, 2012). These studies suggested that a proportion of global warming observed in the last century timescale could be related to local warming induced by urbanisation. Uttara *et al.* (2012) note that the pattern and trend of urban population and number of towns in India from 1901 to 2001, show that the total urban population has increased more than tenfold, from 26 million to 285 million, whereas the total population has increased less than five times, from 238 million to 1027 million in the same period. Rapid urban growth has resulted in the expansion of built-up areas in and around cities, particularly for nations and regions experiencing demographic expansion (Azam and Khan, 2016). This plays a crucial role in the near-surface warming and on temperature (Grimmond, 2007). In India, urbanisation has led to the vast growth of slums which have helped alter the environment and climate negatively.

The urban transition leads to alterations in landscape conditions and important modifications in the urban climate along with several environmental problems, for instance, on water use and quality, on the

generation of air pollution and the production of solid waste and sewage (Paranunzio *et al.,* 2019). China provides the most dramatic example as it has the largest number of urban and rural dwellers in the low-elevation coastal zone and it still has a very strong trend towards increasing population concentration in this zone (Zhou *et al.,* 2004). Increasing trade and market-driven movements, often supported by government incentives, is still attracting people to the coast (Man, 2011). The coastal provinces of China experienced a net in-migration of about 17 million people between 1995 and 2000, creating pressures in the crowded coastal zone (Zenou, 2010). Other East Asian countries have undergone unprecedented urbanisation in the 20th Century. The urbanisation rates of the world average, that is, in terms of the population, have passed 50%. The rapid urbanisation processes have been accompanied by significant changes in climate over urban areas (Chapman *et al.,* 2017). Furthermore, temperate East Asia is remarkably affected by larger-scale climate change and variability, including the East Asian monsoon variability and global warming. Climate mitigation and adaptation considerations are also influencing the spatial planning and development of the suburban landscape in the Czech Republic (While and Whitehead, 2013).

In Africa, it is noted that rural-urban migration has become one of the survival strategies across the continent in times of environmental stress where people migrate to urban areas for employment opportunities (Swinkels *et al.,* 2019). Consequently, if those people fail to access jobs in urban areas, they will look for other survival strategies to sustain their livelihoods such as wetland farming (Frenken *et al.,* 2002). The increasing farming activities in wetlands expose them to environmental threats that affect their nature and biodiversity. Therefore, ecosystem services situated in wetlands are found at the receiving end as a result of the increasing population in urban areas (Nyamadzawo *et al.,* 2015). There is also increased documentation on the inadequacies in drainage and flood protection for urban centres in Africa and Asia and of the trend towards increased numbers of deaths and injuries from flooding (Satterthwaite, 2007). Since urbanisation is likely to increase in the future, it is important to assess the relationship between the effect of urbanisation trends on local and global warming as they are key issues from the climate change perspective (Paranunzio *et al.,* 2019).

THEORETICAL FRAMEWORK

The chapter is based on four important theoretical elements which include the theory of human landscape relationship, that is, the main theme, feeding into other essential themes such as the theory of urbanisation, theory of land and earth fragility and vulnerability and the theory of environmental degradation. These theories form the basis of the study as they help explain the cause-effect relationship between climate change and urbanisation.

THE THEORY OF HUMAN LANDSCAPE RELATIONSHIP

A landscape includes the physical elements of geographically defined landforms such as mountains, hills, water bodies such as rivers, lakes, ponds and the sea, living elements of land cover, including indigenous vegetation, human elements, including different forms of land use, buildings and structures (Hunziker *et al.,* 2007). Therefore, a landscape is spaces and places in which humans exist. The relationship between a human being and his/her environment is where the theory of the human-landscape relationship stems from. Humans are organisms that survive on the earth (Agnew, 2011). They interpret the earth and its resources differently as they are diverse organisms.

Humans fulfil different basic human needs through recreational and aesthetical activities and restoration, on the one hand, regulation of identity and representation of meanings (values, norms, experiences) (Kitchin and Thrift, 2009). Thus, humans have been treated mainly as a cause of disturbances in natural systems, but more and more humans are also recognised as legitimate users of the system, particularly as "receivers" of material goods such as agricultural and forestry products and immaterial goods such as psychological restoration and (visual) information (Hunziker *et al.,* 2007). Therefore, this theory exposes that activities done by humans have an impact on the environment, which then impacts climate change. The fast-growing African cities have people clearing land and creating their own residential areas and the loss of tree coverage has been directly linked to the increase of urban temperatures. The creation of Glaudina in Harare, Zimbabwe, saw a lot of forest land lost to create this residential area, which also has an impact on infiltration and flourishing of a natural ecosystem when it is tainted by humans (Moyo,

2022). The theory highlights that there is a negative relationship between humans and the natural landscape.

