

# Chapter 12

## Review on Climate Change Impacts on Air Quality in Nigeria



Nwanneka N. Onwudiwe

**Abstract** Climate change and air pollution pose the greatest environmental challenges that are affecting the whole nations in the world. These environmental challenges have not been effectively managed or controlled by environmental policies in Nigeria because of poor coping capacity. There is an ample evidence that climate change impacts in Nigeria result from climate related factors such as increased temperatures, increased rainfall, sea-level rise, extreme weather events, and, especially, increased health risk. Climate change has an impact on air quality because it is highly dependent on weather. Human activities have added more and more greenhouse gases into the atmosphere. The air quality we breathe in Nigeria is mainly affected by the release of air contaminants via production of petroleum products and bush burning, which has affected lives and health condition of many people in environment and the emission of greenhouse gases (GHGs) into the atmosphere is confirmed to deplete the activities of the ozone layer which protects us from harmful ultraviolet radiation. The impact of the change will be difficult to handle and it will be potentially very long lasting. However, this study reviews causes of climate change in Nigeria, its impact on air quality in the environments and useful policies to enforce to achieve sustainability of lives.

**Keywords** Climate change · Greenhouse gases · Air quality · Policies

### Introduction

Climate change is regarded as the differences in the mean daily weather factors such as precipitation, wind, humidity, sunlight, and degree in temperature of a place over a given time. An alteration to the chemistry of the global atmosphere brought about by human activities could also be described as a change of weather conditions

---

N. N. Onwudiwe (✉)  
Natural Science Unit, University of Nigeria, Nsukka, Nigeria  
e-mail: [diego.onwudiwe25@gmail.com](mailto:diego.onwudiwe25@gmail.com)

(Adejuwon 2006). Climate change causes environmental problems such as desertification, debasement of land, water scarcity, food security, and air and water contamination. Increasing alterations in weather designs and predicted maximum climate events may threaten people's subsistence if no action is taken. According to scientific proof, climate change and global warming are undeniably causing severe and potentially damaging effects. Climate change and air pollution are the most critical health and sustainability issues facing the world. The two are very much related. Besides its effects on human health, atmospheric gases (CO<sub>2</sub>) influence the climate of the Earth by absorbing energy and blocking heat from escaping, causing climate variability (Akinola et al. 2014). Till date, with a little collaboration, policymaking on climate change and air quality goes on parallel ways and the strategy is designed in a way that it will meet both present and future needs without any compromise. Virtually all the nations in the world with this design are developing solutions to minimize climate change and air pollution impacts in our environments (Ajijere and Nwaerema 2020). The effect of climate change has outspread on both human and natural ecosystem beyond the global. In other parts of the world, its impact is evident, but in Africa, its impact is considered endangered since the ecosystems and economy is fragile (Ajijere and Nwaerema 2020). Policymaking on climate and air quality is integrated to use tools to assess greenhouse gas emissions and air pollutants together. This allows multiple impacts on climate, health, and crops to be quantified. A number of Nigeria's policies and strategic initiatives can act as climate change mitigation measures, if properly implemented. Some of the policy initiatives like "oases rehabilitation in the National Action to Combat Desertification and the National Policy on Drought and Desertification" could be adapted as measure and plans and modify into policy options for climate change response in the Nation (Obioh 2008). This strategic response will enable policies to be translated into purposeful intersectional pursuit for the maintenance of the environments (Obioh 2008).

Climate change was identified by the World Health Organization as one of the top ten threats to global health in 2019; Nigeria is among the top 10 countries most vulnerable to climate change, with approximately 6% of the country's land area are affected by extreme weather conditions (World Bank 2019). Furthermore, the rural and urban migration stream flow on the significant increase and decrease of other effects of climate change in Nigeria have been documented (Cattaneo and Massetti 2019; Akinwumi et al. 2020). As a result of climate change, Nigeria's agriculture and food security, water resources, public health, and settlements have suffered significantly. Climate change is likely to cause about 250,000 deaths worldwide within the year 2030 and 2050 resulting from malnutrition, malaria, diarrhea, and heat stress. This was estimated by the World Health Organization (WHO) and the evaluation of this report was done to express the cost of annual damage to health (WHO 2021a). Moreover, record from the National Emergency Management Agency (NEMA) stated that flood displaced 2 millions of people in Nigeria as at 2012 another record of about the number 100000 displaced in 2015, 92,000 in 2016, 250,000 in 2017, and roughly 1.9 million in 2018 were injured.

The impact of climate change is not only vulnerable to agriculture and environment but it also poses a risk to people and have various unpleasant consequences on health

and social activities (Pittock 2005). A rise in sea-level of about 2 m to 6 m in the coastal region of the world could lead to the migration of millions of people from their home (Rowley et al. 2007; Nicholls et al. 2011). IPCC (2007a) revealed that by 2022, some 75 and 50 million people in Africa will be at risk of severe impacts due to weather extremes. It has also been reported that 27–53 million Nigerians living in the coastal region were forced out of their homes as a result of the rise in sea-level (USAID 2012). Increased recurring outbreak of vector and water borne diseases that is associated with climate change could lead to morbidity and mortality (WHO 2020).

The developed nations encounter less effects of climate change more than the developing nations (Maikasuwa 2013). The fact is that the developed nations have progressed a lot in research and technology despite being the major contributors of climate change to discover working policies for adaptive measures that could help to minimize the outcomes of climate change impacts in their nation (Jagtap 2007; Enete and Amusa 2010; Ebele and Emodi 2016; Elum and Momodu 2017). Such an advanced adaptive response and technologies are very slim in developing country like Nigeria. However, the African countries especially are more vulnerable to climate change effect and lack of willingness to enhance durability of adaptive response are very low (ND-GAIN 2021).

