The Role of Engineers in Combating the Effect of Climate Change in Africa

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ABSTRACT: *This paper presents an overview of the effects of global warming in Africa as it affects our environment. The challenges of climate change were discussed. The paper focuses further on future climate change and variability and their impact on key sectors: water, food security and agriculture, health, and biodiversity and ecosystems. Finally, the paper summarizes the role of engineers in combating climate change, in a bid to control and reduce global warming around the world.*

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INTRODUCTION

Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location; weather refers to the day-to-day fluctuations in these conditions at the same location. The variables that are commonly used by meteorologists to measure daily weather phenomena are air temperature, precipitation (e.g., rain, sleet, snow and hail), atmospheric pressure and humidity, wind, and sunshine and cloud cover. When these weather phenomena are measured systematically at a specific location over several years, a record of observations is accumulated from which averages, ranges, maximums and minimums for each variable can be computed, along with the frequency and duration of more extreme events (Food and Agriculture Organization of the United States, 2008).

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions, or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). Climate change is caused by factors that include oceanic processes (such as oceanic circulation), variations in solar radiation received by earth, plate tectonic and volcanic eruptions, and human-induced alterations of the natural world; these latter effects are currently causing global warming, and "climate change" is often used to describe human-specific impacts.

Naturally, climate does change but not noticeable except for over a long period of years. What gives one concern about the climate change is the alarming rate at which human activities influence climate pattern (Sanni and Olanade 2010). Scientific evidence that humans were changing the climate first emerged in the international public arena in 1979 at the First World

Climate Conference (Depledge & Lamb 2005). At this time when the effects of human-induced climate change were first discovered, the changes were so small that it didn't seem like a big issue. But by 1988 when the Intergovernmental Panel Climate Change (IPCC) was formed the dangerous consequences of climate change were becoming clear (Sanni and Olanade, 2010).

Africa is one of the most vulnerable continents to climate change. This situation is further worsened by its poor state of economic development and low adaptive capacity. Extreme poverty, frequent natural disasters such as droughts and floods, and heavy dependence of agriculture on rainfall further increases the continent's vulnerability (Know, 2013).

Climate change refers to an increase in average global temperatures. Natural events and human activities are believed to be contributing to an increase in average global temperatures. This is caused primarily by increases in greenhouse gases such as Carbon Dioxide (CO_2). Nigeria is experiencing adverse climate conditions with negative impacts on the welfare of millions of people. Persistent droughts and flooding, off season rains and dry spells have sent growing seasons out of orbit, on a country dependent on a rain fed agriculture. Alarm bells are ringing with lakes drying up and a reduction in river flow in the arid and semi-arid region. The result is fewer water supplies for use in agriculture, hydro power generation and other users. The main suspect for all this havoc is Climate Change. Scientific studies show snows are disappearing rapidly. Climate Change has been confirmed following release of the 4th IPCC Assessment report. Africa will be worst hit by the effects of Climate Change which Nigeria is part of it (Nasiru, 2011). The Working Group I contribution to the IPCC Fourth Assessment Report describes progress in understanding of the human and natural drivers of climate change, observed climate change, climate processes and attribution, and estimates of projected future climate change. It builds upon past IPCC assessments and incorporates new findings from the past six years of research. Scientific progress since the Third Assessment Report (TAR) is based upon large amounts of new and more comprehensive data, more sophisticated analyses of data, improvements in understanding of processes and their simulation in models and more extensive exploration of uncertainty ranges.

The agricultural sector contributes some percentage of the Nigerian Gross National Product and majority of the rural populace are employed in this sector. The dominant role of agriculture makes it obvious that even minor climate deteriorations can cause devastating socioeconomic consequences. Policies to curb the climate change by reducing the consumption of fossil fuels like oil, gas or carbon, have significant economic impacts on the producers or rather the suppliers of these fuels. Nigeria is the eighth largest oil supplier in the world and the ninth largest deposits of gas. The Nigerian national economy would be massively affected by a sustainable reduction of fossil energy consumption. Nigeria is practically a monoculture: about 80% of the government

income, 90-95% of the export earnings and more than 90% of the foreign exchange revenues evolve from the oil sector. However, during the last years the government of Nigeria tried to diversify. Special attention is nowadays paid to gas which emerges in the joint-production of oil. So far the gas has mainly been flared (75%), simply due to the lack of technical facilities to make use of it (Nasiru, 2011).

