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Minireview Article

The Impact of Climate Change in Sub-Saharan Africa and Its Mitigation Measures

Abstract

Sub-Saharan Africa is particularly vulnerable to climate change because of its dependence on natural resources, fragile economy, weak infrastructure and the already warm weather. Nowadays, food security and agricultural production in some countries in the region is getting worse because of the sever impacts of climate change and variability.

The effect of climate change is higher in the developing nations, those with low economic/mitigation capacity and of contributing a little to the greenhouse gas emissions than that of the industrialized countries. However, experts have found different climate change mitigation and adaptation measures. Some of these measures are: conductive governance system, effective agricultural management, using of renewable energy and carbon trading and sequestration projects. Furthermore, the governments of the developing nations, particularly Sub-Saharan countries, need to work 'hand in glove' with the international community to manage the climate risks and mitigate the future climate.

Keywords

Climate change, Sub-Saharan Africa, climate change mitigation, effective agricultural management, renewable energy, carbon trading and sequestration

Introduction

Climate change is the change of weather patterns over a long time periods. Nowadays, it's a global issue. Irrespective of its sources, it will adversely affect the global environment as a whole. However, the impact and mitigation and adaptation measures of Climate change may vary from place to place based on the economic potential and the levels of vulnerability (IPCC 1990a). This is also true for the

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countries in Africa. However, the vulnerability and economic capacity of sub-Saharan countries are almost the same. This is because of that one major cause of vulnerability to climate change is dependence of the exposure unit on sectors such as agriculture, forestry and fishery that are very sensitive to climate change (Sperling 2003). Therefore, almost all countries in Sub-Saharan Africa have very fragile soil, sensitive ecosystems and weak economic potential, which is agriculture lead economy (Adejuwon 2006). Thus, even though there are some differences among them, the impacts and mitigation measures of climate change may not vary significantly.

This paper shows the special vulnerability of Sub-Saharan countries to climate change and the mitigation and adaptation measures that should be taken into account to manage the risks of the changing climate. It emphasizes on the importance of effective agricultural management, improving carbon trading and sequestration projects and using renewable energy sources. Furthermore, it also considers the roles of the people and governments of sub-Saharan countries and the international community in mitigating the changing climate in the region.

1. Vulnerability of Sub-Saharan Countries to Climate Change

As shown in (figure 1), the levels of green house gases (GHGs) in the atmosphere have been increasing since the beginning of the industrial revolution and the large scale use of fossil fuels (IPCC 1990c; Olivier et al. 2012*)*. However, as shown in (figure-2), Africa's contribution to the increasing

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concentrations of greenhouse gases has been relatively minimal compared to the developed regions (DFID 2009; Boko et al. 2007; MacKinnon, Sobrevila and Hickey 2008; IPCC 1990c*).*

Nevertheless, according to (Boko et al. 2007; Glantz 2005*;* A hostile climate 2006; Drying up and flooding out 2007; Mwinjaka, Gupta and Bresser 2010*;* and MacKinnon, Sobrevila and Hickey 2008; IPCC 1990a*),* Sub-Saharan Africa is the most vulnerable region to climate change (IPCC 1995). The main reasons for this are: Firstly, Sub-Saharan countries are already warmer compared to other non-tropical countries. Secondly, most Sub-Saharan African economies are predominantly based on agriculture, which is the most climate sensitive of all the productive sectors. Over 60% of the population in sub-Saharan Africa depends on agriculture for their livelihood; and agriculture accounted on average for 29% of Gross Domestic product (GDP) of the region from 1998-2000 (IAASTD 2009). Furthermore, the livelihood of the majority of the population is being threatened by the rapid depletion of natural resources, such as forests. For instance, the rainforest of the Congo basin is the second largest on the earth, next to the Amazon (SCBD and COMIFAC 2009; Somorin et al. 2011; Sonwa et al. 2009). However, land clearing is being the main problem in the region, for the people depends on it for food, shelter, medicine and agriculture (DFID 2009).