THEORY OF URBANISATION

Urbanisation is a process that leads to the growth of cities due to industrialisation and economic development and that also leads to urban-specific changes in specialisation, labour division and human behaviours(Uttara *et al.,* 2012). Urbanisation can be seen through the lenses of population growth or urban expansion. Urban growth occurs because of the economic advantages of cities in terms of scale and density, but reaping these benefits requires investments.

From the public and the private sector and an enabling policy environment:

- **Urbanisation as an engine for economic development and growth.** Recognising that urbanisation is both an unprecedented but also positive transformation for the Eastern and Central African region and that many of the countries in the area are still at the early stages of urbanisation.
- **Urbanisation as a means to foster productive and liveable places:** Harnessing the advantages of cities to generate productive and liveable areas that foster social cohesion, stimulate innovation and employment but at the same time support environmental sustainability.
- **Urbanisation as a potential for upward mobility:** Acknowledging the relationship between urbanisation and increased income and thus the capacity for urbanisation to support poverty reduction and foster greater equality by delivering higher earnings, the better quality of life and thus prosperity to its inhabitants.
- **Urbanisation as positive, rapid and transformative process:** Underlining that managing effective urbanisation requires an integrated, multi-stakeholder approach and stressing the need to plan now for the present and the future.
- **Urbanisation as a foundation for innovation and entrepreneurship**: Affirming that well-structured cities can generate higher productivity and clusters of firms that can foster innovation and entrepreneurship and thus encourage increased employment.

- **Urbanisation as an opportunity to deliver climate-smart cities:** Acknowledging the negative impacts of urbanisation on climate change and thus the current opportunities that exist to support the evolution of climate-smart cities to mitigate these effects(Angelo, 2016; Van Noorloos and Kloosterboer, 2018).

THEORY OF EARTH AND LAND FRAGILITY AND VULNERABILITY

The earth is a planet that consists of five systems: geosphere, biosphere, cryosphere, hydrosphere and atmosphere (Mbereko *et al.,* 2007). These systems interact to produce the environments that we are familiar with, such as rain forests, deserts and water bodies (USAID, 2018). These systems are, however, delicate and if the earth's resources are misused, the land becomes vulnerable to effects such as climate change. Vulnerability to the impacts of climate change is described as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (Mavhura, 2019). Vulnerability is a function of the character, magnitude and rate. Adaptation to climate change in Southern Africa is a function of climate change and variation to which a system is exposed, its sensitivity and adaptive capacity (UNFCCC, 2007). Vulnerability is thus understood as the result of the interactions between socio-economic conditions,(for instance, poverty, income distribution and infrastructure) and their institutional context (quality of governance, rule of law, decentralisation). Vulnerability is considerably influenced by poverty, particularly in developing countries, because the poor are typically more dependent on the direct use of natural resources and have less buff capacity to cope with economic damage caused by natural disasters or incremental degradation (Kaeser, 2016).

THEORY OF ENVIRONMENTAL DEGRADATION

Environmental degradation is a process through which the natural environment is compromised in some way, reducing biological diversity and the general health of the environment (Azam and Khan, 2016). This process can be entirely natural in origin, or it can be accelerated or caused by human activities. Environmental degradation can be described as the disintegration of the earth or deterioration of the environment through the consumption of assets, for example, air, water and soil; the destruction of environments and the eradication of wildlife (Grimmond, 2007). Environmental degradation is caused by various issues such as

urbanisation, population growth, economic growth, intensification of agriculture, increase in energy use and increase in transportation (Akintunde, 2017). The primary cause of environmental degradation is human disturbance.

