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Adaptation to Climate Change Vulnerabilities

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Abstract
This paper revealed that increased human population and industrialisation have aggravated vulnerabilities to climate change consequences like flooding, drought and desertification among others. It also emphasised that climate change poses a global existential challenge. The basic concepts of climate change such as vulnerability, adaptation and mitigation were discussed. Existing climate change protocols originating from various United Nations facilitated meetings and future action plans such as low carbon emissions and adoption of cleaner technologies were highlighted. Recommendations were made among others that mitigation and adaptation to climate change be part of the key objectives of government at all levels, local to national.

Adaptation aux Vulnérabilités aux Changements Climatiques

Résumé
Cet article a montré que la population humaine et l'industrialisation ont aggravé les vulnérabilités aux conséquences du changement climatique comme les inondations, la sécheresse et la désertification, entre autres. Il a également souligné que le changement climatique posait un défi existentiel mondial. Les concepts de base du changement climatique tels que la vulnérabilité, l'adaptation et l'atténuation ont été discutés. Les protocoles existants sur les changements climatiques émanant de diverses réunions facilitées par les Nations Unies et de futurs plans d'action tels que les émissions à faible émission de carbone et l'adoption de technologies plus propres ont été mis en évidence. Des recommandations ont été faites, entre autres, selon lesquelles l'atténuation et l'adaptation au changement climatique font partie des objectifs clés du gouvernement à tous les niveaux, du niveau local au niveau national.

Introduction

Air pollution is the world's worst environmental risk, chiefly because of the uncontrolled emission of greenhouse gases (GHGs). The major GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride). The fluorinated

gases are largely substitutes for chlorofluorocarbons (CFCs), the principal ozone depleting substances (ODS) (Liu *et al.,* 2014; Okedeyi *et al.,* 2013; Lee, 2009).

The generation of energy from nuclear power stations avoids these emissions, but it carries its own health risks and presents serious problem of disposal of radioactive wastes (Lee, 2009). Alternative sources of renewable energy such as, solar, wind, hydroelectric and geothermal power put far less pressure on the environment. However, they have attracted the least global attention which to a large extent, can be attributed to technological limitations (Watanabe, 2009; Heck *et al.,* 2009).

Extreme events of climate resulting in changes in regional and global biogeochemical cycles, loss of major ice sheets and land cover, and the shutdown of the meridional overturning circulation (changes in ocean circulation due largely to deglaciation) are of concern (Singh et al., 2017; Mossler *et al.,* 2017; Raven *et al.,* 2008; McManus *et al.,* 2004).

Ultimately, extreme events of climate change impacts negatively on ecosystem productivity. Climate change consequences, like flooding, drought, desertification, coastal erosion arising from global warming stares humanity in the face. The time is ripe to match words and plans with action to avert the looming crisis. The last six annual Climate Change Conferences held in Durban, 2011; Doha, 2012; Warsaw, 2013; and New York, 2014; Paris, 2015; Marrakesh, 2016 respectively brought to the fore the debilitating effects of climate change and the uncoordinated global efforts in addressing this scourge (EEA, 2016; UNEP, 2014; UNFCCC, 2014).

After the "Only One Earth" summit of 1972 in Stockholm, Sweden and the celebrated Rio de Janeiro, Brazil Earth Summit in 1992, subtitled "Our Last Chance to Save the Earth" to the most recent "Low Carbon Earth Summit", held in November 2016 in Qingdao, China (LCES, 2016), the United Nations Environment Program (UNEP) has continued to make concerted effort in galvanizing world leaders and experts, to address issues concerning global warming in a sustainable and apolitical manner (Lesnikowski *et al.,* 2017; Mossler *et al.,* 2017).

Today's global population is projected to be 9 billion by 2050 and 10 billion by 2100, with more people living in cities than ever before (UNDESA, 2015). The need for accelerated action on mitigating climate change vulnerabilities cannot be over emphasized (Singh *et al.,* 2017; Sherman *et al.,* 2016; Austin *et al.,* 2015).

Greenhouse Effect and Global Warming

The Greenhouse Effect: The mean temperature of the earth is around 15 °C, compared to the -18 °C it would be if the earth had no atmosphere. The effect of the atmosphere producing earth temperatures that can sustain life, constitutes the natural greenhouse effect. Incoming short-wave radiation from the sun passes through the atmosphere to the earth's surface from which it is radiated back at longer wavelengths. Certain 'greenhouse gases' in the atmosphere selectively absorb radiation at these longer wavelengths, effectively 'trapping' it. The radiation is repeatedly absorbed and re-emitted by gas molecules until some is ultimately lost to space and some reach the earth, where its energy warms the surface (USNOAA, 2017; UNEP, 2014).

