

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

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

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

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43 1. Vulnerability of Sub-Saharan Countries to Climate Change

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

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

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

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

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 (CO₂) 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 CO₂ are Methane (CH₄) and Nitrous Oxide (N₂O). 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 (N₂O) 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 N₂O. N₂O 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

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

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

99 **3.1. Identifying the roles of People and Governments of Sub-Saharan Countries and the** 100 **International Community**

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

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

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

119 **3.2. Effective Agricultural Management**

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

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

130 **3.2.1. Balanced nitrogen fertilizer application**

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

135 **3.2.2. Crop Rotation and Sequencing**

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

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

141 **3.2.3. Effective Genetic Modification and Adaptation of Crops**

142 Effective genetic modification and adaptation of crops is also another basic measure, for it has multi-
143 purposes in addition to climate change mitigation and adaptation. For instance, the types of crops in the
144 most desert parts of Africa need to be drought resistant; otherwise, the productivity of the land will
145 become less because of the lack of water. Therefore, genetic modification may enhance the Agricultural
146 productivity and food security in sub-Saharan Africa. The genetically modified sorghum by “the
147 sorghum master, Professor Gabisa Ejeta”, who won the world food prize in 2009, is the best example. It
148 has increased the agricultural productivity in the Sub-Saharan countries that have been using it since
149 2009. And it also has a valuable contribution towards climate change mitigation.

150 **3.2.4. Improving the Traditional Rainfed Farming to Drip Irrigation System**

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

159 3.2.5. Spate Irrigation System

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

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

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

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

186 **3.3. Using Renewable Energy Resources**

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

194 **3.4. Carbon Trading and Sequestration Projects**

195 Another valuable solution for sub-Saharan Africa to deal with climate change is improving the carbon
 196 trading and sequestration projects (Drying up and flooding out 2007). Firstly, the governments in the
 197 region should have well designed policies on terrestrial, oceanic, and geological carbon sequestration
 198 projects. Terrestrial carbon sequestration is the process through which CO₂ is absorbed naturally
 199 through photosynthesis and stored as carbon in biomass and soils. Some of the ways to reduce
 200 greenhouse gases using the terrestrial carbon sequestration are:

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

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

204 Carbon accumulation eventually reaches saturation point where additional sequestration is no longer
 205 possible. After saturation, the trees or agricultural practices still need to be sustained to maintain the
 206 accumulated carbon and prevent subsequent losses of carbon back to the atmosphere. Therefore, to do
 207 so, strong policies and strategies on biodiversity conservation need to be designed. Moreover, Storing
 208 CO₂ underground in rock formations (geologic sequestration) and the oceanic sequestration are also
 209 able to retain large amounts of CO₂ over a long time period.