Air pollution is the release of pollutants into our environment. It can be defined as the presence of quantities of biological materials or particulate pollutants in the outdoor or indoor atmosphere and of time duration such as to be harmful to human and other living organisms (Fagorite et al. 2021). Air pollution is an outcome of reduced air quality as a result of emission of natural substances and human pursuit in the form of gases into the atmosphere which has direct or indirect harmful impacts on human health and environment (IPCC 2014). The emission of contaminated substance into the atmospheric environment has been a serious problem affecting all nations in various ways. The emission of these polluted substances are the main reason the air is contaminated they include carbon monoxides (CO), nitric oxides (NO<sub>x</sub>) volatile organic compounds (VOCs) and sulfur dioxide (SO<sub>2</sub>). These air pollutants have posed a great threat to the most sustainable programs in Nigeria and have tremendous effect on the life of citizens. The major sources of gas emission in some parts of Nigeria, such as the Southwest particularly Lagos, are the landfills, combustion of waste materials, and generator set (Akinola et al. 2014) meanwhile, in the oil producing Niger region, the air quality is poor and happened to be among the top 10 most polluted areas in the world, this is because of the menace of black soot and other hazardous chemical which are being emitted into the atmosphere which have become a great concern to people living in the state (Weil 2014; Kuenzer et al. 2014; Ede and Edokpa 2015).

According to the World Health Organization (WHO) regulations, air pollution affects health even at low levels and the average concentrations of PM<sub>2.5</sub> should not go beyond 5 µg/m<sup>3</sup> per year, and the average daily exposure of particulate matter of air should not go beyond 25 µg/m<sup>3</sup> in a year. Its yearly exposure was reported to cause about 7 millions of premature deaths (WHO 2021b). The cause of air pollution in our environments has risen so greatly with transformation of

work, population, and commercial development (Grutter et al. 2014), and the sources of these particulate substances are mainly caused by release of gases, waste, and toxicants from the commercial industries during productions, rise in movement of vehicles in the city due to continuous congestions, road and building construction activities, and domestic burning activities (Fort Air Partnership (FAP) 2014). This study is aim to review causes of climate change and the impact on air quality in Nigeria.

## **General Effects of Climate Change in Nigeria**

The challenges existing with climate change vary beyond the nation. Nigeria's climate consists of two seasons, the dry and rainy (wet) seasons. This has led to seasons of drought and excess flood, which affected agricultural activities and caused a loss of shelter (Akande et al. 2017). These seasons differ in lengths depending on the geographical location. Studies on climate change susceptibility demonstrated that states in the north are more vulnerable to climate change than the southern states (Madu 2016; Federal Ministry of Environment 2014). For instant, South usually has a longer period of rainy season which starts between the months of March to November than the Northern part; theirs is short and happens between the months of May to September. The Northern region experience frequent dry season which is usually hot and their average value of temperature reaches about 38 °C per month. The North Central is the least susceptibility to climate change, which could be related to steady precipitations and irrigation which occurs yearly due to the disposal of lakes in the region, which helps to make up for lower than anticipated rains (Federal Ministry of Environment 2014). Although the North Central area also experience climate change toward dryness, as well as varying decrease in rainfall, these factors are a growing concern about the region and a downward spiral affecting its economic performance and agriculture output, and a falling drift in precipitation has been observed in Plateau, Nasarawa, and the Federal Capital Territory (Ideki and Weli 2019). The most vulnerable regions are the Northeast and Northwest, and the results of high level of heat and less rainfalls has quickened desertification, destroying wetlands and reducing the quantity of surface water and biodiversity resources on the land (Abdulkadir et al. 2017; Akande et al. 2017; Ebele and Emodi 2016; Federal Ministry of Environment 2014).

Generally, the Harmattan is a hot and dry wind, which is felt more in the North than in the South. The mean temperature in south is around 32–33 °C. The vulnerability features vary beyond the country and the most vulnerable area is the Northeast. One of the exposed factors which affect the North is decreased rainfall which jeopardizes rain fed agriculture and affects water supply. Meanwhile, the Southeast is exposed to high level of water decline because of soil porosity (Federal Ministry of Environment 2014). There is less vulnerability in the Southeast and Southwest than in the North. The South-South (Niger Delta region) is highly exposed; this is because of rise in rainfall and overflowing of water on the land which has caused displacement of many

communities (Sayne 2011; Federal Ministry of Environment 2014; Saheed et al. 2019). The effects of climate change on human health in Nigeria are numerous and indirect. Already, Nigeria's residents are experiencing poor nutritional imbalances and climate change will only exacerbate this problem. There could be a shift in the prevalence of vector-borne diseases, such as malaria (mosquitoes) and sleeping sickness (tsetse flies). The changes in patterns of rainfall and temperature have caused mosquitoes to thrive in areas that have water logging and poor drainage (Akpomi and Vipene 2016). Climate change often appears very esoteric but in Nigeria, it's real. We already have an increasing incidence of disease, declining agricultural productivity, and a rising number of heat waves. There is clear evidence that climate change is reality and it affects almost every aspect of our lives. Our everyday lives involve adapting to change and mitigating its effects. However, we must first understand what climate change is, how we contribute to it, in order to adapt and reduce our vulnerabilities (Olaniyi et al. 2013).