A study commissioned by the World Bank in 2007 Nigeria accounts for roughly one-sixth of the world-wide gas flaring which in turn spews some 400 million tons of carbon dioxide into the atmosphere. However, the World Bank survey has listed Nigeria and 15 other oil producers, as countries that have progressively reduced gas flaring. Following the Kyoto-Protocol is a double-edged sword for Nigeria: The probably positive long term effects on the climate change are opposed to the negative short term effects for the economic development. Observing the Kyoto-Protocol would reduce the income of the OPEC – States, amongst them Nigeria, about 25% until 2010. This would be a catastrophe for the Nigerian development plan.

With this emerging global warming, the engineers have a lot to contribute in combating climate change. First and foremost, he must keep the level of environmental pollution to an absolute minimum in improving the present state of technology. The engineer is best equipped for this challenge because he has an improved ability to anticipate and understand the consequences of technological hazard and environmental impacts of engineering activities and the ways to reduce harmful effects of engineering upon the environment.

THE PROBLEM OF CLIMATE CHANGE

Factory farming intensifies climate change, releasing vast volumes of greenhouse gases. We now know that man-made climate change is real and that it poses a great threat to the planet and its inhabitants. Current data suggest that we need to reduce greenhouse-gas emissions in developed countries by at least 80% by 2050 in order to have a chance of staying below an average temperature rise of over 2ºC. Factory farming is a major contributor to the climate change challenge, releasing vast volumes of greenhouse gases.

Factory farming produces greenhouse gases throughout the 'supply chain'; for example, forest clearance to grow the crops and rear the animals reduces vital carbon 'sinks' and releases gases previously stored in the soil and vegetation.

Factory farming also requires large amounts of energy in order to function. This isn't just to rear the animals, but also to grow the vast amounts of feed they need. According to a study published by The Royal Society, (Woods et al., 2010) feed is the dominant energy user, taking around 75% of the total energy required. The rest is needed for factors such as heating, lighting and ventilation. Livestock farming accounts for around 18% of our global greenhouse gas emissions - more than the global transport sector (UNFAO, 2006).

It's not just carbon dioxide that's the problem - gases including methane and nitrous oxide are also produced in significant quantities, released through various sources including animal waste and fertilizer use. Livestock farming produces 37% and 65% of our global methane and

nitrous oxide emissions respectively. Both gases are much more potent than carbon dioxide. Methane and nitrous oxide are 25 times and 298 times more potent than carbon dioxide respectively in terms of their potential to intensify global warming (IPCC, 2007).

Climate change is already harming food production[7] and these impacts are projected to increase over time, with potentially devastating effects. Higher temperatures, for example, could place further stress on water-scarce regions and make it harder to rear animals and grow food crops. According to the Convention on Biological Diversity climate change may affect plant growth and production by promoting the spread of pests and diseases, increasing exposure to heat stress and encouraging soil erosion due to stronger winds. Added heat stress, shifting monsoons, and drier soils may reduce yields by as much as a third in the tropics and subtropics, where crops are already near their maximum heat tolerance.

KEY IMPACT OF CLIMATE CHANGE IN AFRICA

The Third Assessment Report (TAR) of the IPCC (IPCC, 2001) highlights major issues related to potential impacts that could occur as a result of climate change in Africa. It also underlined the fact that Africa is characterized by a low adaptive capacity. Major areas of concern addressed in the TAR regarding the possible impacts of climate change relate to water resources and food security/agriculture, including changes in: precipitation and insulation, length of growing seasons, water availability, carbon uptake, incidences of extreme weather events, changes in flood risks, desertification, distribution and prevalence of human diseases and plant pests (UNFCCC, 2006). The report also revealed that the impact of increased temperature and reduced precipitation in some regions resulting from climate change could lead to overall reduction in agricultural productivity and yields, including rangeland and livestock production, threatening food security and heightening the risk of famine.

