

# Urbanisation and the incidence of urban heat island implications for climate change and global warming

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## 1 ABSTRACT

Human activities as a result of urbanisation and industrial revolution have substantially added to the amount of heat-trapping greenhouse gases in the atmosphere. The burning of fossil fuels and biomass has also resulted in emissions of aerosols that absorb and emit heat, and reflect light. Today, a major development challenges facing the nations of the world is how to cope with the urbanisation that is currently on the increase and minimise its adverse effects especially on the ecosystem. Hence, this paper examines the effects of urbanisation and incidence of urban heat island on the ecosystem and the implication for climate change and global warming. An overview of urbanisation, urban heat island effect, climate change and global warming were examined. Some basic concepts and theories of ecology such as anthropocentrism and biocentrism were employed. It went further by isolating the negative effects of urbanisation and urban heat island on the ecosystem and the implication for climate change and global warming. Finally, Practicable solutions to the identified effects were suggested.

## 2 INTRODUCTION

Environmental effects due to urbanisation have been observed as far back as early 18th century. Until the middle of the 20th century, urbanisation levels were too low and the number of large cities was too small for there to be any significant effects other than local climatic and hydrologic impacts. In the 1950s, less than 30% of the world's population lived in urban areas. It is projected that by 2030, 60% of the world's population will live in cities. Today, urban areas all over the world are facing an increasing concentration of almost all economic, financial and cultural activities of humanity (Abbate, G et al, 1990). The growth in the urban population and the supporting built infrastructure has impact on both urban environments and also on areas which surround urban areas.

Urbanization as a complex process of social change and as a recent phenomenon in the history of man has over time had devastating consequences on human lives and environment in general. Urbanisation involves the concentration of population, lost of natural space, and expansion of living space above and below ground. All of these factors alter the balance radiation, heat and water, and also generate a climate typical of urban area (Yamamoto, 2006). Increased population growth and human activities that result in the generation of anthropogenic heat have led to the development of urban heat in cities. Recent studies have shown that there is increase in global temperature. This is mostly noticed in the urban areas in form of excessive heat. The Urban heat island effect is a phenomenon whereby cities are warmer than the surrounding suburbs. In other words, there is a temperature difference in the cities and the area surrounding them.

Today, a major challenge facing the nations of the world is how to cope with the rate, processes and patterns of urban changes that are currently on the increase and perhaps their effects on the ecosystem. Therefore, this paper examines the effects of urbanisation and incidence of urban heat island on the ecosystem and the implication for global climate change and global warming.

### 2.1 Anthropocentrism As The Bane of Environmental Degradation

Main thrust of the theory of anthropocentrism says that the world exists for humanity. Believers in this philosophy say that humans can rightfully try to benefit as much as possible from the environment. Anthropocentrism as noted by Christopher Manes has been identified as the root cause of the ecological crisis, human overpopulation, and extinctions of many non-human species. Anthropocentrism, or human-centeredness, is believed to be the central problematic concept in environmental philosophy, where it is used to draw attention to a systematic bias in traditional Western attitudes to the non-human world (Naess 1973).

### 2.2 The Concept of Urbanisation

Urban has been defined by various researchers on the basis of its size, legal status or socio-cultural characteristics. Some of the definitions include:

- A community with a population of 200 or more in Denmark, 1000 in Canada and USSR, 2,000 in France, 2,500 in the USA, 3,500 in Britain, 5,000 in India, 20,000 in Nigeria, 10,000 in Spain and Switzerland, 30,000 in Japan and 40,000 in South Korea
- A relatively large dense and permanent settlement of socially heterogeneous individual (Wirth 1933)
- A community of substantial size and population density that shelter a variety of non-agricultural specialties, including literate elite. (Sjoberg Gideon, 1955)
- An administrative, religious, political and economic centre of all the territory of the tribe whose name is customarily took. (Pirenne. H 1945)

Therefore, Urbanisation is the expansion of a city or metropolitan area. This could take the form of the proportion of total population or area in urban localities or areas (cities and towns), or the increase of this proportion over time. Thus, it can represent a level of urban relative to total population or area, or the rate at which the urban proportion is increasing. Both can be expressed in percentage terms, the rate of change as a percentage per year, decade or period between censuses. It can also be defined as a process by which a country's population changes from primarily rural to urban. It is caused by the migration of people from the countryside to the city in search of better jobs and living conditions as well as high birth rates and migration.

