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The Developing World's Contribution to Global Warming and the Resulting Consequences of Climate Change in These Regions: A Nigerian Case Study

Angela Oyilieze Akanwa and Ngozi Joe-Ikechebelu

Abstract

Hundreds of millions of urban dwellers in low- and middle-income nations are at risk as 4-5 of the global weather-driven disasters experienced are consequent of a changing climate. Studies have shown that residents in least developed countries have ten times more chances of being affected by these climate disasters than those in wealthy countries. Further, critical views have it, that it would take over 100 years for lower income countries to attain the resiliency of developed countries. Unfortunately, global South is surrounded by a myriad of socio-economic and environmental factors limiting their fight against climate crisis. It is this germane reality that provoked the cause of this review. Hence, this paper reviewed the developing world's contribution to global warming and the resulting consequences of climate change with focus on Nigeria. This purposive approach adopted an analysis of secondary data related to climate information. The findings from the paper affirmed that impacts of climate change in developing countries include loss in agriculture/forestry resources, water shortage, food insecurity, biodiversity loss, health risks among others. Finally, it identified the major factors that exacerbate climate crisis, the human actions that trigger global warming and adaptive and mitigation approaches to minimize climate change related disasters.

Keywords: climate change, human actions, environment, acclimatization options, GHG emission and Nigeria

1. Introduction

Humans have emitted about 450 billion tonnes of carbon since the industrial revolution which has contributed to the world's present climate crisis [1]. Additionally, the dependence on agro-economy, use of fossil fuels and industrial activities by developing countries have made huge contributions to increased levels of greenhouse gases (GHG) that have escalated global warming and sponsored a changing climate [2–5]. The United Nations Framework Convention on Climate Change [6] defined climate change as a change that is distributed directly or indirectly to human activity, altering the composition of the global atmosphere.

The changes in climate characteristics that include temperature, humidity, rainfall and wind, among others, are influenced by natural and human processes over long periods of time [7–10].

The principal and most abundant GHGs in the atmosphere are water vapour, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and fluorinated gases (HFCs, PFCs, SF₆) [11–13]. Carbon dioxide (CO₂) makes up 60% of the greenhouse gases which alter the carbon cycle balance [14, 15]. They are emitted into our fragile atmosphere through human activities such as industrialization, burning of fossils, gas flaring, urbanization and agriculture. They increase global temperatures, thereby disrupting the current socio-economic and environmental processes [16, 17].

Human activities can also reduce the amount of carbon absorbed from the atmosphere through deforestation, land-use change, water pollution and agricultural production [18, 19]. In addition, developing countries are also involved in massive deforestation due to resource exploitation, urban expansion [2, 20] and agriculture in particular, which can cause carbon to be released from the soil at a faster rate than it is replaced.

Garrett Hardin's [21] concept of the “tragedy of the commons” identified that human unguarded actions are responsible for the depletion of natural resources and huge environmental compromise over the years. Rural areas that represent the resource base often get worse off by resource depletion and trickle-down effect of the urban vices. The aggressive demand placed on the environment and the unprotected means of processing raw materials are detrimental to climate change and the environment. Factors like improper/uncoordinated, non-participatory planning, non-implementation and enforcement of policies, among others, have been the bane of developing countries like Nigeria [2].

However, with the recent trend in global warming and the extent of man's responsibility in contributing to climate change, there is environmental concern towards sustainability. The concept of sustainability has become a major development process that will facilitate resource management and the minimization of impacts from human activities. The World Commission on Environment and Development [22] defines sustainable development as “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs”.

The core component of the definition is the conservation and development of resources. Hence, there must be responsible interaction with the environment in the process of development to avoid depletion of natural resources and also allow for long-term restoration of environmental quality [3]. Unarguably, balancing human means of resource exploitation/production and environmental sustainability is a necessity since their outcomes have negative impacts on the environment. Hence, the need to review the extent of the developing world's contribution to global warming and the resulting consequences of climate change in these regions with focus on Nigeria as a case study and also to suggest possible solutions is the motivation for this study.

2. Background

Nigeria is ranked seventh in the world and has an estimated population of over 200.96 million. It accounts for about 47% of West Africa population including the largest populations of youth in the world [23]. Indeed, Nigeria is the giant of Africa with a federation that consists of 36 autonomous states, occupying a geographical area of 923,768 sq. km, has abundance of resources, is the largest oil exporter and is the largest natural gas reserve in the continent and yet a multi-ethnic and culturally

diverse society with over 500 different ethnic groups [24]. Nigeria is blessed with physical, natural and human resources; however, she is surrounded by numerous environmental problems that have been exacerbated by climate crisis affecting its socio-economic and political sectors.