Currently, a number of Sub-Saharan countries are facing climatic conditions that make agriculture challenging (Anne 2009). In fact, it is not easy to exactly know the rate of warming. What we can easily identify is that the earth is warming, heavy rainfall is becoming more common and dry areas like Sub-Saharan countries are generally becoming drier. The length of growing seasons is likely to reduce in these regions due to the effect of global warming on the earth's climate and at worst may force large regions of marginal agriculture out of production (Thornton 2006; IPCC 2007b;). Failure of crop yields in these poor countries will therefore primarily affect the small scale farmers, those who play a considerable role in the economic development. Thus, this will inevitably adversely affect food security in the region.

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2. *Climate Change Mitigation and Adaptation Measures*

Climate change mitigation is an activity which contributes to the objectives of stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This can be done by promoting efforts to reduce/limit GHG emissions or to enhance GHG sequestration. Protection and enhancement of sinks and reservoirs of GHGs through sustainable forest management and Methane emission reductions through waste management or sewage treatments are examples of mitigation measures.

Although industrialization is low in sub-Saharan Africa, the polluted environment due to the high carbon dioxide (CO_2) emissions from the industrialized world will affect this extremely impoverished region directly and/or indirectly. The direct effect is when the climate is changed globally the people in the impoverished dry land will suffer more (Drying up and flooding out 2007). On the other hand, the indirect effect of climate change is its negative impact on the food supplies that the region can get from the rest of the world, for the change in climate has an effect on the crop yields.

The main greenhouse gases apart from CO_2 are Methane (CH_4) and Nitrous Oxide (N_2O). Methane is produced by anaerobic decay of organic materials in landfills, wetlands, and agricultural areas. It also can be found from animal manure, waste water and fossil fuel combustion.

Nitrous oxide (N_2O) is naturally present in the atmosphere as part of the earth's nitrogen cycle. It has different natural sources. However, human activities such as agriculture, fossil fuel combustion, and industrial processes are affecting the natural balance of the nitrogen cycle and increasing atmospheric N_2O. N_2O can warm the atmosphere over 300 times of that of carbon dioxide (EPA 2014).

Thus, in addition to the GHGs coming from the industrial sectors, gases that could come from ineffectually managed agriculture could also contribute to climate change. Although it is minimal in

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comparison to what is coming from the developed world, GHGs that emanate from an inadequately managed agriculture within the region by itself can also contribute to climate change.

Therefore, these changes in climate may influence the Sub-Saharan countries to suffer from shortage of pure water, food and other related basic necessities. And this situation can lead to violent conflicts. In general, climate change will add another crisis on top of the current problems in the region. However, climate change can be mitigated in the region by fulfilling the following mitigation measures:

3.1. Identifying the roles of People and Governments of Sub-Saharan Countries and the International Community

To mitigate climate change in sub-Saharan Africa, both the people and governments of the region and the international community should play significant roles. Although it sometimes depends on the government policies and strategies, people, especially farmers, should participate in biodiversity conservation processes. Additionally, the governments in the region should take the responsibility to develop an action plan and policies regarding environmental management. In fact, there are hopeful starts in countries like Ethiopia, Ghana, Tanzania and some other countries in sub-Saharan Africa (Obama 2012). These countries have started to design policies involving citizens in national issues. In addition, they also have opened the doors of development by introducing the small farm holders with traders and supplying improved fertilizers to farmers. However, free and conductive government policy, which encourages the small holders and provides land ownership rights to the farmers, is needed in all countries in the region, for it is considerably important to enhance food security and mitigate climate change.

The poor countries should work hand in glove with the international community to mitigate the changing climate (Climate change: meeting the challenge to 2050 2008; IPCC 1990a**).** Furthermore, the largest financial responsibility for climate change mitigation should be covered by the rich countries

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(Prowse and Peskett 2008; DFID 2009). Therefore, developing countries, which have the least contributions to greenhouse gas emissions, and may possibly suffer most from the impact, should pay fewer prices to mitigate climate change (DFID 2009; IPCC 1990a).

3.2. Effective Agricultural Management

According to different researchers in the environmental science and related fields of studies, there are different proposed solutions to mitigate climate change. One of the proposed solutions for climate change mitigation in sub-Saharan Africa is effective agricultural management (Bryan et al 2011).