### 2.2.1 Urbanisation Trend With Reference To Nigeria

Since the end of World War II urbanization in developing countries has accelerated greatly, with an increasing proportion of the urban population in each country concentrating in the large urban agglomerations. Presently, it is almost a truism that the planet's future is an urban one and that the largest and fastest growing cities are primarily in developing countries Ajala (2004).

Urbanization is not a new phenomenon on the continent of Africa as shown by centres like Lagos, Ibadan, Addis Ababa, Cairo, Kano and Timbuktu. What is noteworthy about contemporary urbanization in Africa is its fast pace. In Africa, it is expected that over half the population will be urban by 2020 (UN, 2004)

Nigeria is not an exception to this fast rate of urbanisation in the 21st century. In fact, Nigeria cities have been classified as parts of the fastest growing cities in the world. According to the world population policies 2003 by United Nations 47 percent of the population lives in urban centers with annual urban growth rate of 4.4 percent (UN 2004). Available data reveal that Nigeria's urban population has been growing at an alarming rate. Nigerian towns and cities are exploding – growing in leaps and bounds. A little more than 50 years ago, fewer than 7% of Nigeria lived in urban areas (that is, settlements with population of 20,000 or more). This proportion rose to 10% in 1952 and 19.2% in 1963. It is now estimated at about 47% as at 2003. Presently, Nigeria now has 7 cities with population at 1 million; 18 cities at more than 500,000; 36 at more than 200,000; and 78 at more than 100,000 and 5,050 towns with more than 20,000 people.

### 2.2.2 Effects Of Urbanization On Urban Ecosystem

Urban ecosystems are characterized by complex interactions among physical, social, economic, institutional, and environmental variables. These interactions generate complex human-dominated landscapes, which significantly influence the functioning of local and global earth ecosystems and the services they provide to humans and other life on earth. Urban development (urbanization) fragments, isolates, and degrades natural habitats; simplifies and homogenizes species composition; disrupts hydrological systems; and modifies energy flow and nutrient cycling. Urban areas also appropriate a large share of earth's carrying capacity from other regions in terms of resource input and waste sinks. Urbanization affects the spatial heterogeneity of the urban ecosystem, bio-diversity and cause extinction of some useful species. Changes in ecological conditions that result from human actions in urban areas ultimately affect human health and well-being.

Cities have become sites for greenhouse gas emissions because of the high energy demands by urban residents and activities. These emissions extend the (indirect) influence of cities on climate to much larger scales. Locally altered urban climates cause large scale climate change of the entire earth surface. The effect of urbanisation on environment include the following

Lost of Farm Land and Biodiversity

Unchecked urbanization has taken its toll on land and forest resources especially in developing countries at the expense of alternative uses of these resources. Increasing urban population has necessitated increasing

demand for urban land uses such as building for accommodation, institutional offices, and social infrastructures including schools and hospitals as well as roads for accessibility. The demand on land means absorption of adjacent agricultural lands for urban development by implication more agricultural lands are lost to urban development. In addition, large expanse of forest vegetation is lost to construction activities. Furthermore, the rate of urban physical expansion in various part of the country necessitates a high demand for timber products for construction leading to deforestation and loss of biodiversity.