Nigerian and most developing countries in spite of their huge deposits in natural resources are still heavily dependent on agricultural production for their livelihoods. It is estimated that a total of 133 billion tonnes of carbon has been lost since humans first settled into agricultural life around 12,000 years ago. Also, crop production and cattle grazing have contributed almost equally to global losses too [25]. Further, a study carried out by Brandt et al. [26] also confirmed the contribution of agriculture to atmospheric carbon absorption by revealing that sub-Saharan Africa's vegetation carbon stocks changed between 2010 and 2016 with an overall loss of 2.6 billion tonnes of CO₂ in the past 7 years and yearly losses averaging at 367 million tonnes of CO₂. Developing countries like Ghana, Ivory Coast, Nigeria, Uganda and Kenya are experiencing the largest drop in carbon stocks with implications that climate change could make extreme events more frequent [26].

Hence, developing countries are exposed to climate vulnerability; as a result livelihoods, urban areas, infrastructures, human lives, health, socio-economic life and the built environment are threatened, particularly in Africa where sustainable resilient practices are mediocre. With low institutional capacity, sophisticated technology, finance and adequate resources are limited in these poor and most vulnerable regions [27].

It is quite alarming that the rate at which temperature increases is accelerating global warming incidence, revealing the need to operate environmentally friendly options and adaptive measures for climate regulation in order to ameliorate drastic weather predictions [3, 4, 28]. It is the need to review the developing world's contribution to global warming and the consequences of climate change in these regions with focus on Nigeria as a case study that has prompted these pertinent and their possible solutions:

1. What is the present climate situation in Nigeria and other developing countries?
2. What are the major limiting factors that exacerbate climate risks in these regions?
3. What are the impacts of climate change in these regions?
4. What efforts are these regions making to salvage the climate situation?
5. What are the research gap(s) in climate change studies in Nigeria and other developing countries?

3. Method

The search of databases was carried out by the authors. The search of articles was limited to the English language only. The search list included studies, grey literature and policy papers with relevant documents. The information sources included articles from Springer, PubMed, ResearchGate, Google Scholar and Social Sciences Abstracts from January 1990 to June 2019. Referenced sections of

the articles identified were used to find additional references not retrieved by the initial search engines. The following search terms were employed (text words and climate related subject headings): climate change or climate crisis and sustainable development, health impacts, tragedy of commons concept and community-based approaches to climate change in developing world (in low- and middle-income nations) and climate change in Nigeria. The search terms were reviewed and tested with an information specialist. Review articles were adopted using measures across climate change challenges, sustainable development concept and community-based approaches in developing and developed nations. All titles and abstracts were screened by AA, and the decision to include or exclude was recorded by both authors. Studies were managed by using a reference management software. The reviews particularly related to climate change in high-income countries were excluded. However, the focus of the study was on low- and middle-income nations in Asia and Africa with more emphasis on a highly populated West African sub-region (Nigeria). Data were extracted from papers on climate change and health impacts. Data was also extracted from related recent studies carried by the authors, and the study took a narrative synthesis of results in line with research objectives.

3.1 Global warming and climate situation in the developing world

Developed countries have been able to minimize the adverse effects of climate change due to some factors such as natural advantage, high adaptation techniques, high technology, mechanized agricultural system and wealth status. For example, countries such as Norway, New Zealand, Sweden, Finland and Denmark were found to be most prepared to adapt to climate change [29, 30].

However, a report by ND-GAIN [31] indicated that it will take more than 100 years for the world's poorest countries to reach the current adaptive capacity of higher-income OECD countries. Unfortunately, developing countries such as Nigeria have had major setbacks that have escalated climate change problems. Given the predictions made by climate change research organizations and scientific reports, there are increased frequency and intensity of climate change in developing countries, especially in parts of Asia and Africa. This vulnerability has led to several environmental impacts observed majorly as flooding, drought, food shortages, heat waves and health risks, among others [17]. **Table 1** summarizes these environmental impacts.

The future of developing countries in the face of a changing climate if appropriate actions are not quickly enforced will definitely be unbearable. Indeed, sub-Saharan Africa will be the most vulnerable region with poorly supplied infrastructure, the domestic per capita food production has declined by 10% in the last 20 years, and about 800 million people are poorly fed [33, 34]. Overtly, the prevailing crisis covering poor living and feeding conditions will be escalated further by the consequences of changing climate with prevalent issues of food insecurity and health risks.

Further, Podesta and Ogden [35] asserted that West Africa suffers the greatest losses due to climate change, with increases ranging between 36 and 44% of the losses for the entire continent and between 42 and 60% of agricultural regional GDP. IPCC [36] and Climate Change [37] predicted that glacier melt will increase flooding and rock avalanches and affect water resources in Tibet, India and Bangladesh. Bangladesh will be most affected because it both is low-lying and has about 13 million people and Dhaka's GDP per capita is the lowest of all the cities. This will affect its capacity to adapt to climate change [17].