- **Observed changes**

Records shows that, a warming of approximately 0.7°C over most of the continent during the 20th century is reported in the Third Assessment Report (TAR) of the Intergovernmental Panel Climate Change (IPCC) (IPCC, 2001). With regard to changes in precipitation, an average of a 25 percent decrease in rainfall has occurred over the African Sahel during the past 30 years. This change has been characterized by a decrease in the number of rainfall events.

- **Floods**

Floods are recurrent in some countries of Africa; even communities located in dry areas have been affected by floods. According to Aljazeera report dated 29 January 2013, that more than 40 people dead and almost 150,000 residents have been displaced and forced to flee to higher ground by rains and overflowing rivers in Mozambique. The year 2012 witnessed a huge flooding event in Nigeria, particularly the Niger Delta region. This has made half million people homeless and several losing their lives. The floods had devastating

effects on livelihoods, destroying agricultural crops, disrupting electricity supplies and demolishing basic infrastructure such as roads, homes, and bridges.

- **Drought**

Drought is defined in general terms as a 50 percent shortfall in rainfall over three months (UNDP, 2004). The duration of a drought plays the most important role in characterizing its hazard level, since it develops slowly and may last over a period of many years. African countries were identified as having the highest vulnerability to drought. The Africa Sahel, situated at the southern fringe of the Sahara desert and stretching from the West African coast to the East African highlands, is particularly prone to drought. Estimates suggest that one third of African people live in drought-prone areas and that around 220 million people are annually exposed to drought (UNDP 2004). Droughts are often synonymous with famines. The 1980s witnessed very severe famines associated with the famous drought of 1984-85 that hit sub-Saharan Africa, causing many casualties, and loss of life and assets.

- **Dust and Sand Storms**

Atmospheric dust is a major element of the Saharan environments. The Sahara is the world's largest source of airborne mineral dust, and according to some estimates, up to one billion tonnes of dust is exported from the Sahel-Sahara region annually (varying year to year), (Andreae, 1996). Human impacts like overgrazing, deforestation are contributing factors to the increase in dust storms through the creation of new source of dust; the Sahel is now a more significant source of dust than the Sahara. Dust storms can have negative impacts on Agriculture: eroding fertile soil, and uprooting of young plants; Water: burying water canals and increasing evaporation; Infrastructure: burying houses and other properties; Health: causing respiratory problems. Meningitis transmission, associated with dust in semi-arid conditions and overcrowded living conditions, may increase with climate change as arid and dusty conditions spread across the Sahelian belt of Africa (DFID, 2004).

- **Desertification**

Desertification has its greatest impact in Africa. Two thirds of the continent is desert or dry lands. However, the link between desertification and climate change needs to be better explored. Africa's desertification is strongly linked to poverty, since poor people have little choice but to overexploit the land. Extensive agriculture in the dry lands of Africa and the heavy dependence of rural people on natural resources for subsistence has largely contributed to land degradation and desertification. This situation could be further aggravated by the impacts of expected climatic changes e.g. a decrease in precipitation and increasing temperature.

KEY IMPACTS AND VULNERABILITIES TO FUTURE CLIMATE CHANGE

UNFCCC, Article 2, sets an ultimate objective of stabilizing greenhouse gas emissions "At a level that would prevent dangerous anthropogenic (human induced) interference with the climate system." It states that "such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic

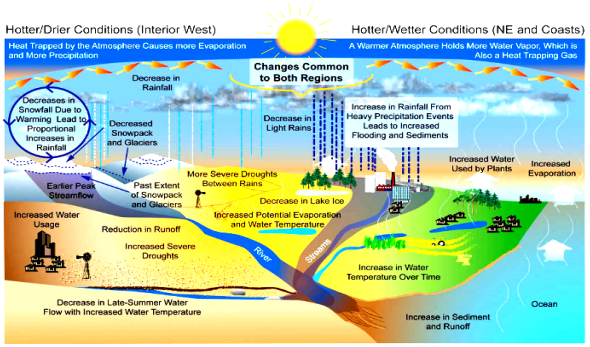
development to proceed in a sustainable manner." The key vulnerable sectors/areas identified by the majority of the African parties included agriculture and food security, and water resources (UNFCCC, 2006). Africa's vulnerability to climate change is acknowledged in the IPCC TAR, areas of particular concern to Africa being: water resources, agriculture and food security, human health, ecosystems and biodiversity, forestry, coastal zones and attaining the Millennium Development Goals (MDGs). Elaborated assessment of these impacts is given below.

- **Water Resources**

Water resources are important to both society and ecosystems. We depend on a reliable, clean supply of drinking water to sustain our health. We also need water for agriculture, energy production, navigation, recreation, and manufacturing. Many of these uses put pressure on water resources, stresses that are likely to be exacerbated by climate change. In many areas, climate change is likely to increase water demand while shrinking water supplies. This shifting balance would challenge water managers to simultaneously meet the needs of growing communities, sensitive ecosystems, farmers, ranchers, energy producers, and manufacturers (UEPA, 2012).

In some areas, water shortages will be less of a problem than increases in runoff, flooding, or sea level rise. These effects can reduce the quality of water and can damage the infrastructure that we use to transport and deliver water.

The impacts of climate change - including changes in temperature, precipitation and sea levels - are expected to have varying consequences for the availability of freshwater around the world. This is of particular concern to Africa, where around 300 million people have no access to potable water or adequate sanitation (UNEP, 1999).



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Projected changes in the water cycle.
Source: USGCRP (2009)

The water cycle (shown in the figure above) is a delicate balance of precipitation, evaporation, and all of the steps in between. Warmer temperatures increase the rate of evaporation of water into the atmosphere, in effect increasing the atmosphere's capacity to "hold" water (USGCRP, 2009).

Increased evaporation may dry out some areas and fall as excess precipitation on other areas. As temperatures rise, people and animals need more water to maintain their health and thrive. Many important economic activities, like producing energy at power plants, raising livestock, and growing food crops, also require water. The amount of water available for these activities may be reduced as Earth warms, and if competition for water resources increases (USGCRP, 2009) water quality could suffer in areas

experiencing increases in rainfall due to heavy precipitation events that could cause problems for the water infrastructure, as sewer systems and water treatment plants are overwhelmed by the increased volumes of water (UEPA, 2006).

Climate change impacts on water supply and quality will also affect tourism and recreation. The quality of lakes, streams, coastal beaches, and other water bodies that are used for swimming, fishing, and other recreational activities can be affected by changes in precipitation, increases in temperature, and sea level rise. In addition, winter sport activities that depend on the production of snow and ice could be limited in the future as temperatures increase.

- **Health**

The health effects of a rapidly changing climate are likely to be overwhelmingly negative (IPCC). Desanker et al., (2001) stressed that the vulnerability of Africa to health impacts is a function of climatic as well many other non-climatic factors such as: poverty, conflicts and population displacement, access and availability and management of health services, in addition to other factors related to drug sensitivity of the pathogens, awareness and attitude towards preventive measures. Urban growth unaccompanied by strong public health infrastructure makes African countries even more vulnerable. Africa is already vulnerable to a number of climate-sensitive diseases (Guernier et al., 2004), some of the most important of which are highlighted below:

- Rift valley fever, which afflicts people and livestock, is closely related to heavy rainfall events, which are predicted to increase with climate change. An outbreak in 1997 associated with an El Niño event killed up to 80 percent of livestock in Somalia and northern Kenya.
- Cholera, associated with both floods and droughts, may increase with climate change.

Increased temperatures could increase the levels of cholera bacteria in tropical seas and lakes. Changes in rainfall will affect the transmission potential, and the presence and absence of vector- and water-borne pathogens (IPCC 2001).