## Causes of Climate Change in Nigeria

The natural processes (biogeographical) and human activities known as (anthropogenic) are the factors that cause climate change (Odjugo 2010). The natural processes consist of astronomical and extraterrestrial features. Among the Earth's astronomical features are the eccentricity of its orbit all over the Sun, the orbit's changes over time, changes in volcanic activity, and changes in orbital trajectories, while extraterrestrial factors include the quantity and quality of solar radiation (IPCC 2007b; Odjugo 2010). In addition to external changes in the climate system, such as ocean currents or atmospheric circulation, climate variability can also result from internal changes (IPCC 2005; NRC 2011). Spore (2008) outlined how weather patterns can provide an easy understanding of climate change. He claims that sunlight is emitted onto Earth's surface by the Sun every day. Part of the heat is absorbed by the Earth; another part is reflected into the atmosphere, and a third part is radiated as infrared rays. Under normal conditions, the Earth's temperature is stabilized by cloud cover and water vapor absorbing these rays. As a result of human activity, GHG concentrations have increased significantly, and our planet is facing an increasingly dangerous situation. These gases absorb solar radiation and radiate it back to Earth, resulting in a general rise in temperatures known as global warming. Human activities is a major component of anthropogenic factor which involve the release of large quantity of greenhouse gases (GHGs) into the atmosphere which deplete the ozone layer and create a reduction in the amount of carbon in the atmosphere (IPCC 2007b). According to Chukwu and Asiegbu (2011), other important factor contributing to greenhouse gas emission into our environment is the growing number of rearing farm animals whose digestive processes continuously produce methane and nitrous oxide. It has been established that human activities, directly or indirectly, knowingly or inadvertently, to degrade our environment is irrefutably responsible for the climate change that we experience, in addition to natural variability seen over

a similar timeframe (Chukwu 2008; Olaniyi et al. 2013; Dipeolu 2015). Although some agricultural practices and desertification release GHG gases into the atmosphere, these gases originate from the combustion of fossil fuels. The greenhouse gases that cause global warming are carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), water vapor, and hydrofluorocarbon (HFCs). The fact is that, CO<sub>2</sub> is the primary gas that causes climate change, but its impact is very low. One molecule of CO<sub>2</sub> can damage ozone layer for only a few years, but other greenhouse gases can damage the ozone layer for decades to thousands of years (Odjugo 2013). The emission of CO<sub>2</sub> by human activities may contribute less to the greenhouse effect than many other gases and heat radiation from the Sun to the Earth's surface can be effectively absorbed by greenhouse gases. It works by keeping the atmosphere warmer than it should be. Based on current GHG emission trends, the Earth is projected to experience temperature increase between 1.5 and 4.5 °C by 2030 (Nebedum and Emodi 2016). As reported by Ogunniran (2018), climate change due to greenhouse effects has been a threat to people, natural systems, and the environment for more than a decade due to high temperatures, acidic rain, flooding, and susceptibility to pests and disease outbreaks, which makes life more difficult. There is no doubt that climate change is global phenomenon, as are its impacts. However, the developing countries will be hit more severely than the developed countries due to their limited coping abilities (Nwafor 2007; Jagtap 2007) and Nigeria is one of those countries. Nigeria has already been affected by various ecological problems caused by changing or variable climate (Odjugo 2001; Odjugo and Ikhuoria 2003) (Fig. 12.1).

## Causes of Air Pollution in Nigeria

In this day and age, air pollution is the greatest plague, affecting not only our climate but also the public and our individual health, resulting in increased morbidity and mortality (Komolafe et al. 2014). The two major factors that cause air pollution are natural and anthropogenic activities. Even so, the anthropogenic sources produce most of the pollutants in urban areas; most of them are emitted by human activities (Abaje et al. 2020). The natural phenomenon results from natural processes that are not induced by human activity. Air pollution and urban climate are interconnected in several ways. Different studies in other region of the world have explored the relationship between meteorological parameters and pollutants such as ozone, SO<sub>2</sub>, and NO<sub>2</sub> (Broomfield et al. 1996; Davis et al. 1998; Perez and Trier 2001; Krupa et al. 2003), but no studies as reported by Odekanle et al. (2017), have been conducted on the effects of meteorological parameters on air pollution during transport in Nigeria. People who live in large urban areas are mostly affected by air pollution, as road emissions contribute the most to poor air quality. Industrial accidents also exist; however, this can lead to the spread of a toxic fog that is deadly to the local populations. Many factors play a role in the dispersion of pollutants, including atmospheric stability, wind direction, and wind speed (Kelishadi and Poursafa 2010). Some other sources of pollution include dust, animal waste, combustion of fossil fuel, vegetation,

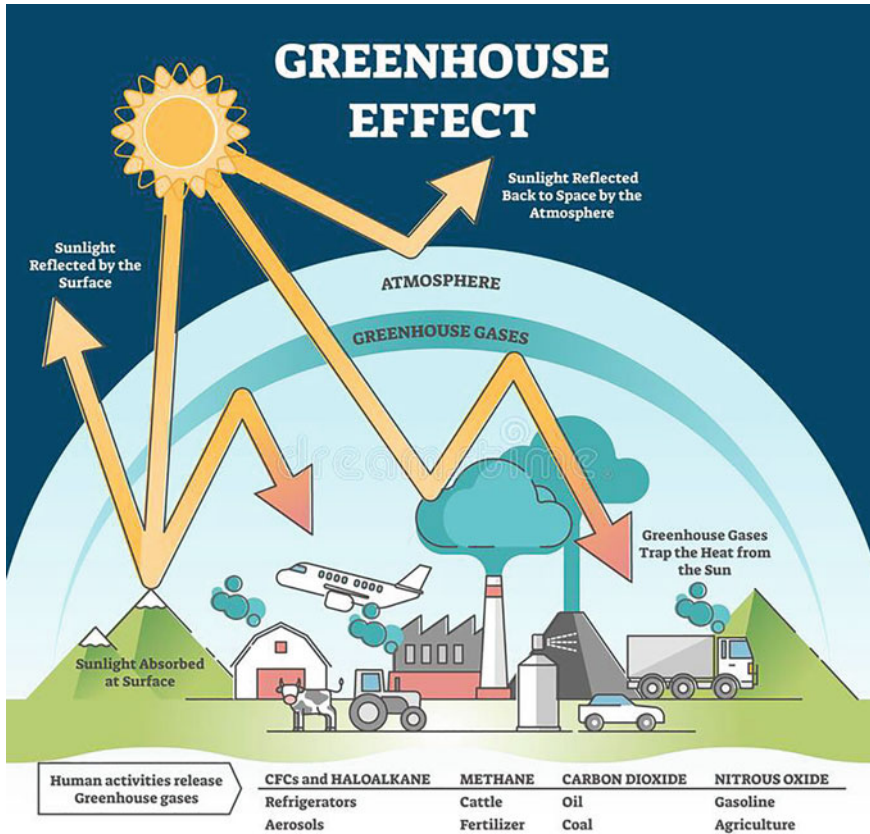


Fig. 12.1 Greenhouse effect and climate change from global warming outline concept. Source Dreamstime.com