Agriculture is the source of livelihood and sustenance for the majority of the Earth's poor and an engine of economic growth in most of the developing world like sub-Saharan countries. However, nowadays, climate risks are being the main challenges for agricultural productions. And it is a special menace for those whose livelihoods depend precariously on rainfed agriculture in marginal, high-risk environments. Therefore, advancing and protecting food security and rural prosperity through effective agricultural management could fairly help to mitigate climate change in sub-Saharan countries. Some of the effective agricultural management techniques are discussed below.

3.2.1. Balanced nitrogen fertilizer application

Improving nitrogen fertilizer application and management contributes to a sustainable and ecologically sound agriculture. In contrast, the unbalanced application and poor management of nitrogen fertilizers is a potential source of environmental pollution. Therefore, a balanced nitrogen fertilizer application is one of the main strategies to reduce the load of nitrous oxide to the atmosphere.

3.2.2. Crop Rotation and Sequencing

It is possible to reduce the loss of nitrous oxide to the atmosphere by rotating high nitrogen demanding crops with those requiring less nitrogen. This process may result in less nitrogen accumulation in the

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soil profile and less denitrification. Other possibilities include double cropping or intercropping processes. Therefore, these processes help not only in decreasing the load of nitrous oxide to the atmosphere but also in improving food security.

3.2.3. Effective Genetic Modification and Adaptation of Crops

Effective genetic modification and adaptation of crops is also another basic measure, for it has multi-purposes in addition to climate change mitigation and adaptation. For instance, the types of crops in the most desert parts of Africa need to be drought resistant; otherwise, the productivity of the land will become less because of the lack of water. Therefore, genetic modification may enhance the Agricultural productivity and food security in sub-Saharan Africa. The genetically modified sorghum by "the sorghum master, Professor Gabisa Ejeta", who won the world food prize in 2009, is the best example. It has increased the agricultural productivity in the Sub-Saharan countries that have been using it since 2009. And it also has a valuable contribution towards climate change mitigation.

3.2.4. Improving the Traditional Rainfed Farming to Drip Irrigation System

Improving the traditional rainfed farming to drip irrigation system is helpful especially for efficient use of water in an area where drought and lack of water are the main problems (Eriksen and Brown 2011 and Sharma 2010). The real benefits of drip irrigation include reduced runoff loss and decreased water, labor, equipment and energy costs. This may boost the agricultural productivity and food security of the people in sub-Saharan Africa. Moreover, efficient use of water due to drip irrigation system may also help to create an aerobic condition on the soil profile. As a result, it decreases the amount of nitrogen to be denitrified. Then, less amount of denitrification will result a less amount of nitrous oxide loss to the atmosphere.

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3.2.5. Spate Irrigation System

High dependence on variable rainfall and exposure to unmitigated climate risk are common features in the marginal, rainfed regions of the tropics and sub-tropics. Climate shocks, such as drought, flooding and heat waves lead to loss of life and long-term loss of livelihood through loss of productive assets, impaired health and destroyed infrastructure.

The continued trend of frequent and intense droughts and variations in rainfall due to climate change is then affecting most of the traditional agricultural practices in sub-Saharan Africa. The rate of groundwater depletion, Violent stresses of cyclones, prolonged floods, and saltwater intrusion are increasing. The average temperature has increased in the summer while winter season has shortened. Therefore, to manage these all problems in sub-Saharan Africa, one of the prior actions should be introducing a modernized spate irrigation system to the region. This is because of that ensuring soil fertility and rangeland management and improving agriculture and rural welfare using spate irrigation system provides multiple benefits across the agro-ecological zones of the region.

In fact, irrigation and soil and water conservation are essential in the arid and semi-arid zones. However, the conventional types of irrigation systems may not work in some parts of the region especially where the groundwater table is much deeper. Therefore, the effective type of irrigation system in arid and semi-arid areas is spate irrigation system. This is because of that spate irrigation is a form of water management whereby occasional floods are diverted to irrigate farms, rangelands and forests. So, in this system of irrigation, farmers can inundate their farmland by the flood which comes from upstream. Thus, without the help of groundwater, they can grow crops by conserving the water in the soil and supplying additional water from the ponds when the moisture within the root zone decreases.