UN-Habitat's [17] report further stated that more than a billion people could have water shortages by the 2050s. Southeast Asia, especially the heavily populated mega delta regions, will be at risk from flooding. Around 30% of Asia's coral reefs are likely to be lost in the next 30 years due to multiple stresses and climate change.

No	Environmental impacts	Socio-economic resources and sectors affected
1	Changes in rainfall patterns	Water resource settlements:
	Increased frequency and severity of: Floods Droughts Storms Heat waves Changes in growing seasons and regions	Agriculture and forestry Food security Human health Infrastructure (e.g. transport) Displacement of inhabitants and loss of livelihood
2	Changes in water quality and quantity	Coastal management
3	Sea level rise	Industry and energy
4	Glacial melt	Disaster response and recovery plans

Adapted from UK Parliament Publications [32].

Table 1.
Climate change impacts in the developing countries.

Damage to coastal cities will impact on tourism too. For instance, the coastal city of Mombasa, in Kenya, could lose 17% of its land, which will affect amenities and features that draw tourism. Changes in rainfall will increase diarrheal diseases mainly associated with floods and droughts and possibly increase malaria distribution [38].

By 2080, an increase of 5–8% of arid and semi-arid land is projected under a range of scenarios. Already by 2020, between 75 and 250 million people will be exposed to increased water stress due to climate change. Agricultural production, including access to food, is projected to be severely compromised. In some countries, yields from rain-fed agriculture could be reduced by up to 50%. Sea level rise will affect major cities in low-lying coastal areas, such as Alexandria, Cairo, Lomé, Cotonou, Lagos and Massawa [38]; Climate Change 2007 and [36]. Hence, developing countries are in dire need of sustainable measures for establishing a low-carbon region.

3.2 Factors responsible for climate change vulnerability in developing countries

Several studies and authors have provided a number of interrelated factors which are responsible for climate change vulnerability in developing countries. They are categorized as natural, human and inadequate infrastructures, poor urban planning, low level of adaptation capacity and inadequate preparedness [39–42]. UN-Habitat [17] reported that developing countries have lower adaptive capacity covering human, financial and other resources to adapt to the effects of climate change.

Natural factors have left most developing countries vulnerable such as the Democratic Republic of the Congo, Central African Republic, Eritrea, Burundi and Chad which are affected by climate change [31]. People living in vulnerable areas like deltas and semi-arid and coastal regions are equally vulnerable. More than 1 million people live in deltas, semi-arid lands glacier- and snowpack-dependent river basins in Africa and Asia, and the hot spot regions that are the most vulnerable to climate change [43]. **Table 2** showed some developing countries and their vulnerability and capability ranking in response to climate change. It showed that Uganda has the highest vulnerability index (160) and the lowest readiness capacity (36.9) to climate change.

Further, adequate housing and its associated facilities also contribute to the vulnerability of developing countries to climate change. According to UN-Habitat [17], around 30% of the urban population in developing regions was living in the slums in 2012, and this figure was over 60% in sub-Saharan Africa. Kampala in Uganda has been experiencing rapid urbanization and slum expansion as over 50%

Country	Vulnerability		Readiness		Overall	
	World rank	Score	World rank	Score	World rank	Score
Bangladesh	140	0.534	148	0.327	140	39.7
India	118	0.473	122	0.377	120	45.2
Nepal	128	0.495	115	0.393	122	44.9
Pakistan	115	0.469	142	0.341	126	43.6
Tajikistan	78	0.409	131	0.357	111	47.4
Burkina Faso	145	0.555	155	0.319	148	38.2
Ghana	124	0.484	102	0.442	108	47.9
Mali	164	0.604	138	0.348	156	37.2
Senegal	146	0.556	127	0.368	137	40.6
Ethiopia	144	0.553	146	0.330	145	38.9
Kenya	147	0.557	159	0.312	154	37.7
Tanzania	143	0.550	144	0.353	139	40.1
Uganda	156	0.573	159	0.312	160	36.9
Botswana	123	0.483	76	0.494	94	50.5
Namibia	141	0.547	99	0.445	122	44.9

Source: University of Notre Dame Global Adaptation Index [29].

Table 2.
Showing the measure of countries’ vulnerability and their capability to respond to climate change.

of its urban population live in slums [44]. These types of settlements are often built in areas that are more vulnerable to the effects of climate change because they are less expensive and poorly built with little capacity to resist events such as flooding.

In addition, developing countries have experienced growth that has been largely unplanned, uncontrolled and lacking adequate infrastructure, as most of these cities emerged without master plans [45]. Indeed, human and urban planning factors such as growth in population, poor governance, decaying infrastructure and lack of proper environmental planning and management exacerbated extreme weather incidents in Nigerian largest cities [46].