Greenhouse gases: Although nitrogen and oxygen make up about 99 % of the atmosphere, it is other gases, present in trace amounts, which act as GHGs. Rice production in flooded fields prevents atmospheric oxygen from entering the soil, when rice is grown with no oxygen, soil organic matter decomposes under anaerobic conditions and produce methane (UNEP, 2014; Lee, 2009).

CH_4 and CO_2 are also released during gas, oil and coal exploitation and from burning and decay of biomass. The fluorinated gases are largely from anthropogenic sources (USEPA, 2010; Lee, 2009; Raven et al., 2008).

Global warming: As concentrations of GHGs increase in the atmosphere as a result of anthropogenic emissions, the natural greenhouse effect is enhanced, accelerating the warming of the earth's surface. According to data obtained from the National Climatic Data Centre of USNOAA (United States National Oceanic and Atmospheric Administration), the average global

land and ocean surface temperature for January–March 2017 was 0.97°C (1.75°F) above the 20th century average of 12.3°C (54.1°F)—the second highest global land and ocean temperature for January–March in the 1880 –2017 record, behind 2016 by 0.18°C (0.32°F), but 0.15°C (0.27°F) higher than 2015 (USNOAA, 2017).

Concepts of Climate Change

There are three important concepts associated with climate change; these are vulnerability, adaptation and mitigation (UNEP, 2014, Mertz *et al.,* 2009).

Vulnerability: This is the combined measure of threats to a particular system. It is also the degree to which a system is unable to cope with the adverse effects of climate change. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed; its sensitivity, and adaptive capacity.

Adaptation: It's the ability of a system to adjust to climate change so as to reduce vulnerability and enhance its resilience to observed and anticipated impacts of climate change. It involves changes in social and environmental processes, perception of climatic risk, practices and functions to reduce risk as well as the exploration of new opportunities to cope with the changed environment (UNEP, 2014). The severity of an event in any system depends on the coping and resilience ranges. Without adaptation measures, coping range and resilience range shrink while failure range widens. Whereas, with adaptation measures in place, coping and resilience ranges increase and failure range decreases. Consequently, a system with adaptation measures is resilient to damage in case a severe climate change takes place. A UNEP study of Bangladesh, a nation of about 140 million people is an important case study. Cyclones, floods and droughts have been part of the country's history and have intensified in recent years. As a result of the long exposure to these hazards, the country has developed a robust adaptation strategy over time. Bangladesh spends close to 7% of its annual budget on climate change adaptation and mitigation (UNEP, 2014).

Mitigation: Mitigation is any strategy or action taken to prevent or reduce GHGs emissions. Nevertheless, IPCC defines mitigation as, "technological change and substitution that reduce resource inputs and emission per unit of output with respect to climate change, it means implementing policies to reduce GHGs emissions and enhance sinks" (Van Aelst and Holvoet, 2017; IPCC, 2007). It is imperative to design mitigation strategies in ways that help to ensure sustainable development. A number of voluntary initiatives are being implemented to reduce GHGs emissions. These include CSLF (Carbon Sequestration Leadership Forum), which promotes carbon capture and storage; the Methane to Markets Partnership (MPP), which seeks to capture and utilize methane gas, and the Asia-Pacific Partnership for Clean Development and Climate (IPCC, 2007). These efforts, however remain uncoordinated because of lack of institutional commitments, a gap which the 2015 Paris Agreement seeks to bridge (Lesnikowski *et al.,* 2017).

Adaptation and mitigation are complementary to each other. For example, if mitigation measures are undertaken effectively, lesser will be the impacts to which we will need to adapt. Similarly, if adaptation measures (or the degree of preparedness) are strong, lesser might be the impacts associated with any given degree of climate change (Raven et al., 2008; IPCC, 2007).

Effects of Global Climate Change

Flood and Drought: Severe flooding, harsh winters, heat waves, coastal erosion, desertification and drought are some of the direct consequences of climate change. Incidences of collapsed buildings, bridges, roads and oil pipelines in cities resulting from unusual heavy rainfall events and violent winds have been recorded in cities across the developed and developing countries. In Lagos, the Bar beach is now very close to Ahmadu Bello Way in Victoria Island, whereas some twenty years or more ago, one could only access the beach from Ahmadu Bello after a few meters walk(Sunday and John, 2006). Marked reduction in the original size of Lake Chad has been reported (Magrin, 2016). Reports have it that some villages and

farmlands have been taken over by flood waters in the banks of Rivers Niger and Benue. There are communities in the Lagos/Ogun axis that are perennially under flood water. The Peruvian Amazon in Peru, Athens, Greece and Buenos Aires, Argentina among others recently suffered severe flooding (Sherman *et al.*, 2016; Coe *et al.,* 2012).

