

The Negative Impacts of Climate Change in Sub-Saharan Africa and Their 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 are getting worse because of the negative impacts of climate change and variability. Generally, the effect of climate change is higher in the developing nations, those with low economic capacity and of contributing a little to the greenhouse gas emissions than that of the industrialized countries. However, unless it is the weakness of the policies that the developing countries have, experts have found different climate change mitigation and adaptation measures. Therefore, this paper specifically concentrates on the negative impacts of climate change on the countries in Sub-Saharan Africa, 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, for Sub-Saharan countries particularly need to work ‘hand in glove’ with the international community to manage the current climate risks and mitigate the future climate.

Keywords

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

23 1 Introduction

24 Climate change is a long-term shift in the statistics of the weather, including its averages (NOAA
25 National Weather Service 2007). Nowadays, it is a global issue. There are different factors causing
26 climate change, which can be distinguished into ‘natural’ and ‘anthropogenic’ (human-induced) factors.
27 According to The Fourth Assessment Report of the Intergovernmental Panel on Climate Change
28 (IPCC), it is greater than a 90 percent certainty that emissions of heat-trapping gases from human
29 activities have caused “most of the observed increase in globally averaged temperatures since the mid-
30 20th century (IPCC 2007). Some of the anthropogenic activities that causes climate change are burning
31 coal, oil and gas (fossil fuels) to generate electricity or drive cars and deforestation (Foster et al. 2007;
32 Bowen et al. 2009). On the other hand, some of the natural factors that cause climate change include
33 the energy from the sun, periodic volcanic eruptions of tiny particles, dust, and salt spray (all known as
34 aerosols), and natural carbon and nitrate cycle processes such as termite mounds in Africa that emit
35 methane or tiny organisms in the ocean surface that take up carbon dioxide (Foster et al. 2007; Alley et
36 al 2007; Hansen et al. 2005).

37 However, irrespective of its sources, climate change will adversely affect the global environment as a
38 whole. Though, the impact and mitigation and adaptation measures of Climate change may vary from
39 place to place based on the economic potential and the levels of vulnerability (IPCC 1990a). This is
40 also true for the countries in Africa. However, the vulnerability and economic capacity of sub-Saharan
41 countries are almost the same (Nkonya et al. 2011). This is because of that one major cause of
42 vulnerability to climate change is dependence on sectors such as agriculture, forestry and fishery that
43 are very sensitive to climate change (Sperling 2003). Almost all countries in Sub-Saharan Africa have
44 very fragile soil, sensitive ecosystems and weak economic potential, which is agriculture lead economy
45 (Adejuwon 2006; Nkonya et al. 2011). Thus, even though there are some differences among the Sub-
46 Saharan African countries, the impacts and mitigation measures of climate change may not vary
47 significantly.

48 Climate change mitigation consists of actions to limit the magnitude and/or rate of long-term climate
49 change. Climate change mitigation generally involves reductions in anthropogenic emissions
50 of greenhouse gases (IPCC 2007). Mitigation may also be achieved by increasing the capacity
51 of carbon sinks, e.g., through reforestation (IPCC 2007). Mitigation policies can substantially reduce
52 the risks associated with human-induced global warming (IPCC 2007; Anne 2009; IPCC 1995).

The objective of this paper is therefore to clearly show the negative impacts of climate change in Sub-Saharan Africa and to suggest the most appropriate mitigation measures that should be taken into consideration; i.e., 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.

2. 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 (figures 2 and 3), Africa's contribution to the increasing concentrations of greenhouse gases has been relatively minimal compared to the developed regions (DFID 2009; Boko et al. 2007; MacKinnon et al. 2008; IPCC 1990c; IEA 2013).

Nevertheless, according to (Boko et al. 2007; Glantz 2005; A hostile climate 2006; Drying up and flooding out 2007; Mwinjaka, Gupta and Bresser 2010; MacKinnon et al. 2008; IPCC 1990a; Nkonya et al. 2011; IPCC 1995), Sub-Saharan Africa is the most vulnerable region to climate change. The main reasons for this are: Firstly, Sub-Saharan countries are already warmer compared to other non-tropical countries (Christensen et al. 2007; Cline 2007; Boko et al. 2007). Secondly, most Sub-Saharan African economies are predominantly based on agriculture, which is the most climate sensitive of all the productive sectors (Nkonya et al. 2011; Boko et al. 2007). Over 60% of the population in sub-Saharan Africa depends on agriculture for their livelihood (Mendelsohn et al. 2000a, b; Devereux and Maxwell 2001); 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 (UNEP/GRID-Arendal, 2002; Thomas et al., 2004; Boko et al. 2007). 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

84 regions of marginal agriculture out of production (Thornton 2006; IPCC 2007b;). Failure of crop yields
85 in these poor countries will therefore primarily affect the small scale farmers, those who play a
86 considerable role in the economic development. Thus, this will inevitably adversely affect food security
87 in the region.