Okonkwo and Akanwa [47] affirmed that the underlying major causes that exacerbated flooding in urbanized cities such as Lagos, Kano, Ibadan and Anambra is the lack of sustainable urban designs complicated by improper refuse disposal, erecting of structures on flood plains, improper development of urban planning and infrastructure and other indiscriminate actions that interfere directly or indirectly with the free flow of water.

Table 3 showed African countries and their level of urban access to these basic infrastructures: sanitation, safe water and health. **Table 3** indicated that Benin had to be the least urban access to basic infrastructures, while South Africa had 99% in 2000 and Namibia had 100% in 2000 for sanitation and safe water infrastructures, respectively.

3.3 Global warming and climate change: the Nigerian case

The world population has continued to gallop coupled with urbanization trends [50] and has exploded from an estimated maximum of 15 million people in prehistory to the 7 billion humans today. About 70% of the world’s urban population lived

Country	Sanitation		Safe water		Health
	1990%	2000%	1900%	2000%	
Benin	46	46	NA	74	42
Burkina Faso	88	88	74	84	NA
Cameroun	99	99	76	82	NA
Comoros	98	98	97	98	NA
Cote d'Ivoire	78	NA	89	90	NA
Ghana	59	62	83	87	25
Guinea	94	94	72	72	25
Lesotho	NA	93	NA	98	NA
Madagascar	70	70	85	85	NA
Namibia	84	96	98	100	NA
Nigeria	77	85	78	81	67
Senegal	86	94	90	92	40
South Africa	NA	99	NA	92	NA
Togo	71	69	82	85	NA
Tanzania	97	98	80	80	93

Source: World Bank [48] African Development Indicators. NA = not available (adapted: [49]).

Table 3.
Percentage of urban population with access to some basic infrastructure in selected countries in sub-Saharan Africa.

in developing countries in 2010 [51]. Increasing and large population numbers with land densities make people aggressively dependent on available natural resources and the environment for survival, especially in developing countries like [52].

In 2017, Nigeria had a population of 190 million with 2.6% annual growth and GDP capita of 1.969 USD and ranked 139th globally [53]. Nigeria is projected to contribute 10% of the 2.2 billion increases in global population expected by 2050 [53]. The economy of Nigeria is mainly dependent on crude oil resources and rain-fed agriculture can have a huge influence on ecosystems and temperature trends and climate change impacts.

There has been provoking evidence of climate change in Nigeria with increase in the temperature trend since 1901. A study carried out by Odjugo [19] investigated the mean air temperature in Nigeria for 105 years covering between 1901 and 2005. He reported that the temperature increase for 105 years was 1.1°C and the mean air temperature in Nigeria was 26.6°C. This showed higher than the global mean temperature increase of 0.74°C recorded since 1860 which is the original date of inception for scientific temperature measurement [36, 54]. Also, NIMET [55] confirmed that there have been changes in Nigeria's climate as proven observations from 1941 to 2000 showed evidence of long-term temperature increase in most of the country. The most significant increases were recorded in the extreme northeast, extreme northwest and extreme southwest, where average temperatures rose by 1.4–1.9°C. The rising temperature trend showed an increase in temperature when averaged over the country from about 26.2°C in 1951 to about 27.6°C over the years.

Obviously, increasing temperature levels have been ignited by human activities globally and in Nigeria as well. There are several human actions that contribute to increased temperatures in Nigeria. With huge deposits of crude oil in the Niger Delta region, Nigeria accounts for roughly one sixth of worldwide gas-flaring nations and flares about 75% of her gas [56]. Other livelihood patterns such as the

clearing of forestland for firewood and wood charcoal, agriculture and commercial logging that have largely contributed to land-use emissions which account for 52% of our GHG production, with recent estimates showing that Nigeria is responsible for 490 million tonnes of GHG emissions (CO₂ equivalent) annually, just over 1% of global production. About 39% of this arises from land-use change and forestry, 33% from energy production (oil and gas extraction and the power sector), 14% from waste (incineration of municipal waste), 13% from agriculture and 2% from industry [5].

Further, apart from activities that emit GHG in Nigeria, there are also human actions that reduce carbon sinks; such as deforestation and agricultural production. They are means by which huge amounts of vegetation cover are lost. Satellite data has revealed that between 1987 and 2011, lowland, mangrove and freshwater forest areas in the Niger Delta have decreased by 15–40% [57]. Another satellite data and GIS study carried out by Akanwa et al. [2] affirmed that 402.855 ha of green cover have been lost in Ebonyi State, Nigeria, as a result of quarrying activities. The resultant loss of carbon sinks has been accompanied by significant loss in biodiversity and the ecosystem services they offer, both of which exacerbate global warming. Notably, if the present situation is unrestrained in Nigeria, there may be a crisis of temperature increase between the middle (2.5°C) and high (4.5°C) in the year 2100 [19].