and anthropogenic causes. These sources follow a natural cycle, which occur more common under certain conditions and less frequently under others. Dust storms are often cause by wind, especially in areas where there is little or no vegetation as a result of lack of rainfall (Fagorite et al. 2021). When this pollutant is present in the air, it can warm the atmosphere and pose a health hazard for living organism, it can also interfere with photosynthesis (Brook et al. 2010). Beside dust; other cause of air pollution is digestion from animals, especially from cattle which help in the emission of gas known as methane. When it is warmer, number of flowers and trees do release large volume of volatile compounds. A number of these compounds react with nitrogen oxides, sulfur dioxide, and carbon compounds to produce ground-level recurrent hazes made of ozone (Tawari and Abowei 2012). Among the sources of carbon emissions are transportation, manufacturing processes, the burning of bushes, aerosol usage, and the combustion of fossil fuels in other for power supply in the production companies and residential areas (Yakubu 2017). Furthermore, large the portion

of the electricity required for other services and air conditioning is also consumed, which results in more emissions of pollutants in the environment. All gases emitted by burning fossil fuel and combustion vehicles are part of human activities which is anthropogenic cause and has pose a great contribution in global warming of the Earth (Olaniyi et al. 2013). In addition, air can also be polluted through building up of waste and agriculture practices (Ekiyor et al. 2019). The height of distress on air pollution on people living in the environment of these mega cities in Nigeria (Lagos, Kano, Port Harcourt, Ibadan and Warri) through refineries and other industrial activities is very pathetic and on assumption that the nation is affected majorly by the pollutants from all these industrial practices and the inhabitants of these cities are to be informed about the effect of air pollution to their health so to take precaution and measures (Ibemere 2019). The use of some construction materials like the cement, asbestos roofing, and ceiling tiles contributes to indoor air pollution and can lead to some health issues indirectly. According to the central pollution control board, the cement industry ranks among the 17 most polluting industries, and cement manufacture creates dust during its production (Ogedengbe and Oke 2011). The amount of air pollutants created via industrial and mobile sources affect the environmental outdoor air space, and the transportation of these air contaminants over long distance have significant consequences on the environment. Generally, air pollution in Nigeria is very alarming and havoc to the citizen (Fig. 12.2).



**Fig. 12.2** How air pollution is silently choking life out of Nigerians in major cities. *Source* Bussinessday.ng



## Impacts of Climate Change on Air in Nigeria

The effects of climate change on human health, as well as the environment, are already evident in Nigeria. The Earth's temperature increases as a result of introducing carbon dioxide into the atmosphere via combustion of fossil fuel such as coal and gas and this increase in temperature makes the Earth to become much like a large blanket of heat around us throughout the year. This heat trapped in the environment disrupts many interconnected systems. The air quality of an environment is tied to the atmospheric processes of the location, on measures of how human actions affect the environment (Ezeonyejiaku and Obiakor 2013) and poor air quality is when the emissions of nitrogen oxides, methane, and other harmful gases are above levels acceptable for human health (Ajere and Nwaerema 2020). The decrease in the quality of air as a result of climate change via the emission of pollutants can affect human health. It has been estimated that over seven million people die every year from diseases caused by air pollution (Ezeonyejiaku et al. 2022). Moreover, it elevates particulate matter and ozone levels in the air, which has detrimental effects on health. Nigeria, especially in the Niger Delta region, has been struggling with the issue of pollution of the air quality (Tawari and Abowei 2012), especially after the appearance of carbon black (black soot) in the city of Port-Harcourt atmosphere. Nevertheless, the adverse health effects of poor air quality due to pollution in the city have become a source of concern in recent years (Yakubu 2017; Ugbebor et al. 2019). According to some reports, the soot pollution is attributed to the incomplete combustion of fossil fuels, biomass, tires, and illegal artisanal refineries. Among its serious risks are a decrease in human health, a decrease in agriculture, and a reduction in climate change (Akinfolarin et al. 2018).

Air pollutants compromises air quality of the environment (Ibe et al. 2017). As pollutants, air pollution is incredibly hazardous to human health and the effect of much exposure of it could lead to development of diseases such as asthma, bronchitis, coughing, breathing difficulties, or decrease lung function. The adverse effects of these conditions of climate change can lead to more medication usage, frequenting hospitals for consultation and can also lead to untimely death (Omoruyi and Onafalajo 2011; WHO 2014; Ibe et al. 2017). It is conceivable that changes in climate conditions will extend the transmission seasons of important vector-borne diseases and change the geographical distribution of these diseases. There is evidence that malaria is caused by climate conditions, a unicellular organism known as Plasmodium, and transmitted through the bite of an infected female Anopheles mosquito. A survey shows that malaria accounts for over 45% of all outpatient visits and almost 50% of Nigerians experience malaria at least once a year (Ayeni 2011). Wildfires in Nigeria are caused by human activities and lightning fires are very rare because of the hot and dry Harmattan winds flowing from the north to south between December and March. The area situated above latitude 10°N in Nigeria experiences more wildfire, mainly because this is the savanna ecozones with a shorter duration of rainfall and a longer period of dryness (IFFN 2006). Therefore, wildfires is very much experience when there is increase in drought and increased wildfires spread due to climate

change can decrease air quality and lead to some ailments such as respiratory and cardiovascular diseases. Much exposure of it could affect organs in our body and worsen existing health conditions that are linked with climate change. Obviously, people react to air pollutants, but the interaction depends on the characteristics of pollutant they are exposed to, the level of exposure, as well as genetic makeup (Dufflo et al. 2008). Those who are sensitive will experience greater allergic reactions when they are exposed to both allergens and air pollutants and this could lead to increased risk of respiratory illness (APHA 2016).