#### Air Pollution

Air pollution is another impact of urbanization, which comes from both indoor and out door sources. The primary activities responsible for out door pollution are industrial activities and vehicular emissions while for indoor pollution are cooking and heating. The increasing number of vehicles on our urban roads as a sign of affluence has caused a rising demand for gasoline based transport systems with the attendant increasing emission of carbon dioxide and suspended particles. Also, the emissions of various gasses from industrial plant, such as sulfur dioxide, nitrous oxides among others are contributed to air pollution. At the household level, biomass consumption is on the increase as a result of the increase in fuel prices especially kerosene. Many urban households have resulted to the use of fuel wood for cooking and heating as means of coping strategy in the face of economic hardship. The negative effects arising from air pollution is health deterioration inform of respiration problems, retardation among children, and lower productivity among adults.

#### Water Pollution

Many cities are face with acute shortage of portable water for their ever increasing population. As a result of shortage of portable water, larger proportion of urban population depends on untreated water. Water shortage has in urban center has significant economic and social impacts. Water pollution from industrial and domestic sources is a threat to human health. Another pollutant for water contamination in urban area is human waste. High urbanization rate have placed the existing inadequate sanitation in the cities under stress. Therefore, the uncontrolled disposals of liquid waste into open gutters, open space, along roads etc poses serious health hazard for urban populace.

#### Habitat Destruction and Species Extinction

Human population poses a threat to the biosphere by habitat destruction, especially by the destruction of tropical rainforests (deforestation). This process is driving thousands of species each year to extinction and reducing biological diversity. Many species of wildlife had lost their homes due to urban development, as they have to compete with people and their pets for space which they used to live in. This has actually led to extinction of many species and some are currently endangered. Estimates range that from 4,000 to as many as 50,000 species per year become extinct. The leading cause of extinction is habitat destruction, particularly of the world's richest ecosystems—tropical rain forests and coral reefs. Yamamoto (2006) observed that if the world's rain forests continue to be cut down at the current rate, they may completely disappear by the year 2030. In addition, if the world's population continues to grow at its present rate and puts even more pressure on these habitats, they might well be destroyed sooner.

#### Depletion of the Ozone Layer

The ozone layer, a thin band in the stratosphere (layer of the upper atmosphere), serves to shield Earth from the Sun's harmful ultraviolet rays. Chlorofluorocarbons (CFCs)—chemicals used in refrigeration, air-conditioning systems, cleaning solvents, and aerosol sprays—destroy the ozone layer. CFCs release chlorine into the atmosphere; chlorine, in turn, breaks down ozone molecules. The consequences of continued depletion of the ozone layer can not be over emphasized. Increased ultraviolet radiation would lead to a growing number of skin cancers and cataracts and also reduce the ability of immune systems to respond to infection. Additionally, growth of the world's oceanic plankton, the base of most marine food chains, would decline. Plankton contains photosynthetic organisms that break down carbon dioxide. If plankton populations decline, it may lead to increased carbon dioxide levels in the atmosphere and thus to global warming

#### Global Warming

Like the glass panes in a greenhouse, certain gases in the Earth's atmosphere permit the Sun's radiation to heat Earth. At the same time, these gases retard the escape into space of the infrared energy radiated back out by Earth. This process is referred to as the greenhouse effect. These gases, primarily carbon dioxide,

methane, nitrous oxide, and water vapor, insulate Earth's surface, helping to maintain warm temperatures. Without these gases, Earth would be a frozen planet with an average temperature of about  $-18^{\circ}\text{C}$  (about  $0^{\circ}\text{F}$ ) instead of a comfortable  $15^{\circ}\text{C}$  ( $59^{\circ}\text{F}$ ). If the concentration of these gases rises, they trap more heat within the atmosphere, causing worldwide temperatures to rise.

Within the last century, the amount of carbon dioxide in the atmosphere has increased dramatically, largely because people burn vast amounts of fossil fuels—coal and petroleum and its derivatives. Average global temperature also has increased—by about 0.6 Celsius degrees (1 Fahrenheit degree) within the past century.