The undeniable temperature increase in Nigeria has incited extreme weather consequences and impacts like increase in rainfall intensity, flooding, displacement of people, destruction of buildings, infrastructures, loss of lives, biodiversity loss, health risks, overflowing of farmlands and food shortages. In fact, there has been abnormal rainfall pattern and corresponding extreme events such as floods and drought since 1951–2015 [55]. Coastal cities in Nigeria like Port Harcourt, Yenagoa, Warri, Anambra and Calabar have experienced an increase in rainfall pattern observed by storm surges in recent times [33, 58, 59]. It was estimated that a metre rise in sea level will displace about 14 million people from the coastal areas of Nigeria [60].

Also, over 70% of Nigerian communities are agrarian, and their activities are rain controlled. Climate change which affects rainfall patterns and threatens livelihood with extreme weather events such as thunderstorms, heavy winds and floods could devastate farm lands, leading to crop failure [33]. Moreover, climate variations accentuate pest and crop disease spread which will potentially pose a threat to livestock and food security [61]. Notably, there have been some observable changes in agricultural production especially in the southern parts of Nigeria where farming activities normally start from March when the early wet season starts and farming normally kicks off. Recently, there are observed deviations in the commencement of agricultural activity, for instance, due to changes in the arrival of the wet season [55, 62, 63]. It is projected that Nigeria would experience yield decreases in cash crops of 5–40% by 2050 if no technological innovation in farming methods is implemented [33, 64, 65].

Nigeria has also experienced drought in the northern region whereby nomadic herders are moving southwards into the fertile Middle Belt to find suitable pastures for their livestock [26]. This has brought about ethnic clashes between the rural farmers and herdsmen. The shrinking of Lake Chad basin is indicative of climate change's footprint in the Sahel region. Odjugo and Ikhuoria [66] also observed that Nigeria North of 12° N is under severe threat of desert encroachment and sand dunes are now common features of desertification in states such as Yobe, Borno, Sokoto, Jigawa and Katsina. This has prompted massive emigration and resettlement of people to areas less threatened by desertification, thereby creating crisis elsewhere.

Notably, there are resultant health risks influenced by high temperatures and stagnant water from flooding. This leads to high incidence of the spread of malaria, water-borne diseases and the transmission of contagious diseases such as cholera and influenza. This has resulted in deaths, sickness and injuries due to increased exposure to heat waves [7, 67, 68].

The above stated impacts cuts across agriculture/forestry, water shortage, food security, biodiversity, infrastructure, human and animal life, drought, human health and livelihoods. Indeed, climate change affects a vast, if not the entire sphere of our environment and human existence. Further, seven countries are predicted to suffer the largest average losses in the agricultural sector with Nigeria suffering the highest in the group [35].

Developing countries like Nigeria depend solely on natural resource harvesting and agriculture and these activities are easily affected by climate change. Considering that the presently, Nigeria's economy is affected due to these aforementioned impacts and future predictions continue to reveal a projected severe economic effect of climate change in Nigeria with a rise in sea level from 1990 level to 0.3 m by 2020 and 1 m by 2050 and rise in temperature of up to 3.2°C by 2050 following a drastic climate change [69]. Ultimately, climate change impacts could result in a loss in GDP of between 6 and 30% by 2050, worth an estimated US\$100–460 billion dollars. By 2020, if no adaptation is implemented, between 2 and 11% of Nigeria's GDP could potentially be lost [5, 70, 71].

3.4 The Nigerian response to climate change

In addition, Nigeria adopted its Climate Change Policy Response and Strategy (CCPRS) in 2012 to ensure an effective national response to the multi-faceted impacts of climate change. The main goals of the CCPRS include implementation of mitigation measures that will promote low-carbon as well as sustainable and high economic growth; enhancement of national capacity to adapt to climate change; raising climate change-related science, technology and research; and many more. The National Adaptation Strategy and Plan of Action for Climate Change in Nigeria (NASPA-CCN) have been developed and describes the adaptation priorities. According to the NASPA [72] report, the programme will enable federal, state and local governments, civil society, the private sector and various agencies and institutions to effectively integrate climate change adaptation concern into their development policies and programmes such as water and other natural resource, agriculture, health and infrastructure. NASPA will give priority to community-level input as an important source of information, recognizing that grassroots communities are key stakeholders and providing a voice to the most vulnerable (including women and youth), ensuring that everyone is represented in the plan [46, 72]. The actualization of this strategy will depend heavily on our ability to respond to the prevailing climate change effects as a nation and our survival instinct to protect our future.