The degree of the environmental impact varies with the cause, the habitat and the plants and animals that inhabit it. There are several ways in which environmental degradation works. Classically, resources simply become depleted (Hollis, 1990). Air, water and soil are all resources that are susceptible to depletion through overuse, as are natural resources like minerals and oil deposits. Habitat pressures that force animals into a small area can also contribute to resource depletion, as the animals consume a high volume of materials in a small area. Pollution is another cause of environmental degradation (Uttara *et al.,* 2012). When the environment becomes polluted, toxic substances have render it unhealthy. Pollution comes from a variety of sources, including vehicle emissions, agricultural runoff, accidental chemical release from factories and poorly-managed harvesting of natural resources (Azam and Khan, 2016).

LITERATURE REVIEW

Azam and Khan (2016) describe the term 'urbanisation' as a process where a large-scale labour force is going from an agribusiness-based economy to an urban-based industrial economy. This transformation is a trend of economic and social development. According to the World Bank Group(2018), urbanisation has brought unsustainable economic activities such as unregulated wetland agriculture in urban areas, which have resulted in climate change. The relationship between urbanisation and climate change is thus seen to be rooted in human activities and their relationship with the environment (Karsenty *et al.,* 2012; Nyamadzawo, Wuta, Nyamangara and Nyamugafata, 2015; Van Noorloos and Kloosterboer, 2018; Kupika *et al.,* 2019; Matenga, 2019).

Humans have been classified as consumers of the environment and its natural resources. This has brought out a negative relationship, one where the humans reap all the benefits at the expense of the environment and subsequent climate. Trees have been used for furniture and building materials, forests have been cleared to create utilisable land, and wetlands have been encroached upon. The widely encouraged urbanisation has brought with it negative impacts onto the environment such as the

deterioration of biodiversity in urban areas. The bleeding environment has been strained enough to alter the climate of the world and the people now feel those impacts as well.

Human-caused climate change presents significant risks to cities beyond the familiar risks caused by natural variations in climate and seasonal weather patterns. While and Whitehead (2013) state that urbanisation tends to be associated with elevated surface and air temperature, a condition referred to as the urban heat island. Urban centres and cities are often several degrees warmer than surrounding areas due to the presence of heat-absorbing materials, reduced evaporative cooling caused by lack of vegetation and production of waste heat (Bauer and Scholz, 2010).

There has been a growth in the 'urban' setup that has been attributed to urban sprawl, which has seen areas previously unoccupied or designated for urban agriculture being developed to provide housing for people. This has seen the formation of slums and informal settlements such as Kibera and Mathare in Kenya. These slums are characterised by deforestation that has led to compactness of soil, which reduces infiltration and percolation. This exacerbates flooding in the created settlements. There are other extreme events that happen in cities around the world that include heat waves, droughts, heavy downpours and coastal flooding. These are projected to increase in frequency and intensity as urbanisation continues (Chapman *et al.,* 2017).

Peri-urbanisation has also increased as regional areas are adopting urban trends. There has been an increase in development and the extension of city features such as roads, bridges and other buildings. The development of peri-urban areas has been credited to an increase in income and investment in rural areas. This has also increased the concrete surfaces which alter infiltration and cleared forests, leading to climate change as the temperatures in these areas increase. High human traffic volumes cause an increase in activities that produce heat, smoke, dust and other carbon emissions, thereby further straining the environment.

The warming climate, combined with the urban heat island effect, will exacerbate air pollution in cities. The concentration of people, infrastructure, economic activity and ecology within the coastal zone merits specific consideration of hazards exacerbated by a changing climate. Climate change and urbanisation are likely to increase the

vulnerability of biodiversity hotspots, urban species and critical ecosystem services (UNFCCC, 2007). It is supported that climate change is part of a shift to a new era of 'urban ecological security driven by resource shortages, carbon taxes and the physical effects of climate change' (Ren, 2017).

Furthermore, increasing heat waves as a result of air pollution and tall buildings has also exacerbated the increase of the changing climate in urban areas (Hua, 2016). The changing climate in urban areas has exposed wetlands to urban agriculture since they are adaptive to climate change (Rosenzweig *et al.,* 2015). Climate change has the potential to increase flooding risks in cities in three ways, from the sea (higher sea levels and storm surges); from rainfall, for instance, by heavier rainfall or rainfall that is more prolonged than in the past; and from changes that increase river flows, for instance, through the increased glacial melt. The activities that produce heat in cities have led to climatic changes that bring floods. These floods are destroying infrastructure and human life. Cyclones such as Cyclone Idai wiped away about 50% of farm land with maize, yam and bananas was (IFRC, 2020).