When the concentration of toxic gases, nitrogen oxides, and methane is higher than what is considered safe for human health, the air of that place has poor quality. At high concentrations, ground-level ozone is a toxic pollutant that is formed by combining other gases under favorable conditions. It can affect both human and crop, as well as damage the environments. Similarly, a third form of ozone is found in the stratosphere, and it acts as a barrier against UV radiation from the Sun. Thus, climate change is expected to result in greater concentrations of ground level ozone when environmental conditions change, such as increased temperature (Kath 2010).

Assessing population exposure to air pollutants requires air quality monitoring. Public health effects are influenced by the type, severity, frequency, duration, and toxicity of the pollutant (Zhang et al. 2019; Manisalidis et al. 2020). Nonetheless, the air quality index has become a widely used indicator for assessing and indexing the state of an air environment over a place or a region, it is still considered a matrix in its own time. Most developed countries use air quality indexes for routine and daily activities, which are available on digital platforms. But some developing countries lack access to such platforms, such as Nigeria, where air quality monitoring is rarely measured (Ezeonyejiaku et al. 2022).

As reported by Ede and Edokpa (2015), the south-south (Niger delta region) of Nigeria has poor air quality which affects emissions circulation. There is also evidence from another study that the air quality in the North-eastern Nigeria that is, the same region of the country Nigeria particularly Port Harcourt is very unhealthy and is a risk health factor to the exposed people and can disrupt the respiratory and cardiovascular systems after a long exposure (Ugbebor et al. 2019).

Recent research recorded by Ezeonyejiaku et al. (2022), on air quality measure in some areas (Awka, Ekwulobia and Nnewi) of Anambra state located in the eastern part of Nigeria, indicated that oxides of carbon (CO<sub>2</sub> and CO) showed highest mean concentrations across towns within the residential and commercial areas. Meanwhile, methane (CH<sub>4</sub>) concentrations in all the towns examined, excluding Onitsha, were higher and exceeded WHO limits.

Industrial developments in Nigeria process both wet and dry wet, and each of these activities entails related environmental impacts and contributes significantly to climate change. The paper, cement, iron, and steel industries that emit pollutant or toxicants into the atmosphere are the most vulnerable to climate regulation. As a consequence, manufacturing companies in Nigeria rely on hydropower, which is epileptic, requiring the use of more generating sets, which in turn leads to more carbon emissions (Saka 2020; Etim et al. 2021).

## Policy that Can be Use to Improve Air Quality in Nigeria

Several rules and regulations accompany the Nigeria climate policy intended for agencies and individuals to adhere in order to attain its objective. A major objective of the policy is to address variety of human-caused causes of climate change in so many of ways. It aims to mitigate climate change's negative impact. In order to mitigate climate change, Nigeria should implement a national climate change policy and enact laws that prohibit the release of toxic gases from industrial areas. Mitigation measures of the effect of climate change could include the following:

Climate change impacts and its vulnerability effect on populations should be brought into the spotlight by agencies in control. This can be accomplished by providing basic training, workshops, and awareness programs to raise awareness and promote climate change adaptation (Madu 2016). In addition, these actions would provide benefits to global health in the long run (Borokinni 2017). However, climate change threatens air quality in Nigeria, but air pollution can be minimized by improving access to clean household energy, which in turn would involve using refined cooking stoves without hydrocarbon and solar light (Ajiere and Nwaerema 2020).

To the industry, we must provide clean technologies that can minimize smokestack emissions and improve on urban solid waste management.

In the field of transportation, it is necessary to reduce the number of large polluting long-distance vehicles such as trucks and lorries that release polluting gases to the environment and to reintroduce rail transportation systems, electric cars, reposition heavy-duty vehicles to cleaner models, and use high-efficiency vehicles and fuels (Suleiman 2013). Some developed economies have successfully evolved effective climate change measures for their countries. The political leadership in this country should seek the support of developed economies that have succeeded in implementing such measures in their countries. By providing such aid, the crisis could be rapidly addressed in the areas of health, waste management, water quality, and food shortages. In order to build environmental stability, soil fertility, and greater food production, reduce environmental-induced migration, and stabilize the political arena; the government must establish a nationwide program of reforestation, tree planting, and windbreaks in the northern areas (Urim et al. 2013).

## Conclusion

Children, as well as adults in Nigeria, are affected by the issues associated with climate change and air quality studies face a lot of challenges. The most prominent issues in "Nigeria" has been deficiencies in equipment, infrastructure, and lack of expertise and weak policy frameworks. In addition to these and many other factors, the country has been unable to achieve their long term desire objectives, the ecosystem quality and safety of public health it is pursuing. In Nigeria, air quality

can be improved by implementing mitigation measures in several sectors, including transportation, industry, waste, oil and gas, agriculture, power, cooking, and lighting households.

## Recommendation

In light of the fact that the effects of climate change can be felt in a wide variety of ways, including air quality, human settlements, health, wetlands, water resources, business, commerce, financial services, food security, land degradation, forestry, and biodiversity, it is recommended that Nigerian citizens become aware of the issues surrounding climate change. A sustainable way to achieve this objective is through education and capacity building as a means of integrating adaptation and mitigation.

The government should also put more of their efforts to plant trees, as this will help clean up the environment. Government should abate illegal refining of crude oil and finance into low-carbon fuels and solar products in Nigeria. It is also very important for the government to take, support, and enforce policies to combat air pollution to ensure quality environment. However, there should also be joint efforts between the citizens and the government to address climate change on air quality in every community in Nigeria.