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The structures constructed in spate irrigation system including the pond, which is used to store the excess flood during heavy rainfall, makes the system preferable in arid and semi-arid areas. Therefore, by increasing the moisture in the soil, recharging groundwater, improving rangeland management, conserving soil and water and enhancing food securities, spate irrigation systems have livelihood and environmental benefits.

3.3. Using Renewable Energy Resources

The use of renewable energy has an important role in climate change mitigation and adaptation processes. Developing countries have to use small-scale solar, wind, and geothermal devices to provide energy to urban and rural populations. These types of energy productions are especially useful in remote locations because of the excessive cost of transporting electricity from large-scale power plants. Besides, most of the time, the source of energy in remote areas of each country in sub-Saharan Africa is wood. Thus, the development of renewable energy in these areas may help to prevent deforestation and decrease environmental pollution.

3.4. Carbon Trading and Sequestration Projects

Another valuable solution for sub-Saharan Africa to deal with climate change is improving the carbon trading and sequestration projects (Drying up and flooding out 2007). Firstly, the governments in the region should have well designed policies on terrestrial, oceanic, and geological carbon sequestration projects. Terrestrial carbon sequestration is the process through which CO_2 is absorbed naturally through photosynthesis and stored as carbon in biomass and soils. Some of the ways to reduce greenhouse gases using the terrestrial carbon sequestration are:

- avoiding emissions by maintaining existing carbon storage in trees and soils

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- increasing carbon storage by tree planting or conversion from conventional to conservation tillage practices in agricultural lands

Carbon accumulation eventually reaches saturation point where additional sequestration is no longer possible. After saturation, the trees or agricultural practices still need to be sustained to maintain the accumulated carbon and prevent subsequent losses of carbon back to the atmosphere. Therefore, to do so, strong policies and strategies on biodiversity conservation need to be designed. Moreover, Storing CO_2 underground in rock formations (geologic sequestration) and the oceanic sequestration are also able to retain large amounts of CO_2 over a long time period.

Furthermore, the countries in sub-Saharan Africa should work cooperatively with the developed countries in carbon trading projects. Additionally, the developed countries should share the emission credits and provide allowances in compensation to Sub-Saharan countries.

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4. Conclusion

In conclusion, even though there are hopeful starts in some Sub-Saharan countries, the region as a whole needs effective leadership and management policies in order to enhance food security and mitigate climate change. Additionally, the collaborated work between the developed world and sub-Saharan countries is very important for the effective management of the current climate risks and future climate mitigation.