Food Security: The rise in sea level has caused water to inundate river deltas which are some of the world's best agricultural lands, resulting in reduced farm yields, and the propagation of mutant agricultural pests. Severe droughts in large swathes of land are also some of the consequences of climate change. Climate-induced changes to agriculture requires, cultural, economic and infrastructure adaptation. The extent to which such adaptation can keep pace with climate change is uncertain and the threat to global food security is real (Sherman *et al.,* 2016; Mertz *et al.,* 2009; Acemoglo *et al.,* 2006).

Impact on Organisms: Measurable changes in the biology of plant and animal species are now common occurrence. Such effects range from earlier flowering times for plant species to migration of aquatic animals. Even among humans, the phenomenal increase in number of internally displaced citizens and migrants may have been aggravated by extreme weather conditions which exacerbate vulnerabilities (Austin *et al.,* 2015; Liu *et al.,* 2014; Raven *et al.,* 2008).

The Impact of Poverty and Ignorance on Climate Change

Poverty and environmental degradation are birds of the same feather. Consequently, poor and ignorant communities continue to adopt maladaptive practices that are antithetical to sustainable adaptive and mitigative frameworks. These ultimately increase vulnerabilities and worsen climate change consequences. Some of such maladaptive practices are, indiscriminate felling of trees for firewood and charcoal, overgrazing, petroleum pipeline vandalisation and operation of illegal refineries, poor waste management, especially usage of open dumpsites with constant burning of solid waste materials (Coe *et al.,* 2012; Adeniyi *et al.,* 2008; Kambewa *et al.,* 2007).

Polluting industries often target economically poorer communities where unemployment is high. Companies are therefore in a vantage position to recruit workforce willing to live and work in environmental poor conditions with risks to pollution incidents and high GHGs emission. For political reasons, governments look the other way and are reluctant to enforce extant environmental legislations. Tackling poverty in a sustainable manner, alongside evolving proper environmental education policies would go a long way in reducing climate change vulnerabilities. (Van Aelst and Holvoet, 2017; Acemoglo *et al.,* 2006).

Clean Technologies

These are diverse range of products aimed at harnessing renewable non-fossil materials and energy sources. It also entails the trapping, storage and utilisation of greenhouse gases. Investments in clean technologies particularly wind, hydro, solar and biofuels (especially ethanol from sugar cane) have grown considerably in recent years. The synthesis of appropriate zeolites and related micro-porous materials for trapping carbon dioxide and methane in commercial scale are part of the emerging clean technologies. Adopting cleaner technologies have the potential to enhance climate change mitigation endeavours (Johnson and Bartidziria, 2012; Eggleston, 2010; Heck *et al.,* 2009; Watanabe, 2009; IPCC, 2007).

Existing Climate Change Agreements and Future Action Plan

The Kyoto, Japan protocol of 1997 was the first global climate change pact. It is an international agreement linked to the United Nations Framework Convention on Climate Change. This agreement commits its parties by setting internationally binding emission reduction targets. However, this protocol placed a heavier burden on developed nations under the principle

of 'common but differentiated responsibilities'. The detailed rules for the implementation of the protocol were adopted in Marrakesh, Morocco in 2001 referred to as the 'Marrakesh Accords'. Its first commitment period started in 2008 and ended in 2012 (UNEP, 2014). The Doha, Qatar, conference of December, 2012 amended some features of the Kyoto protocol to address some concerns raised about emission levels particularly by the industrialised nations. This opened a new vista for a second commitment period from January 1st 2013 to December 31st 2020.

The 2015 Paris agreement takes a significant step forward in strengthening the adaptation pillar of global climate policy. However, the challenge for parties in implementing the Paris agreement will be to establish credible commitments from state and non-state actors with regard to adaptation planning, implementation and financing (Lesnikowski *et al.,* 2017; Mossler *et al.,* 2017).

Conclusion

From this review, it is evident that, reduction in greenhouse gases emissions through monitoring and enforcement mechanisms by the United Nations as embedded in the 2015 Paris agreement are imperative in reducing vulnerabilities. Also, adaptive and mitigative actions are expected to yield positive results in reducing the adverse effects of global warming. Governments at all levels are equally enjoined to be proactive in addressing issues of climate change and its attendant consequences. The restorations of global temperature to a relatively acceptable level, that will benefit humanity and the natural systems sustainably, remain a key target in the overall reduction of vulnerabilities.

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