The government can help to produce energy for the society by assembling plants and crushing them in a modern bio-power. In the presence of ultraviolet light, free electrons are released from material, causing free radicals to form, which are responsible for oxidizing VOCs and NO<sub>x</sub> emissions. Titanium dioxide can be used; it has been reported to be effective in reducing air pollution by scientists and has been found by researchers to have this property.

Research on the impact of climate change on the quality of air and its mitigation in the society needs to be in-depth.

**Acknowledgements** I want to thank my Colleague Emmanuel Akubunwa who brought the information and topic to my interest. This also motivated me to write. I will also remain grateful to my beloved husband, Mr Uzochukwu Obiegbu for his financial supports, care, advice, and encouragement in writing this work. I sincerely appreciate the editors for their responsibilities toward this work. Above all, I thank God Almighty whose grace has sustained me all through.

## References

- Abaje IB, Bello Y, Ahmad SA (2020) A review of air quality and concentrations of air pollutants in Nigeria. *J Appl Sci Environ Manag* 24(2):373–379
- Abdulkadir A, Maryam LA, Muhammad TI (2017) Climate change and its implications on human existence in Nigeria: a review. *Bayero J Pure Appl Sci* 10(2):152–158
- Adejuwon JO (2006) Food crop production in Nigeria II. Potential effects of climate change. *Climate Res* 32:229–245

- Ajjere S, Nwaerema P (2020) Climate change and air pollution: implication for human health and environment in rivers state. *Int J Res Innov Soc Sci* 4(5):276–279
- Akande A, Ana Cristina C, Jorge M, Roberto H (2017) Geospatial analysis of extreme weather events in Nigeria (1985–2015) using self-organizing maps. *Adv Meteorol* 2:1–11
- Akinfolarin OM, Obunwo CC, Boisa N (2018) Air quality characteristics of emerging industrial areas in Port Harcourt. *Niger J Chem Soc Niger* 43(1):7–14
- Akinola AK, Suleiman AA, Adeleye YBA, Francis OA, Dauda RA (2014) Air pollution and climate change in Lagos, Nigeria: needs for proactive approaches to risk management and adaptation. *Am J Environ Sci* 10(4):412–423
- Akinwumi AM, Adewumi JR, Obiora-Okeke OA (2020) Impact of climate change on the stream-flow of Ala River, Akure, Nigeria. *Sust Water Res Manag* 7(1):1–11
- Akpomi ME, Vipene J (2016) Promoting knowledge of climate change (CC) amongst Nigerians: implications for education managers. *J Educ Pract* 7:32. ISSN 2222-1735
- American Public Health Association (APHA) (2016) Climate change decreases the quality of the air we breathe. <https://www.apha.org/~media/files/pdf/factsheets/climate/airquality.ashx>. Accessed 6 Dec 2021
- Ayeni AO (2011) Malaria morbidity in Akure, Southwest, Nigeria: a temporal observation in a climate change scenario. *Trends Appl Sci Res* 6:488–494
- Borokinni J (2017) Climate change and health impacts. The nation newspaper. <https://nationonline.ng.net/?climate-change-health-impact/>. Accessed 19 July 2022
- Brook RD, Rajagopalan S, Pope CA, Brook JR, Bhatnagar A (2010) Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. *Circulation* 121:2331–2378
- Broomfield P, Royle JA, Steinberg LJ, Yang Q (1996) Accounting for meteorological effects in measuring urban ozone levels and trends. *Atmos B Environ* 17:3067–3077
- Cattaneo C, Massetti E (2019) Does harmful climate increase or decrease migration? Evidence from rural household Nigeria. *Clim Change Econ* 10(4):1950013
- Chukwu GU (2008) Poverty-driven causes and effects of Environmental degradation in Nigeria. *Pac J Sci Technol* 9(2):599–602
- Chukwu GU, Asiegbu AD (2011) Global warming and climate change; impact and implications in Nigeria. *Int J Curr Res* 3(6):112–115
- Davis JM, Eder BK, Nychka D, Yang Q (1998) Modeling the effects of meteorology on ozone in Houston using cluster analysis and generalized additive models. *Atmos Environ* 32:2505–2520
- Dipeolu AA (2015) Climate change and challenges of environmental sustainability in Lagos State, Nigeria. *J Environ Earth Sci* 5:17
- Duflo E, Greenstone M, Hanna R (2008) Indoor air pollution, health and economic well-being. *S.A.P.I.EN.S*, 1(1). [Sapiens.revues.org](http://Sapiens.revues.org). Accessed 27 Dec 2022
- Ebele NE, Emodi NV (2016) Climate change and its impact in Nigerian economy. *J Sci Res Rep* 10(6):1–13
- Ede PN, Edokpa DO (2015a) Regional air quality of the Nigeria's Niger Delta. *Open J Air Pollut* 4(1):4236–54348
- Ekiyor TH, Horsfall IT, Kalagbor AI, Egbara-Dedua (2019) Evaluating the effects of air pollution on the agricultural yield of selected crops in eleme, Nigeria. *J Appl Sci Environ Manage* 23(10):1771–1778
- Elum ZA, Momodu AS (2017) Climate change mitigation and renewable energy for sustainable development in Nigeria: a discourse approach. *Renew Sustain Energy Rev* 76:72–80
- Enete AA, Amusa TA (2010) Challenges of agricultural adaptation to climate change in Nigeria: a synthesis from the literature. *Field action science reports*. *J Field Action* 4:1–11
- Etim MA, Babaremu KO, Justin LD, Omole DO (2021) Health risk and environmental assessment of cement production in Nigeria. *Atmosphere* 12(9):1111
- Ezeonyejiaku CD, Obiakor MO (2013) Spatial biomonitoring of trace element contamination and atmospheric quality assessment. *Am J Life Sci* 1(2):67–73