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Figures

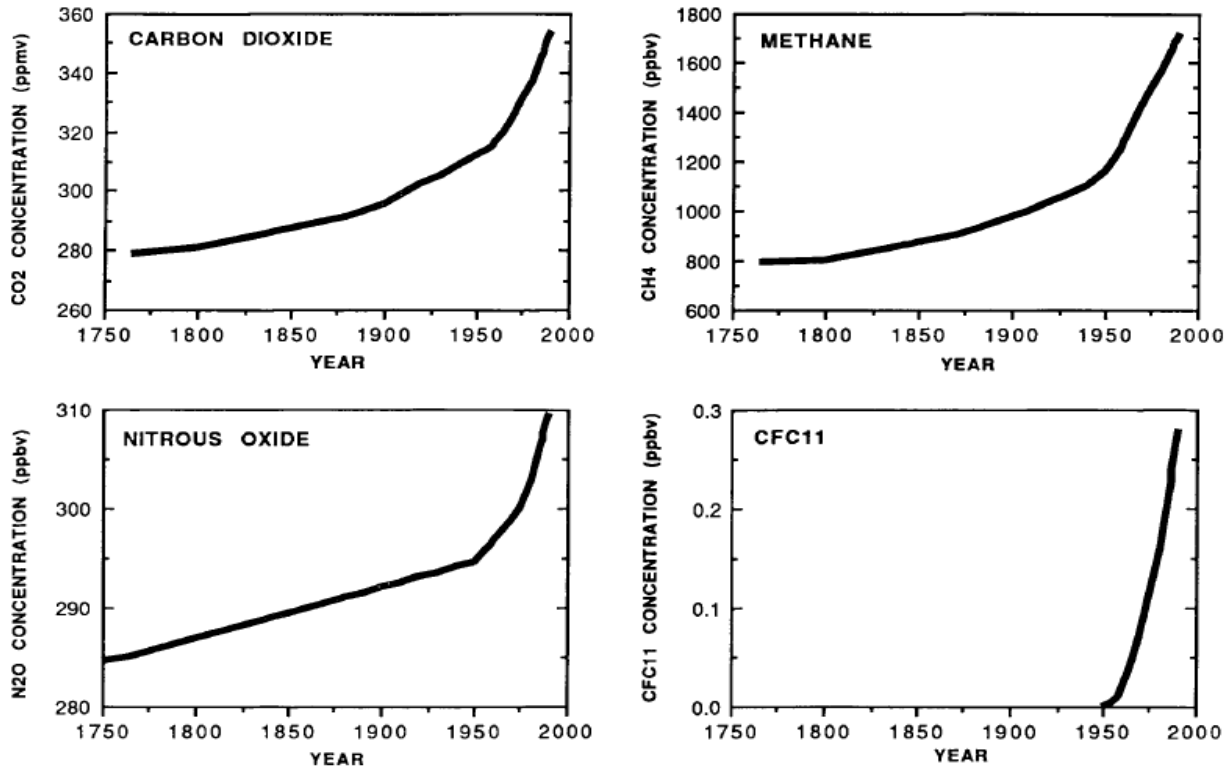

Figure 1: The trend of GHG Emissions

(Modified from IPCC 1990c)

<u>Note</u>: Concentrations of carbon dioxide and methane were relatively constant until the 18th century. However, they have shown a sharp increase since the 18th century. The concentrations of nitrous oxide have also increased since the mid-18th century due to human activities. In the last few decades CFCs were not present in the atmosphere before the 1930s. Nonetheless, it is has shown a dramatic increase since the 1930s because of the industrialization effects.

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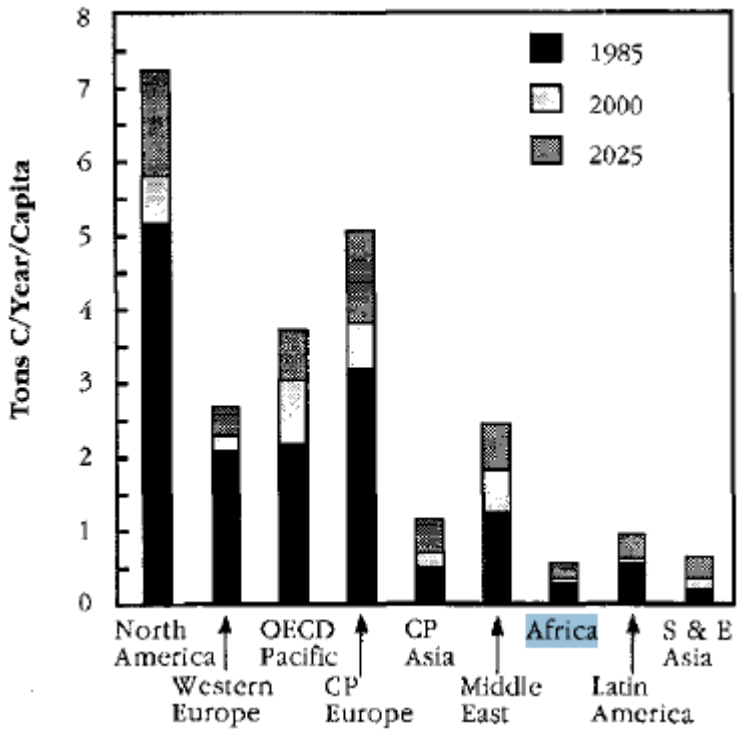

304 **Figure 2: CO_2 emmissions per capita**

305 (Modified from IPCC 1990c)

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