The consequences of such a modest increase in temperature may be devastating. These problems include a rise in sea levels that will completely inundate a number of low-lying island nations and flood many coastal cities. Many plant and animal species will probably be driven into extinction, agriculture will be severely disrupted in many regions, and the frequency of severe hurricanes and droughts will likely increase. Other effects include but not limited to: Accumulation of pollutants and greenhouse gases in the atmosphere, leading to local hazards to soils, vegetation and human health, and the threat of global climate change. Environmental degradation, distorted urban morphology, urban sprawl, social problems, urban congestion, traffic problems, global warming, ozone layer depletion, overcrowding, land squatting, problems of waste disposal, sanitation problems etc. The lists of these effects are endless

### 3 URBAN HEAT ISLAND EFFECT

The Urban heat island effect is an occurrence whereby cities are heater than the surrounding suburbs. In other words, there is a temperature difference in the cities and the area surrounding them. Recent studies have shown that there is a marked difference in temperature between the city core and adjacent rural areas. This temperature difference, which increases with city size, is usually referred to as the urban heat island. In the larger cities with over 10,000,000 inhabitants the mean annual minimum temperature can be as much as  $4^{\circ}\text{F}$  higher than that of the surrounding rural periphery. This difference is much greater in summer than in winter. According to Yamamoto 2006 the effect was first noticed in London and other European cities in the 1830s, followed by the big cities such as New York, Chicago in USA. This could be attributed to their levels of urban development and industrialisation especially during the industrial revolution. Today, the phenomenon is now becoming a major problem in Asia as well as African countries. Indeed, the urban heat island effect exist where there are large cities. A number of factors such as surface cover, anthropogenic heat release, and urban characteristics including geographic features and climatic conditions interact with one another to create this effect.

The report of the third intergovernmental panel on climate change in 2007 revealed that there is a continuous upward trend in global average temperature. The average global temperature rose by some  $0.60\text{ C}$  during the 20th century. For instance some big cities in Japan have experience an average temperature raise of  $2\text{-}30\text{ C}$ . Presently, temperatures are on the rise, particularly in the big cities. In fact, the temperature now stays above  $300\text{ C}$  for longer, over a lager area. Also the number of sweltering nights and day time temperature is increased.

A variety of factors have been attributed to be the cause of urban heat island effect. Removal of vegetation, construction of buildings, roads, pavement and other human transformations of the natural environment, together with direct heat generation from human activity, are known to cause the temperatures of urban areas to rise above those of surrounding rural areas.

#### Increased Anthropogenic Heat Release

Manmade energy produced by industrial, commercial and domestic users as a result of energy consumption in urban area such as combustion of fossil fuels (coals, oil, and natural gas) for electric power generation, transportation, and heating are known to contain greenhouse gases which are catalysts for ozone layer depletion. This process over the years has reduced the thickness of the ozone layer therefore increasing the amount of sun ray that enter the surface of the earth. According to Turner II et al 1990, the presence of pollutants (greenhouse gases) over the city enhances the heat island effect.  $\text{H}_2\text{O}$ ,  $\text{CO}_2$ , and other pollutants enhance the surface temperature through convection and radiation processes.

#### Changes in Surface Cover

Compared to rural surfaces, city surfaces absorb and store significantly more solar radiation. Specifically during the summer months, the buildings, pavement, and concrete of the city absorb and store solar radiation. The concreted city surfaces have both great thermal capacity and conductivity, so that heat is stored during the day and released at night. Because of the high water runoff in the city, less of this energy is used for evaporation. In contrast, the countryside, the presence of evaporation and transpiration results in relatively lower temperatures during the day and night.