- Increased flooding could facilitate the breeding of malaria carriers in formerly arid areas. Small geographical changes in the distribution of malaria may expose large numbers of people to infection e.g. densely populated east African highlands (Cox et al., 2002).

- **Agriculture and Food Security**

Climate change will affect all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Its impacts will be both short term, resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns, People who are already vulnerable and food insecure are likely to be the first affected. Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock. People living on the coasts and floodplains and in

mountains, dry lands and the Arctic are most at risk (Wulf, 2008).

As an indirect effect, low-income people everywhere, but particularly in urban areas, will be at risk of food insecurity owing to loss of assets and lack of adequate insurance coverage. This may also lead to shifting vulnerabilities in both developing and developed countries. Food systems will also be affected through possible internal and international migration, resource-based conflicts and civil unrest triggered by climate change and its impacts. Agriculture, forestry and fisheries will not only be affected by climate change, but also contribute to it through emitting greenhouse gases. They also hold part of the remedy, however; they can contribute to climate change mitigation through reducing greenhouse gas emissions by changing agricultural practices. At the same time, it is necessary to strengthen the resilience of rural people and to help them cope with this additional threat to food security. Particularly in the agriculture sector, climate change adaptation can go hand-in-hand with mitigation. Climate change adaptation and mitigation measures need to be integrated into the overall development approaches and agenda.

Agricultural production in many African countries and regions will be severely affected by climate change. Agricultural losses are estimated to be possibly severe for several areas (like the Sahel, East Africa, and southern Africa) accompanied by changes in the length of growing periods impacting mixed rain-fed, arid and semi-arid systems under certain climate projections. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020. This will lead to loss of livelihood and social anarchy amongst the people.

Agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security [International Food Policy Research Institute (IFPRI), 2009].

The future for farming and agriculture holds many challenges, not least the continued efforts to optimize energy inputs and reduce greenhouse gas (GHG) emissions. This needs to be set against the urgent and growing need to improve yields to meet the anticipated requirements to provide food, feed, fuel, chemicals and materials for the growing global population. These challenges are and will increasingly be influenced by the availability and price of oil, natural gas and coal, as well as by policies set to meet carbon emissions targets and other sustainability requirements (Woods, et al., 2010).

THE WAY FORWARD

In the food and agriculture sector, adaptation and mitigation often go hand in hand, so adopting an integrated strategic approach represents the best way forward.

Several funds within the United Nations system finance specific activities aimed at reducing greenhouse gas emissions and increasing resilience to the negative impacts of climate change. Because many mitigation actions that would have high payoffs also represent good options for adaptation within the food and agriculture sectors of low-income developing countries, it may be possible to obtain additional resources from bilateral and multilateral aid agencies, which are becoming increasingly interested in investing development resources in adaptive responses to climate change.

- **Biodiversity**

Ecosystems: Africa is endowed with a highly diverse range of organisms. Africa contains about a fifth of all known species of plants, mammals and birds in the world, and a sixth of the amphibians and reptiles (UNFCCC 2006). Biodiversity in Africa is already under threat from a number of natural as well as human induced pressures; climate change will be an additional stressor (Desanker, 2002). Other threats include: land-use conversion due to agricultural expansion and subsequent destruction of habitat; pollution; poaching; civil war; high rates of land use change; population growth and the introduction of exotic species. Increasing frequency of droughts and floods associated with climate variability and change could have a negative impact on the ecosystems of some areas in Africa e.g. lakes and reservoirs in the African Sahel could loose part of their storage capacity leading to a complete drying (UNEP, 2004). Changing rainfall patterns could lead to soil erosion, the siltation of rivers and the deterioration of watersheds.

The Potential Role of Engineers to Combat Climate Change

The idea of engineering on a planetary scale in a bid to control climate has been around for more than 50 years but, to date, has remained on the fringes. The potential for dramatic and beneficial change has hitherto been outweighed by the risk of unexpected side effects in the complex climate system, with global consequences.