Urban areas also present some risk to flooding when rainfall occurs (Satterthwaite, 2007). Buildings, roads, infrastructure and other paved areas prevent rainfall from infiltrating into the soil and so produce run-off (Uttara *et al.,* 2012). Heavy and prolonged rainfall produces very large volumes of surface water in any city which can easily overwhelm drainage systems. In well-governed cities, this is rarely a problem because good provision for storm and surface drainage is easily built into the urban fabric, with complementary measures to protect against flooding, for instance, the use of parks and other areas of open space to accommodate floodwaters safely from unusually serious storms (Satterthwaite 2007; Albino *et al.,* 2015; Sim *et al.,* 2018).

There are high cases of environmental pollution that are a result of urbanisation. There has been so much noise pollution from the hustle and bustle of people in the cities. This is exaggerated by the high volumes of people in the cities. There is also an increase in air pollution resulting from exhausts from vehicles, fumes and smoke from industrial areas and smoke from burning litter that includes plastic and other fossil fuels in residential areas. This negatively affects the air quality in cities, making these areas breeding grounds for pneumoconiosis related diseases.

Another aspect of environmental pollution attributed to urbanisation is land pollution. The growing numbers of people and residential areas have become difficult for the authorities to service properly. People have resorted to throwing away litter anywhere. They have begun dumping their garbage alongside roads and in rivers. This further contaminates the water in the rivers and distorts the size, shape and carrying capacity of the rivers. When the rivers get heavily littered, they become shallow such that they can no longer hold much water, resulting in flooding of nearby areas. The river may even be blocked such that water does not flow freely to water reservoirs.

Figure 1: *A picture showing garbage in a river*

Concerning urban heat islands, higher temperatures occur in urban areas than in outlying rural areas because of diurnal cycles of absorption and later, re-radiation of solar energy and, to a much lesser extent, heat generation from built or paved physical structures (Satterthwaite, 2007). These increase the frequency and severity of heat-stress events in cities

and can affect the health, labour productivity and leisure activities of the urban population. There are also economic effects, such as the additional cost of climate-control within buildings and environmental effects, such as the formation of smog in cities and the degradation of green spaces and increased greenhouse gases if additional demand for cooling is met with electricity generated from fossil fuels (Nyamadzawo *et al.,* 2015). However, 80% of global GDP is generated by cities and thus urbanisation is not only an outcome, but also a driver for economic growth and development. Talk is of developing socio-ecological resilience and adaptive capacity in response to new urban exposures and vulnerabilities (While and Whitehead, 2013).

METHODOLOGY

Research approaches are plans and procedures that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation (Creswell, 2014).The study made use of thematic analysis in highlighting the various changing patterns through themes that are going against the present development control regulations set in the RTCPA of 1996. The study made use of documentary analysis, descriptive statistics and secondary data analysis in the depiction of the recent trends of urbanisation and climate change and in finding the relationship that exists between them. Documentary analysis assists in the enhancement of the reliability of the chapter (de Falco *et al.,* 2019). Documents used include books, journals and websites and newspaper articles. Data obtained were then processed into information and analysed through the use of thematic content analysis. Thematic content analysis is the use of textual material in research, reducing it to more relevant, manageable bits of data. It is also a method of analysing the text of social investigation among the set of empirical methods (Kumar *et al.,* 2020). After summarising literature, it was assembled and structured thematically into important concepts. This brought out themes such as spatial planning, urbanisation and the informal sector that need to be incorporated in development control in Zimbabwe.

RESULTS AND ANALYSIS

There is a cause-effect relationship between climate change and the urban-rural landscape. Climate change has also brewed centrifugal tendencies in rural areas as urban space perceivably became lucrative for better livelihood options. Climate change causes various changes to the earth and its systems and urban systems cause climate changes. This is illustrated in Figure 1.