- Ezeonyejiaku CD, Okoye CO, Ezeonyejiaku NJ, Obiakor MO (2022) Air quality in Nigerian urban environments: a comprehensive assessment of gaseous pollutants and particle concentrations. *Curr Appl Sci Technol* 22:5. <https://doi.org/10.55003/cast.2022.05.22.011>
- Fagorite VI, Anifowose FA, Chiokwe VN (2021) Air pollution; causes, effects and remediation in Nigeria. *Int J Adv Acad Res* 7(1):13–30
- Federal Ministry of Environment (2014) United nations climate change Nigeria. National Communication (NC). NC 2. <https://unfccc.int/sites/default/files/resource/nganc2.pdf>. Accessed 17 Nov 2021
- Fort Air Partnership (FAP) (2014) How is air quality monitored? Alberta environment, government of alberta. [www.fortair.org](http://www.fortair.org). Accessed 27 Dec 2022
- Grutter M, Arellano J, Bezanilla H, Friedrich M, Plaza E, Rivera C, Stremme W (2014) Characterization of air pollution in Mexico city by remote sensing. *Geophys Res Abstr* 16:1
- Ibe F, Opara A, Chu N, Ikech A (2017) Ambient air quality assessment of Orlu, Southeastern. *Niger J Appl Sci* 17:441–457
- Ibemere D (2019) How air pollution is silently choking life out of Nigerians in major cities, 22 September 2019. <https://businessday.ng/features/article/how-air-pollution-is-silently-choking-life-out-of-nigerians-in-major-cities/>. Accessed 15th Jul 2022
- Ideki O, Weli V (2019) Assessment of drought vulnerability and occurrence zones in north central Nigeria. *Atmos Climate Sci* 09(03):298–309
- Intergovernmental Panel on Climate Change (IPCC) (2005) Global warming early signs on climate change. <https://www.climatehotmap.org>. Accessed 19 Jun 2022
- International Forest Fire News (IFFN) (2006) Fire situation in Nigeria. <https://gfmc.online/wpcontent/uploads/12-IFFN-34-Nigeria-1.pdf>. Accessed 21 Jul 2022
- Intergovernmental Panel on Climate (IPCC) (2007a) Climate change 2007: AR4 synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change core writing team. In: Pachauri RK, Reisinger A (eds) IPCC, Geneva, Switzerland, pp 104–112
- Intergovernmental panel on climate change (IPCC) (2007b) Climate change impact, adaptation and vulnerability: contribution of working group II to the forth assessment reports of the IPCC. *J Environ Q Madison* 37(6):2407
- Intergovernmental panel on climate change (IPCC) (2014) AR5 Climate change: synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change core writing team. In: Pachauri RK, Reisinger A (eds) IPCC, Geneva, Switzerland, pp 151–169
- Jagtap S (2007) Managing vulnerability to extreme weather and climate events: implications for agriculture and food security in Africa. In: Proceedings of the inter-national conference on climate change and economic sustainability held at Nnamdi Azikiwe University, Awka, Nigeria, pp 42–52
- Kath L (2010) Air Pollution and climate change. *Sci Environ Policy* 24:1–3
- Kelishadi R, Poursafa P (2010) Air pollution and non-respiratory health hazards for children. *Arch Med Sci* 6:483–495
- Komolafe AA, Adegboyega SA, Anifowose AYB, Akinluyi FO, Awoniran DR (2014) Air pollution and climate change in Lagos, Nigeria: needs for proactive approaches to risk management and adaptation. *Am J Environ Sci* 10(4):412–423
- Krupa S, Nosal M, Ferdinand JA, Stevenson RE, Skelly JM (2003) A multivariate statistical model integrating passive sampler and meteorology data to predict the frequency distributions of hourly ambient ozone (O<sub>3</sub>) concentrations. *Environ Pollu* 124:173–178
- Kuenzer C, Van B, Gessner U, Dech S (2014) Land surface dynamics and environmental challenges of the Niger Delta, Africa: remote sensing-based analysis spanning three decades (1986–2013). *Appl Geogr* 53:354–368
- Madu IA (2016) Rurality and climate change vulnerability in Nigeria: assessment towards evidence based even rural development policy. Paper presented at the 2016 Berlin Conference on Global Environmental Change, 23–24 May 2016 at Freie Universität Berlin. <https://pdfs.semanticscholar.org/>. Accessed 19 July 2022