In conclusion, these strategies should be simple, strategic, concise and applicable so that these developments can be the foundation of technological and policy innovation that can minimize GHG and achieve a low-carbon growth in developing countries. Also, it is necessary to create maximum awareness of the total environment, share its concern and have a collective goal towards providing sustainable solutions and equitable developments. Nevertheless, the Global South should focus on the reality of adapting to climate change by finding ways to live with overflowing sea levels, scarce drinking water, higher peak temperatures, depleting species and agriculture altering weather patterns, health risks and poorer food production [73].

3.5 Mitigation and adaptation strategies for minimizing climate change in developing regions

UNFCCC have already identified two ways to address climate change: first through mitigation of climate change by reducing greenhouse gas emissions and enhancing sinks and secondly through adaptation to the impacts of climate change. Mitigation comprises all human activities aimed at reducing the emissions or enhancing sinks of greenhouse gases such as carbon dioxide, methane and nitrous oxide [74, 75]. **Table 4** summarizes areas that require mitigation and the corresponding activity-solutions to enhance the carbon sinks.

Adaptation in the context of climate change refers to any adjustments that take place in natural or human systems in response to actual or expected climatic stimuli or their effects or impacts, aimed at moderating harm or exploiting beneficial opportunities [7, 74].

Areas	Activities
Demand-side, brownfield energy efficiency	Commercial and residential sectors (buildings) Public services Agriculture Industry
Demand-side, greenfield energy efficiency	Construction of new buildings
Supply-side, brownfield energy efficiency	Transmission and distribution systems Power plants
Renewable energy	Electricity generation, greenfield projects Transmission systems, greenfield Heat production, greenfield or brownfield projects
Transport	Vehicle energy efficiency fleet retrofit Urban transport modal change Urban development Interurban transport and freight transport
Agriculture, forestry and land use	Afforestation and reforestation Reducing emissions from the deforestation or degradation of ecosystems Sustainable forest management Agriculture Livestock Biofuels
Waste and wastewater	Solid waste management Wastewater treatment Waste recycling
Non-energy GHG reductions	Industrial processes Air conditioning and cooling Fugitive emissions and carbon capture
Cross-sector activities	Policy and regulation Energy audits Supply chain Financing instruments Low-carbon technologies Activities with greenhouse gas accounting

Source: Ref. [76].

Table 4.
Typology of mitigation activities.

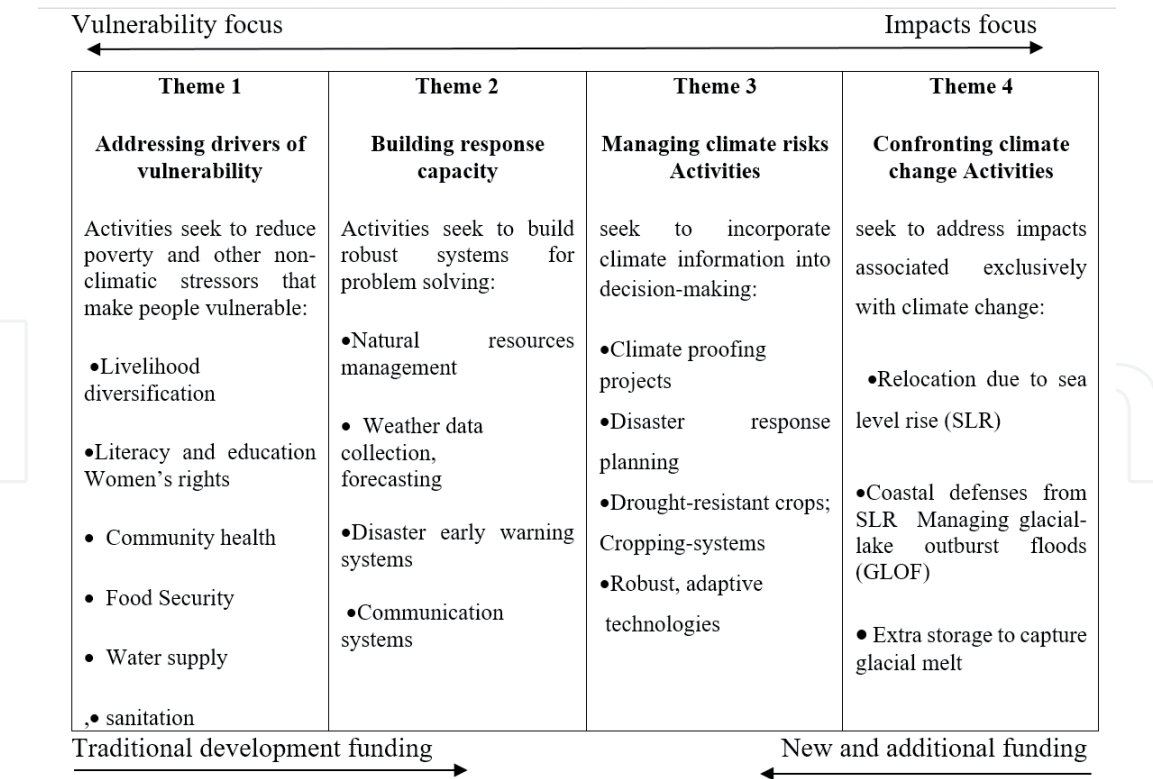


Figure 1.
The continuum of adaptation activities from development to climate change vulnerability focus. Source: Adapted from Ref. [77].