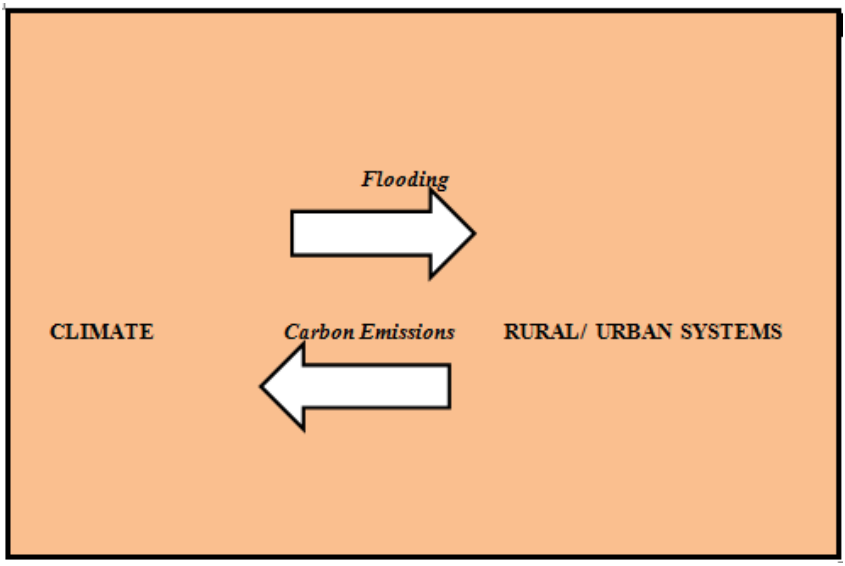

Figure 1: *Cause-effect Relationship between Climate and Rural/Urban Systems (*Adapted from Matenga, 2019).

Figure 1 shows the effects of climate and rural/urban systems on each other. Findings reveal that the relationship between climate and urbanisation is not linear. Climate causes several disasters on the urban/rural landscapes. Climate change causes this prevalence of disorders such as flooding, hail storms, veld fires, earthquakes and cyclones such as Cyclone Idai that occurred in Southern Africa in 2019. However, human interactions with the environment contribute to most of these disasters. The greatest human activity that has altered climate is urbanisation. Urbanisation has brought changes in land use, that is, construction, industrialisation which has resulted in the emission of atmospheric pollutants and the heat island effect. These have led to changes in runoff patterns and momentum fluxes. Changes in cloud condensation, nuclei concentration, changes in cloud amounts, result in rainfall changes in radiation budget, changes in heat and moisture fluxes. The world's poorest and most vulnerable regions between them, the countries of Southern Africa represent roughly one-tenth of the people that Paul Collier refers to as the world's 'bottom billion', the share of the global population that is effectively decoupled from overall global progress(Bauer and Scholz, 2010). That is why the relationship between climate change and urbanisation has had mostly negative impacts on

African urbanisation. The results of the relationship between climate change and urbanisation are illustrated in Table 1.

Table 1: Showing the Relationship between Climate Change and Urbanisation

Urbanisation		Climate Change		Result
Industrialisation	⇨	Low Rainfall	⇨	Hunger
Settlements On Wetlands	⇨	Drought	⇨	Drought
Urban Agriculture	⇨	High Temperatures	⇨	Very Hot Summers
Deforestation	⇨	Ozone Layer Depletion	⇨	Cool and Dry Winters
Stream Bank Cultivation	⇨	Low Rainfall	⇨	High Temperatures
Concrete Jungles	⇨	Global warming	⇨	Urban Heat Islands

Table 1shows the relationship between climate change and urban systems as one element from each of the concepts, causes another element to change. According to Rosenzweig *et al.* (2015):

- Temperatures are rising in cities around the world due to both climate change and the urban heat island effect. Mean annual temperatures have increased at a rate of 0.12 to 0.45°C per decade over the 1961-2010 period.
- Mean annual temperatures in the cities around the world are projected to increase by 0.7 to 1.5°C by the 2020s, 1.3 to 3.0°C by the 2050s and 1.7 to 4.9°C by the 2080s.
- Mean annual precipitation in the cities around the world is projected to change by -7 to +10% by the 2020s, -9 to +15% by the 2050s and -11 to +21% by the 2080s.
- Sea level in the 52 ARC3.2 coastal cities is projected to rise 4 to 19 cm by the 2020s; 15 to 60 cm by the 2050s and 22 to 124 cm by the 2080s.

It can be noted that humans and their activities are a major source of environmental degradation. They pollute the environment through water and air pollution. Water and air pollution are the common causes of environmental degradation. Pollution introduces contaminants into the

environment that can maim or even kill plant and animal life. Humans also degrade the environment through acid rain which occurs when sulphur dioxide from coal plant emissions combines with moisture in the air. A chemical reaction creates acid precipitation. Acid rain can acidify and pollute lakes and streams. It causes similar effects on the soil. If plentiful acid rain falls in a given environment, it can acidify the water or soil to a point where no life can be sustained.