- Maikasuwa SA (2013) Climate change and development countries: issues and policy implication. *J Res Dev* 187(941):1–10
- Manisalidis I, Stavropoulou E, Stavropoulos A, Bezirtzoglou E (2020) Environmental and health impacts of air pollution: a review. *Front Public Health* 8(14). <https://doi.org/10.3389/fpubh.2020.0001>
- National research Council (NRC) (2011) Climate stabilization targets: emissions, concentrations and impacts over decades to Millennia. The National Academies Press, Washington, DC, p 298. <https://doi.org/10.17226/12877>. Accessed 12 Nov 2021
- Nd-Gain (2021) Ranking of country index. <https://gain.nd.edu/our-work/country-index/rankings/>. Accessed 19 Oct 2021
- Nebedum EE, Emodi NV (2016) Climate change and Its Impact in Nigerian economy. *J Sci Res Rep* 10(6):1–13
- Nicholls RJ, Marinova N, Lowe JA, Brown S, Vellinga P, De Gusmao D (2011) *Phil Trans Math Phys Eng Sci* 369:161–181
- Nwafor JC (2007) Global climate change: the driver of multiple causes of flood intensity in Sub-Saharan Africa. Paper presented at the International Conference on Climate Change and Economic Sustain-ability held at Nnamdi Azikiwe University, Enugu, Nigeria, pp 12–14
- Obioh IB (2008) Proposed climate change policy and the framework for integration into national planning in Nigeria. Centre for energy research and development, OAU, IFE, Nigeria. <https://climatechange.gov.ng/wp-content/uploads/2020/09/national-climate-change-policy-1-1.pdf>. Accessed 7 Oct 2021
- Odekanle EL, Adeyeye MA, Akeredolu FA, Sonibare J (2017) Variability of meteorological factors on in-cabin and pedestrians exposures to CO and VOC in South-west Nigeria. *J Atmos Pollut* 5(1):1–8
- Odjugo PAO (2001) A global warming and food production: a global and regional analysis. *Afr J Environ Stud* 2(2):85–91
- Odjugo PAO, Ikuhuria AI (2003) The impact of climate change and anthropogenic factors on desertification in the semi-arid region of Nigeria. *Global J Environ Sci* 2(2):118–126
- Odjugo PAO (2005a) An analysis of rainfall pattern in Nigeria. *Global J Environ Sci* 4(2):139–145
- Odjugo PAO (2005b) General overview of climate change impacts in Nigeria. *J Hum Ecol* 29(1):47–55
- Odjugo PAO (2010) General overview of climate change impacts in Nigeria. *J Hum Ecol* 29(1):47–55
- Ogedengbe I, Oke AO (2011) Pollution impact of cement production on air, soil and water in a production location in Nigeria. *J Sci Technol* 31(2):46–56
- Odjugo PAO (2013) Analysis of climate change awareness in Nigeria. *Acad J* 8(26):1203–1211
- Olaniyi OA, Ojekunle ZO, Amujo BT (2013) Review of climate change and its effect on Nigeria ecosystem. *Int J Afr Asian Stud Open Access Int J* 1:2013. <https://core.ac.uk/download/pdf/234689728.pdf>. Accessed 2 Nov 2021
- Ogunniran BI (2018) Ozone layer depletion and climate change in Nigeria-problems and prospects; a review. *Global J Res Rev* 5(1):2
- Omoruyi EP, Onafalujo AK (2011) Effects of climate change on health risks in Nigeria. *Asian J Bus Manag Sci* 1(1):204–215
- Perez P, Trier A (2001) Prediction of NO and NO<sub>2</sub> concentrations near a street with heavy traffic in Santiago, Chile. *Atmos Environ* 35:1783–1789
- Pittock AB (2005) Climate change: turning up the heat, Ist. Earthscan, London, p 316
- Rowley RJ, Kostelnick D, Braaten X, Li X, Meisel J (2007) Risk of rising sea level to production and land area. *Eos Trans Am Geophys Union* 88(9):105–107
- Saka L (2020) State, industries and regulation in Nigeria: Ife iron and steel company and environmental pollution. *J Manag Soc Sci* 9(1):750–768
- Saheed M, Oludare H, Adedeji IE, Fatima K (2019) Mainstreaming climate change into the EIA process in Nigeria: perspectives from projects in the Niger Delta Region. <https://doi.org/10.3390/cli7020029>. Accessed 4 Jan 2022

- Sayne A (2011) Climate change adaptation and conflict in Nigeria. USIP, Washington, DC. [https://www.usip.org/sites/default/files/Climate\\_Change\\_Nigeria.pdf](https://www.usip.org/sites/default/files/Climate_Change_Nigeria.pdf). Accessed 18 July 2022
- Spore (2008) Climate change. Spore special issue, Aug 2008. CTA, Wageningen, pp 1–23
- Suleiman IL (2013) Examining air pollution and control measures in urban centers of Nigeria. *Int J Environ Eng Manag* 4(6):621–628
- Tawari CC, Abowei JFN (2012) Air pollution in the niger delta area of Nigeria. *Int J Fish Aquat Sci* 1(2):94–117
- Ugbebor JN, Yorkor B, Amadi G (2019) Assessment of air quality and its health implications on Abuja campus residence, University of Port Harcourt, Nigeria. *J Sci Technol Environ Inf* 7(1):500–509
- Urim UM, Imhonopi D, Egharevba ME (2013) Advancing solutions for climate change in Nigeria: an appraisal. In: A panoply of readings in social sciences: lessons for and from Nigeria. Department of Sociology, Covenant University, Ota, Ogun State, pp 233–247
- USAID (2012) Nigeria climate vulnerability profile. [https://www.climatelinks.org/sites/default/files/asset/document/nigeria\\_climate\\_vulnerability\\_profile\\_jan2013.pdf](https://www.climatelinks.org/sites/default/files/asset/document/nigeria_climate_vulnerability_profile_jan2013.pdf). Accessed 3 Nov 2021
- Weli VE (2014) Atmospheric concentration of particulate pollutants and its implications for respiratory health hazard management in Port Harcourt Metropolis, Nigeria. *Civil Environ Res* 6(23):11–17
- WHO (2014) 7 million premature deaths annually linked to air pollution. <https://www.who.int/news/item/25-03-2014-7-million-premature-deaths-annually-linked-to-air-pollution>. Accessed 7 Jan 2022
- World Bank (2019) Building climate resilience: experience from Nigeria. <https://www.worldbank.org/en/results/2019/04/18/building-climate-resilience-experience-from-nigeria>. Accessed 3 Nov 2021
- World Health Organization (WHO). (2021a). Climate change. <https://www.who.int/heli/risks/climate/climatechange/en/>. Accessed 3 Nov 2021a
- World Health Organization (WHO) (2021b) WHO Air quality guidelines. [https://www.c40knowledgehub.org/s/article/WHO-Air-Quality-Guidelines?language=en\\_US](https://www.c40knowledgehub.org/s/article/WHO-Air-Quality-Guidelines?language=en_US). Accessed 5 Nov 2021b
- World health organization Africa (WHO) (2020) Nigeria strengthens capacity to address impact of climate change on health. <https://www.afro.who.int/news/nigeria-strengthens-capacity-address-impact-climate-change-health>. Accessed 3 Nov 2021
- Yakubu O (2017) Particle (soot) pollution in Port Harcourt Rivers State, Nigeria-double air pollution burden understanding and tracking potential environmental public health impacts. *Environments* 5(1):2–8
- Zhang JJ, Adcock IM, Bai Z, Chung KF, Duan X, Fang Z (2019) Health effects of air pollution: what we need to know and to do in the next decade. *J Thorac Dis* 11(4):1727–1730