#### Urban Structure

Heat stagnation due to densely packed buildings and urban expansion contributes to the increase in temperature experience in the urban areas. As surfaces throughout a community or city become more abundant and urban geometry from buildings traps energy and prevents it from re-radiating to the atmosphere, the overall ambient air temperatures increase in comparison to the surrounding rural region. For instance according to Jay and Kamil 2005, in Phoenix, the difference has been documented to be as large as 12° F

Urban heat islands are a clear, well-documented example of an anthropogenic modification to climate that has an atmospheric, biological, and economic impact. The impacts differ from summer to winter. The urban heat island effect in summer varies by city according to unique geographical characteristics. However, urban areas generally are becoming uncomfortable place of abode as a result of higher temperatures during the day and an increasing number of sweltering nights (Yamamoto, 2006). Higher temperature increase demand for air conditioning both at homes and in working places, resulting in increased energy consumption. The present situation in power supply especially in developing countries as epitomized by Nigeria situation has made most families and businesses to result into and rely majorly on generating plant for their energy source. This practice is not environmental friendly and does not make good account of the situation.

Furthermore, as noted by Jay and Kamil 2005, the urban heat island effect can negatively impact the sustainability of regions by increasing the dependence on mechanical cooling, which results in increased greenhouse gas emissions, consumption of water to make electricity, and increased cost of living for residents. The urban heat island effect also can increase the incidence and severity of heat-related illnesses. Summer time heat is known to have a greater impact on human health than any other form of severe weather in the United States. Heat waves claim more lives each year than floods, tornadoes, and hurricanes combined (Jay and Kamil, 2005).

#### Climate Change And Global Warming: Meaning Causes and Implications.

Climate is the long-term average of a region's weather events lumped together. Therefore, climate change represents a change in these long-term weather patterns. They can become warmer or colder. Annual amounts of rainfall or snowfall can increase or decrease. This invariably has implication on global temperature. Global warming refers to an average increase in the Earth's temperature, which in turn causes changes in climate. A warmer Earth may lead to changes in rainfall patterns, a rise in sea level, and a wide range of impacts on plants, wildlife, and humans. When issue of climate change is discussed the main concern is about global warming caused majorly by human activities. Climate change may directly affect human health through increases in average temperature. Such increases may lead to more extreme heat waves during the summer while producing less extreme cold spells during the winter. According to the report of Intergovernmental Panel on Climate Change 2007 in the United States, Chicago is projected to experience 25 percent more frequent heat waves and Los Angeles a four-to-eight-fold increase in heat wave days by the end of the century.

Climate change may increase the risk of some infectious diseases, particularly those diseases that appear in warm areas and are spread by mosquitoes and other insects. These vector-borne diseases include malaria, dengue fever, yellow fever, and encephalitis. Also, algal blooms could occur more frequently as temperatures warm particularly in areas with polluted waters, in which case diseases such as cholera that tend to accompany algal blooms could become more frequent (World Health Organization, 2003).

Higher temperatures are expected to further raise sea level by expanding ocean water, melting mountain glaciers and small ice caps, and causing portions of Greenland and the Antarctic ice sheets to melt. The Intergovernmental Panel on Climate Change (IPCC) in 2007 estimates that the global average sea level will rise between 0.6 and 2 feet (0.18 to 0.59 meters) in the next century. Rising sea levels submerge wetlands and other low-lying lands, erode beaches, intensify flooding, and increase the salinity of rivers, bays, and

groundwater tables. Some of these effects may be further compounded by other effects of a changing climate. Coastal wetland ecosystems, such as salt marshes and mangroves as noted by Titus 1998 are particularly vulnerable to rising sea level because they are generally within a few feet of sea level. Wetlands provide habitat for many species, play a key role in nutrient uptake, serve as the basis for many communities economic livelihoods, provide recreational opportunities, and protect local areas from flooding. As the sea rises, the outer boundary of these wetlands will erode, and new wetlands will form inland as previously dry areas are flooded by the higher water levels. The amount of newly created wetlands, however, could be much smaller than the lost area of wetlands - especially in developed areas protected with walls, embankments, and other structures that keep new wetlands from forming inland. Report by Intergovernmental Panel on Climate Change (IPCC) 2007 suggests that by 2080, sea level rise could convert as much as 33 percent of the world's coastal wetlands to open water.