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

213 **4. Conclusion**

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

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Figures

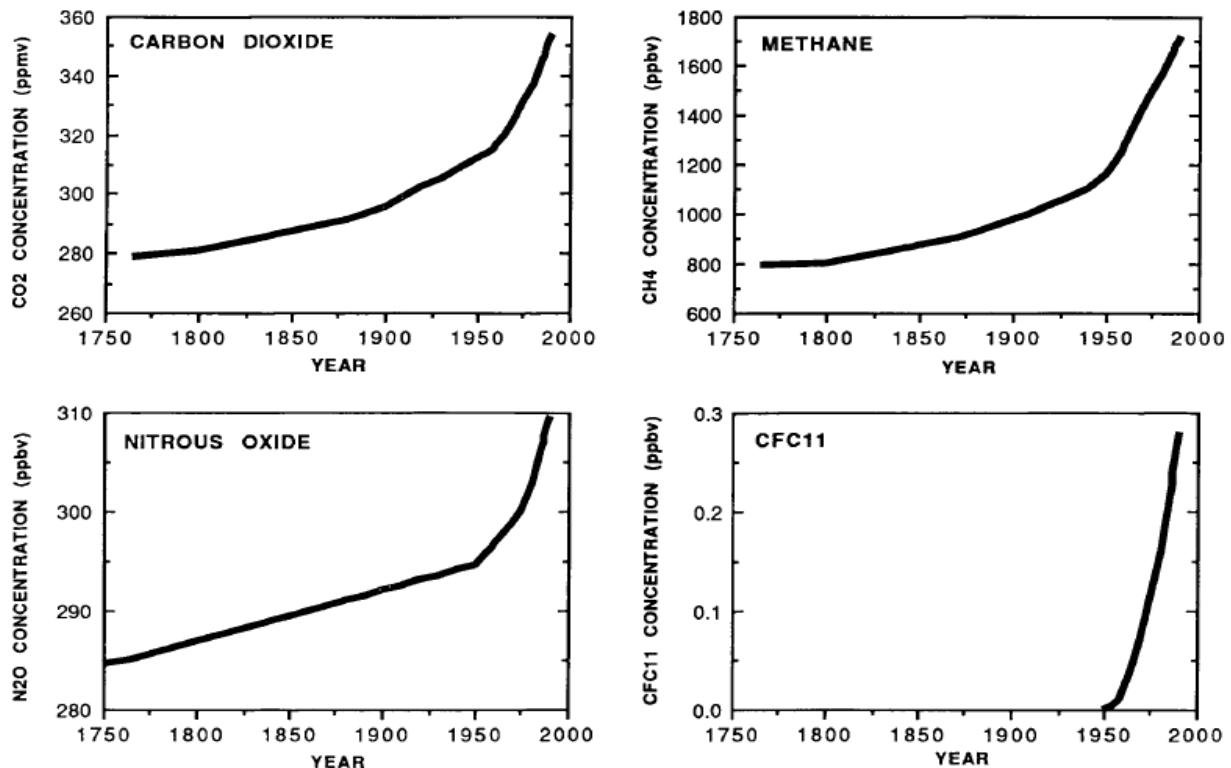


Figure 1: The trend of GHG Emissions

(Modified from IPCC 1990c)

Note: 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 has shown a dramatic increase since the 1930s because of the industrialization effects.

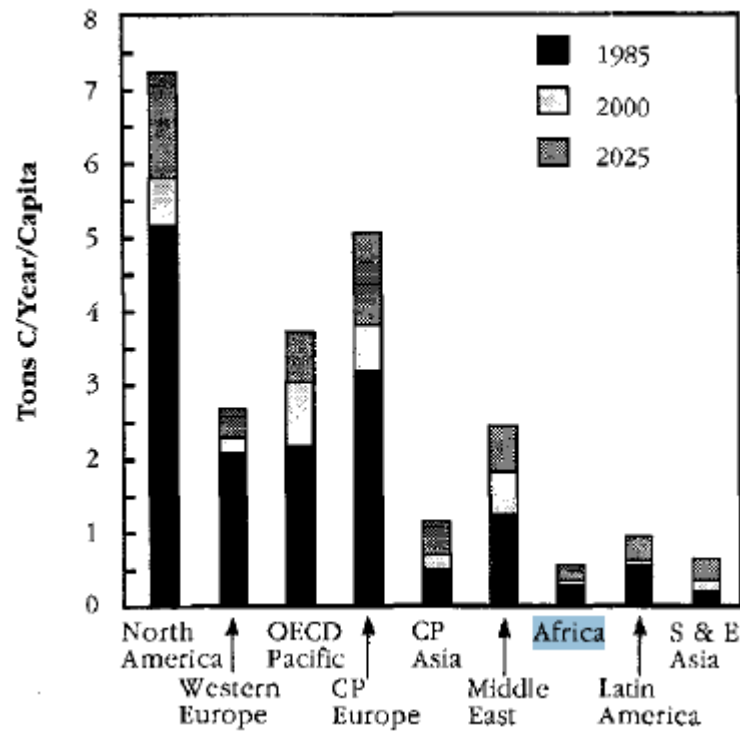


Figure 2: CO₂ emissions per capita

(Modified from IPCC 1990c)