CLIMATE CHANGE, URBANISATION AND WETLANDS

Urban agriculture is a constraint on the usefulness of urban wetlands to mitigate climate change and its negative impacts both on the environment and on humanity. The general proliferation of urban agriculture is fuelled by escalating poverty, high unemployment rate and the availability of open lands in urban areas. Urban agriculture is taking place in wetlands since they are adaptive to climate change. Wetlands play an important role in mitigating climate change. It is noted that the general increase of urban agriculture associated with increasing population has prompted competition in open spaces and wetlands, hence placing residents at loggerheads with city councils that conserve wetlands as a climate change mitigating strategy. Such activities are strictly prohibited by the environmental law, but the implementation of the law is not carried out. Meanwhile, the water provisioning ability of these areas is negatively impacted and the capacity of the dams downstream is reduced due to siltation. According to the *Daily News* (2014, July), Zimbabwe lost over 30 wetlands due to agriculture and urbanisation. The management of wetlands is contested because what is practised by people in wetlands is against environmental laws. Since wetlands are destroyed, the high temperatures in cities cannot be lowered when winds pass over them and so there is no way of lowering temperatures, this increases global warming. Wetlands are supposed to act as absorbers of excess runoff, so without them, the excess runoff floods the streets as some agriculture practices compact the soil and it gets saturated quickly.

CLIMATE CHANGE AND THE URBAN HEAT ISLAND

The surface climate within a city is different from the climate of its surrounding suburbs. This unique local city climate is called urban climate and is generally characterised by higher surface air temperature, weaker mean wind speed and lower relative humidity compared with the suburbs and the countryside (Ren, 2017). Within cities, various neighbourhoods experience different microclimates. Therefore, urban monitoring networks

are needed to address the unique challenges facing various microclimates and the range impacts of extreme climate effects at neighbourhood scales. Cities are characterised by the large diversity of socio-economic groups living nearby. Diversity is often accompanied by stratification based on class, caste, gender, profession, race, ethnicity, age and ability.

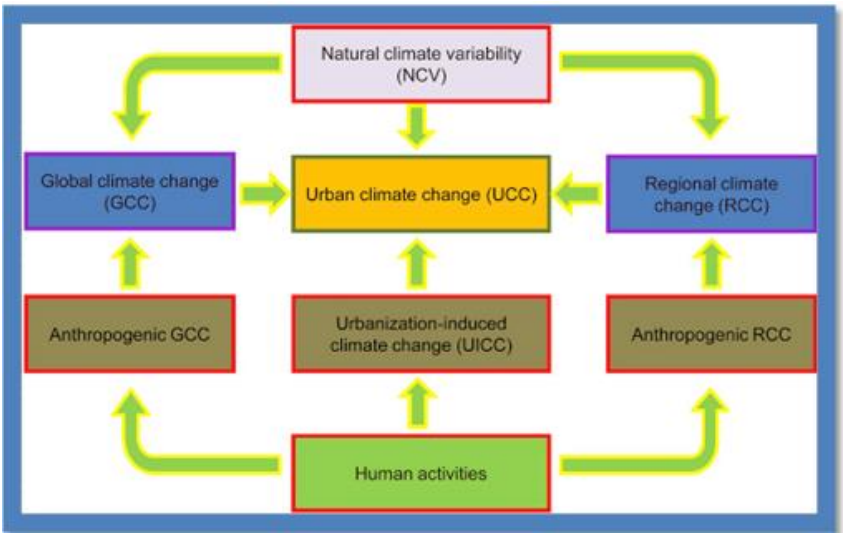

Figure 2: *Urbanisation as the major driver of climate change (* Adopted from Ren, 2017).