McGray et al. [77] showed in their diagram the adaptation and development as an option for dealing with limitations faced by developing countries whereby their development needs or vulnerabilities can be dealt with in order, not to sabotage the adaptation techniques applied. **Figure 1** showed themes 1 and 2 and also showed that unmet development needs (as manifest in poverty or weak institutional capacities) drive vulnerability, including vulnerability to climate change. Such development needs need to be addressed to ascertain that adaptation activities (as in themes 3 and 4) can be effective and sustained. From this perspective, a separation of development from adaptation may in fact be counterproductive to the ultimate goal of achieving climate resilience.

Generally, developing countries and their cities have lower emissions, but there is limited data, and GHG emission levels vary from place to place. There are three sectors that give the highest GHG emissions; they are residential, commercial and transportation. Hence, developing countries can have good planning practices and climate-smart practices around these sectors [17]. They can implement adaptive strategies such as urban greening and farming in order to contribute to carbon sequestration [3, 4]. Urban vegetation, such as trees, can store carbon, provide shade for buildings and reduce air and noise pollution in cities. Urban farming also provides green spaces and carbon sequestration benefits by reducing the urban heat island effect. It can have a positive impact on food security and reduce urban poverty [3]. Green spaces such as roofs and parks bring ecological and social benefits to urban areas. Green roofs can improve drainage of rainwater and thus reduce rainwater run-off in case of extreme weather events [78–81].

Green spaces and public green areas, such as parks, improve the quality of the social life urban dwellers by creating integration and accessibility [82–88].

Also, developing countries can incorporate sustainable urban designs and construction by making use of robust materials for buildings or locating buildings at high or more stable grounds. These approaches could be ad hoc which involves taking

opportunity of a crisis situation. For instance, in Mozambique in 2010, its city Maputo was severely flooded, and the “Living with Flood” initiative took up the project of building schools and community halls that would serve as shelter during future floods [17]. In Nigeria, for example, an energy efficient transport system can be introduced to minimize the high levels of carbon monoxide emitted into the atmosphere.

An ad hoc approach could require partnering with environment- or health-based NGOs to solve a problem. Nigeria has received support from the WHO on water, erosion and drainage projects, among others. Another example is the City of São Paulo; it entered into agreements with the Brazilian company Biogás. Biogás constructed facilities at two landfill sites for a total investment of US\$ 90 million. At the Bandeirantes site, a system captures the methane gas and channels it into a combined heat and power plant. The two landfills together now generate 10% of the city’s electricity requirements. To date, the credits generated by reduced emissions have yielded some 48 million Euros, which the city splits 50/50 with Biogás. The City Council of São Paulo has used its share of the revenues to develop parks and squares in the poor neighbourhoods surrounding these landfills [17]. The challenge was that the 10 million inhabitants generated 15,000 tonnes of garbage daily, and harnessing methane gas was an asset, while reducing GHG emission and improving livelihood were expedient.

Also, developing cities can have specific plans with an implementation strategy. For example, an action plan has been adapted by Cape Town in South Africa for energy and climate change, which has (11) objectives and targets. One of the targets is 10% renewable and cleaner energy supply in 2020. Another plan is to build more compact and resilient-efficient city. The implementation of the plan involved more than 115 projects. Mitigation approach could also be achieved through incorporating climate change into existing plans, policies and programmes, for example, transport, public health, energy management and disaster risk reduction plan. For example, Cambodia’s coastal city of Preah Sihanouk is planning for climate change by mainstreaming into existing planning process [17].

Generally, most developing countries have begun to develop alternative policy frameworks, for example, through national adaptation programmes. These have focused on climate-proofing infrastructure projects, such as transport and irrigation systems, improved disaster monitoring and management and better land-use planning [89]. For instance, the Bangladesh Climate Change Strategy and Action, adopted by the government of Bangladesh in 2009, seeks to guide activities and programmes related to climate change in Bangladesh. The strategy contains 44 programmes formulated around six themes which include food security/social protection/health, comprehensive disaster management, mitigation/low-carbon development and capacity/institutional strengthening. Thirty-four programmes listed under five themes are wholly or partially focused on adaptation [48]. Adaptation measures are also incorporated into disaster preparedness in Bangladesh. Furthermore, Orindi and Murray [90] acknowledged the progress being made in East Africa on integrating adaptation into the most vulnerable sectors. This is also similar in other African countries such as Tanzania, Uganda and Sudan in their national communication to the UNFCCC.