Today, the climate change has become a serious threat to mankind, affecting environment, terrestrial ecosystems and biodiversity. The dependency on carbon-based fuels has resulted in rapid increase in the concentration of greenhouse gases (GHG), causing global warming and severe weather conditions. The engineering fraternity has a role to play in neutralizing the adverse effects on the climate by applying green technologies, phasing out GHG-producing sources and combating the existing effects on climate to save the Earth.

Artificial clouds and creating colossal blooms of oceanic algae are among the ideas engineers say must be considered. This artificial cloud reflects away sunlight, creating colossal blooms of oceanic algae and global use of synthetic carbon-neutral transport fuels are just three of the climate transforming technologies that needs urgent investigation, according to leading scientists. The eminent group argues that, with governments failing to grasp the urgent need for measures to combat dangerous climate change, radical and possibly dangerous solutions must now be seriously considered.

One of the leading climate scientists Ken Caldeira based at the Carnegie Institution in Stanford, California argues that "if a decision is made to move ahead with

climate engineering, it will be essential to understand the point at which the risks and costs of geo-engineering outweigh the impacts of global warming. Some of the most extreme ideas for climate engineering involve reducing the sunlight falling on the Earth's surface, as a way to offset the increase in temperatures caused by greenhouse gas emissions. Caldeira calculates that reflecting just 2% of the sun's light from the right places on earth (mainly the Arctic) would be enough to counteract the warming effect from a doubling of carbon dioxide in the atmosphere. One approach is to insert "scatterers" into the stratosphere. Caldeira cites an idea to deploy jumbo jets into the upper atmosphere and deposit clouds of tiny particles there, such as sulphur dioxide. Dispersing around 1m tons of sulphur dioxide per year across 10m square kilometres of the atmosphere would be enough to reflect away sufficient amounts of sunlight.

Let us look at transport system; more than a fifth of the world's human-induced emissions of carbon dioxide come from transport. While technical fixes for these emissions might not count as geo-engineering by the strictest definition, their global effect means they can be considered alongside other options to reduce the CO_2 in the atmosphere. In the long term, experts believe that people should be driving electric or hydrogen-fueled cars but those technologies will take too long to arrive.

Frank Zeman of Columbia University and David Keith of the University of Calgary have proposed the development of synthetic fuels called Carbon-neutral hydrocarbons (CNHC) as a near-term alternative to petrol and diesel. This is made by reacting together with carbon dioxide and hydrogen; these fuels can be used in cars without the need for major modification of either vehicles or infrastructure. More importantly, burning them would not contribute to global warming, provides the component ingredients have been manufactured in a carbon-neutral way. The CO_2 could come directly from the air, from plants or else from coal-fired power stations using Carbon Capture and Storage technology (CCS). The latter method could also reduce the potential problems of the planned worldwide increase in the number of fossil-fuel power stations.

The future of the planet could change permanently when Geoengineers and their corporate sponsors have their way. Even as scientists and the public become increasingly skeptical on the accuracy of predictions about global warming, the geoengineers are working tirelessly in their insistent advocacy to pollute the planet with chemicals in order to save the Earth. How do you like your skies – Natural or man-made?

CONCLUSION

Until about 200 years ago, climate was a critical determinant for food security. Since the advent of the industrial revolution, however, humanity's ability to control the forces of nature and manage its own environment has grown enormously. As long as the economic returns justify the costs, people can now create artificial microclimates, breed plants and animals

with desired characteristics, enhance soil quality, and control the flow of water.

At the global level, therefore, food system performance today depends more on climate than it did 200 years ago; the possible impacts of climate change on food security have tended to be viewed with most concern in locations where rain fed agriculture is still the primary source of food and income.

However, this viewpoint is short-sighted. It does not take account of the other potentially significant impacts that climate change could have on the global food system, and particularly on market prices. These impacts include those on the water and energy used in food processing, cold storage, transport and intensive production, and those on food itself, reflecting higher market values for land and water and, possibly, payments to farmers for environmental services.

In all this, engineers have a lot of work to do in attempt to combat climate change so that effect could be reduced.

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