Urban surfaces modify the surface hydrologic properties through the increase of impervious surfaces, which reduces rainwater infiltration and evaporation and increases surface runoff. The multi-reflections of sunlight among high-rise buildings are important as well, they significantly increase the absorptivity of heat in the urban canopy. Furthermore, waste heat from winter heating and summer conditioning, along with the air pollution from other human activities within cities, are important. Thus, changes in the energy and water balance in the urban surface will occur, resulting in an increase (decrease) in the absorbed (reflected) solar short-wave radiation during the daytime, a decrease in the emitted ground long-wave radiation into the sky and an increase (decrease) of sensible (latent) heat flux. This, in mid-to-high latitudes, in turn, causes a higher surface air temperature, in particular during the night, a smaller diurnal temperature range (DTR), a smaller near-surface wind speed and a generally lower

(higher) relative humidity in urban areas of humid (arid) regions. For larger, higher-density cities, the temperatures in central "heat islands" can be several degrees higher than in surrounding areas. I n tropical cities, the temperature difference can reach 10 degrees by the end of the night.

Climate Change and Coastal Regions in Sub-Saharan Africa: A Case of Mozambique

Sea level rise affects the massive zones of urbanisation clustered along the world's tidal coastlines and most significantly those cities in places where the land is subsiding. In response to the wide range of risks facing cities and the role that cities play as home to more than half of the world's population, coastal cities such as Beira in Mozambique, have lived with extreme climate events since the onset of urbanisation, but climatic change and rapid urban development are amplifying the challenge of managing risks. For any city, the scale of the risk from these extreme weather events is much influenced by the quality of housing and infrastructure in that city, the extent to which urban planning and land-use management have successfully ensured risk reduction within urban construction and expansion and the level of preparedness among the city's population and key emergency services.

The Southern African region has frequent occurrences of natural disasters and Mozambique tops the list of these countries as the most hit by extreme events across the region with 53 natural disasters in the past 45 years (Brebbia *et al.,* 2004). For small and large coastal settlements, the integrity of coastal ecosystems and in particular protective mangrove and salt marsh systems will also influence risk (Satterthwaite, 2007). In most cities, there is also scope for land-use management and incremental adjustments to increase flood-water management capacity. But in poorly-governed cities, this does not happen. Most residential areas have no drainage systems and rely on natural drainage channels - and it is common for new buildings or infrastructure to obstruct these drainage channels(Satterthwaite, 2007). Floods have very strong impacts on cities and smaller urban centres in many African nations, for instance, the floods in Mozambique in 2000 which included heavy floods in Maputo, the floods in Algiers in 2001 (with around 900 people killed and 45000 affected).Mozambique's long coastline, sprawling river delta and changing weather patterns make it susceptible to multiple hazards as the climate changes.

DISCUSSION

Water resources are diminishing due to large population numbers and wasteful consumption and neglect of conservation. With rapid urbanisation and industrialisation, huge quantities of wastewater enter rivers. Careless use of resources is witnessed mainly in informal settlements. Failure of governance in today's cities has resulted in the growth of informal settlements and slums that constitute unhealthy living and working environments. These have decreased the rate at which evapotranspiration takes place through settling on wetlands, and deforestation. This has altered rainfall patterns in Africa. An adaptation to the impacts of climate change is accomplished through community-based measures to sustain human livelihoods. For instance, the mechanisms developed by rural communities are complex, are used within cultures and depend on the use of indigenous knowledge in the production of subsistence crops (Kupika *et al.,* 2019). People's knowledge of the seasons motivates them to grow subsistence crops with careful consideration of the soil fertility and texture and crop variations which enhance the sustainable production of crops (Green, 2008).The ability of individual households and communities to adapt to climate change depends on their adaptive capacity. 'Adaptive capacity' refers to the potential or ability of a system, region or community to adapt to the effects or impacts of climate (Kupika *et al.,* 2019). This capacity is dynamic and influenced by economic and natural resources, social networks, institutions, governance, human resources and technology (Mugambiwa, 2018).

CONCLUSION AND RECOMMENDATIONS

Climate change and urbanisation are two interlinked concepts that are detrimental to the sustainability of the environment. Urbanisation is the contemporary trend in the world and it has had an effect on over policy-making and vast landscapes. Human settlements and their accompanying activities, such as industrialisation, have detrimental impacts on the environment. The emission of greenhouse gases and deforestation have been some of the main causes of the depletion of the ozone layer. This has led to shifts in climatic patterns on the African landscape. There is need to fully grasp the components that make the relationship between climate change and urbanisation as they feed off each other. These concepts are interconnected or interlinked and they determine how each is formed. There is need to incorporate designs for climate change mitigation into