The mitigation and adaptation strategies enumerated above surmises the UN climate speech of 2017, by the UN Climate Change Executive Secretary, Patricia Espinosa. She called for a more holistic view of health throughout the world, with an inclusion of the concept of planetary health, a re-establishment that there is an intricate connection of the health of humankind to the right condition of the overall environment and other living beings. The Rockefeller-Lancet commission defined planetary health as the health of human civilization and the state of the natural systems on which it depends [91]. Planetary health is a new and emerging field

across disciplines intersecting physical/natural sciences and the health of human. In addition, planetary health is acceptable by international organization, the global north universities, countries and their NGO actors, due to the input of sustainable environmental interventions. However, there is need for the inclusion of developing nations in this new emerging concept. The impacts of climate change in developing nations reveals an ominous threat to the health of the citizenry and the health of the natural systems which they depend.

We have used and abused our natural resources with negative impacts to the populace. We see diseases, food insecurity, poverty, hunger and malnutrition with high risks of vitamin deficiencies. Hence a basic and introductory thrust on which planetary health lies is the innovative and transformative actions for integrative approach to further develop an evidence base to inform solutions that simultaneously address human health, environmental sustainability and economic development [92], in essence, one that directly connects human and animal health with the health of the planet [93] so as to improve the lives of individuals, families and communities in Nigeria and beyond

5. Conclusion

Generally, this study assessed the local and regional contributions of Nigeria and other developing countries to global warming and the resulting consequences of climate change. Findings from the study showed that the impacts of climate change in developing countries include loss in agriculture/forestry resources, water shortage, food insecurity, biodiversity loss, infrastructure damage, loss of human and animal life, drought and health and livelihoods risks. Also, certain factors that were highlighted such as rapid urbanization, poor urban design, inadequate infrastructure, inadequate meteorological information, poor awareness and low levels of literacy combined with human actions such as industrialization, gas flaring, burning of fossil fuels and agricultural practices have immensely escalate climate change-related disasters. These have affected the socio-economic sectors of Nigeria and other developing countries made towards adaptation, adjustment and resilience in Africa.

These issues of global warming are real, and the myriad of limitations faced by developing countries show huge potentials that may totally collapse the economic, social and environmental processes of developing countries particularly in the area of agriculture, tourism and natural resource if sustainable actions are not quickly implemented. Africa battles with data documentation and monitoring systems and the known levels of GHG emitted, moreover, the human health implications cannot be properly accounted for. Hence, Nigeria and other developing countries can become part of planetary health approaches and alliances for sustainable development and safe public health presently adopted in institutions of global North. As Planetary health looks at the health of human civilization and the state of the natural systems on which they depend (Seltenrich, [91]). Though an emerging, multidisciplinary, cross-sectoral concept within borders, planetary health reverts attention to the anthropogenic degradation of our planet with potential to sustainable environmental solutions for the climatic plague of humanity.

Finally, this study advocates an applicable mitigation and adaptation option that is tailored to each developing country's peculiar socio-economic and environmental challenges. The need for community based participatory approaches with population groups that are more disproportionately burdened from the impact of climate change is critical in Nigeria as well as developing countries. It is obvious that community academic partnerships that are wholly driven based on community needs are necessary at this time of climate emergencies in Nigeria. Though community

driven partnerships are of high financial inputs, however, the impacts may come with health and social generated equities. We do know that climate change is an example of a complex problem with multi sectoral and interdisciplinary perspectives. Community oriented interventions have reached a critical level in developing countries especially Nigeria. Though one may argue about the level of built capacity of Nigeria academic in community-based research in climate change, the need for international organizations and universities to ally with local communities and academic can bring on positive outcomes for Nigeria. This can be achieved through ad hoc, strategic research and mainstreaming actions and into plans, projects and programmes on different sectors such as proffering of landscape planning, greening, urban farming, environmental with health interventions and awareness and implementation of holistic protective laws and policies as effective approaches. It also suggests that developing nations can take advantage of their situation and stand together by forming networks to act on climate change. They can make emissions reduction commitments, evaluate adaptation strategies and advocate for national and international financial support from research evidence. This way developing nations can adapt to climate change comfortably and create a resilient environment and climate-proof socio-economic systems.

Author details

Angela Oyilieze Akanwa^{1*} and Ngozi Joe-Ikechebelu²

1 Department of Environmental Management, Chukwuemeka Odumegwu Ojukwu University, (COOU), Uli Campus, Anambra State, Nigeria

2 Department of Community Medicine/Primary Health Care, Chukwuemeka Odumegwu University, Amaku-Awka Campus, Anambra State, Nigeria

*Address all correspondence to: angela.akanwa1@gmail.com

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