Although climate change is an inherently global issue however, the impacts will not be felt equally across the planet. Regional changes are likely to differ from global averages in both magnitude and rates of change. Furthermore, not all ecosystems and human settlements are equally sensitive to changes in climate. Nations and regions within nations vary in their relative vulnerability to changes in temperature, precipitation and extreme weather events and their ability to cope with such changes. Some nations will likely experience more adverse effects than others, while other nations may benefit. Poorer nations are generally more vulnerable to the consequences of global warming. These nations tend to be more dependent on climate-sensitive sectors, such as subsistence agriculture, and may lack the resources to safeguard themselves against the changes that global warming may bring.

#### 4 CONCLUSION

Meeting the challenges of urbanization on the urban ecosystem requires a holistic approach to urban development. The holistic approach as opined in this paper is based on the understanding that for man to continue to exist and enjoy the abundant of the nature, the resources must be exploited in an environmentally friendly. The following recommendations are therefore, suggested:

There must be a policy action to control the rate of rural-urban migration. This can be achieved by meeting the essential basic human needs not only in the urban areas but to include rural areas in a sustainable way.

The principles of sustainable development must be adhered to in all dimensions of urban development. This means that cities must balance the social, economic and environmental needs of the present and future generations. This can be achieved through long time strategic visions using tools such as development strategies, environmental planning and management.

Alternative sources of energy and fuel such as solar power for powering industries, cars, among others should be developed.

There must be concrete effort by all stakeholders through the principles of good urban governance to formulate sound policies to control urbanization and manage environmental problems.

To address the problem of biodiversity lost people should be encourage developing sustainable economic alternatives to destructive harvesting and land use. Rain forest communities should undertake sustainable rain forest logging operations, in which carefully selected trees are extracted in a way that has minimal impact on the forest ecosystem. The same principles should be applied to the harvesting of animals, and other natural resources.

There should be preparation of landscape master plan for urban centres. The implementation of such plan will restore lost aesthetic glory of the cities.

There should be a regulation applicable to individual developer to stipulate the percentage of the land that must be reserved for landscape and tree planting

Streetscape and tree planting in cities should be encouraged these will not only provide shade, shelter and a home for birds and small animals but also serve as carbon sink to absorb green house gasses resulting from human activities.

There should be a research into a better and environmental friendly public mass transport system. If public transport was cheaper and easier to use, more people would use it to travel from the suburbs where they live to the cities where they work. This would go a long way at reducing air pollution and noise pollution.

Eco city concept and principle of healthy city should be applied to the existing urban centres and subsequent urban development.

Urban farming must be encouraged in all urban centres.

Theory of biocentrism sees the planet as nature centeredness and not human centeredness. It is the opposite of anthropocentrism the view that humans are acting out of excessive human-centeredness (anthropocentrism) and thus destroying the planet and the rest of the species which have just as much 'intrinsic right' to live out their biological destiny as we do. Accordingly, Biocentrism (life/earth/nature centeredness) calls for a new way of acting. Specifically, it calls for 'earth-centered' activity and thinking—putting the 'earth first' (instead of putting ourselves first) as a way out of the global dilemma. The believers of this theory recognised the fact that other components of the ecosystem are as important as man in the ecosystem. Therefore, man should be conscious of other elements within the ecosystem while attempting to exploit it for her benefits.

In conclusion, the scenario of the impact of urbanization on urban ecosystem is severe. There is irresistible evidence as detailed above to show that unbridled urbanisation resulting in environmental degradation of the city does not make for healthy living. Also, urban development has led to extinction of some important species in the ecosystem especially the floral which are suppose to serve as carbon pool and carbon sequestration for the excessive emitted greenhouse gasses in the environment. This invariably has reduced global bio-diversity and susceptibility of the city. With out gain saying there is need for all hands to be on deck at solving these problems if humanity is to continue to exist on the surface of the earth.

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