88 **3. Climate Change Mitigation and Adaptation Measures**

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

95 Although industrialization is low in sub-Saharan Africa, the polluted environment due to the high
96 carbon dioxide (CO₂) emissions from the industrialized world will affect this extremely impoverished
97 region directly and/or indirectly. The direct effect is when the climate is changed globally the people in
98 the impoverished dry land will suffer more (Drying up and flooding out 2007). On the other hand, the
99 indirect effect of climate change is its negative impact on the food supplies that the region can get from
100 the rest of the world, for the change in climate has an effect on the crop yields.

101 The main greenhouse gases apart from CO₂ are Methane (CH₄) and Nitrous Oxide (N₂O). Methane is
102 produced by anaerobic decay of organic materials in landfills, wetlands, and agricultural areas. It also
103 can be found from animal manure, waste water and fossil fuel combustion.

104 Nitrous oxide (N₂O) is naturally present in the atmosphere as part of the earth's nitrogen cycle. It has
105 different natural sources. However, human activities such as agriculture, fossil fuel combustion, and
106 industrial processes are affecting the natural balance of the nitrogen cycle and increasing atmospheric
107 N₂O. N₂O can warm the atmosphere over 300 times of that of carbon dioxide (EPA 2014).

108 Thus, in addition to the GHGs coming from the industrial sectors, gases that could come from
109 ineffectually managed agriculture could also contribute to climate change. Although it is minimal in
110 comparison to what is coming from the developed world, GHGs that emanate from an inadequately
111 managed agriculture within the region by itself can also contribute to climate change.

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

116 **3.1. Identifying the Roles of People and Governments of Sub-Saharan Countries and the** 117 **International Community**

118 To mitigate climate change in sub-Saharan Africa, both the people and governments of the region and
119 the international community should play significant roles. Although it sometimes depends on the
120 government policies and strategies, people, especially farmers, should participate in biodiversity
121 conservation processes (Nkonya et al. 2011; Smith et al. 2008; Cooper et al. 2009; Cooper and Coe
122 2011). Additionally, the governments in the region should take the responsibility to develop an action
123 plan and policies regarding environmental management. In fact, there are hopeful starts in countries
124 like Ethiopia, Ghana, Tanzania and some other countries in sub-Saharan Africa (Obama 2012; Yesuf et
125 al. 2008). These countries have started to design policies involving citizens in national issues. In
126 addition, they also have opened the doors of development by introducing the small farm holders with
127 traders and supplying improved fertilizers to farmers. However, free and conducive government
128 policy, which encourages the small holders and provides land ownership rights to the farmers, is
129 needed in all countries in the region, for it is considerably important to enhance food security and
130 mitigate climate change (Nkonya et al. 2011).

131 The poor countries should work hand in glove with the international community to mitigate the
132 changing climate (Climate change: meeting the challenge to 2050 2008; IPCC 1990a). Furthermore, the
133 largest financial responsibility for climate change mitigation should be covered by the rich countries
134 (Prowse and Peskett 2008; DFID 2009). Therefore, developing countries, which have the least
135 contributions to greenhouse gas emissions, and may possibly suffer most from the impact, should pay
136 fewer prices to mitigate climate change (DFID 2009; IPCC 1990a).

137 **3.2. Effective Agricultural Management**

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

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

148 **3.2.1. Balanced nitrogen fertilizer application**

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

153 **3.2.2. Crop Rotation and Sequencing**

154 It is possible to reduce the loss of nitrous oxide to the atmosphere by rotating high nitrogen demanding
155 crops with those requiring less nitrogen. This process may result in less nitrogen accumulation in the
156 soil profile and less denitrification. Other possibilities include double cropping or intercropping
157 processes. Therefore, these processes help not only in decreasing the load of nitrous oxide to the
158 atmosphere but also in improving food security.

159 **3.2.3. Effective Genetic Modification and Adaptation of Crops**

160 Effective genetic modification and adaptation of crops is also another basic measure, for it has multi-
161 purposes in addition to climate change mitigation and adaptation. For instance, the types of crops in the
162 most desert parts of Africa need to be drought resistant; otherwise, the productivity of the land will
163 become less because of the lack of water. Therefore, genetic modification may enhance the Agricultural
164 productivity and food security in sub-Saharan Africa. The genetically modified sorghum by “the
165 sorghum master, Professor Gabisa Ejeta”, who won the world food prize in 2009, is the best example. It
166 has increased the agricultural productivity in the Sub-Saharan countries that have been using it since
167 2009. And it also has a valuable contribution towards climate change mitigation.

168 **3.2.4. Improving the Traditional Rainfed Farming to Drip Irrigation System**

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

177 **3.2.5. Spate Irrigation System**

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

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

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

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

203 **3.3. Using Renewable Energy Resources**

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

211 **3.4. Carbon Trading and Sequestration Projects**

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

- 218 • avoiding emissions by maintaining existing carbon storage in trees and soils
- 219 • increasing carbon storage by tree planting or conversion from conventional to conservation
220 tillage practices in agricultural lands

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

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

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

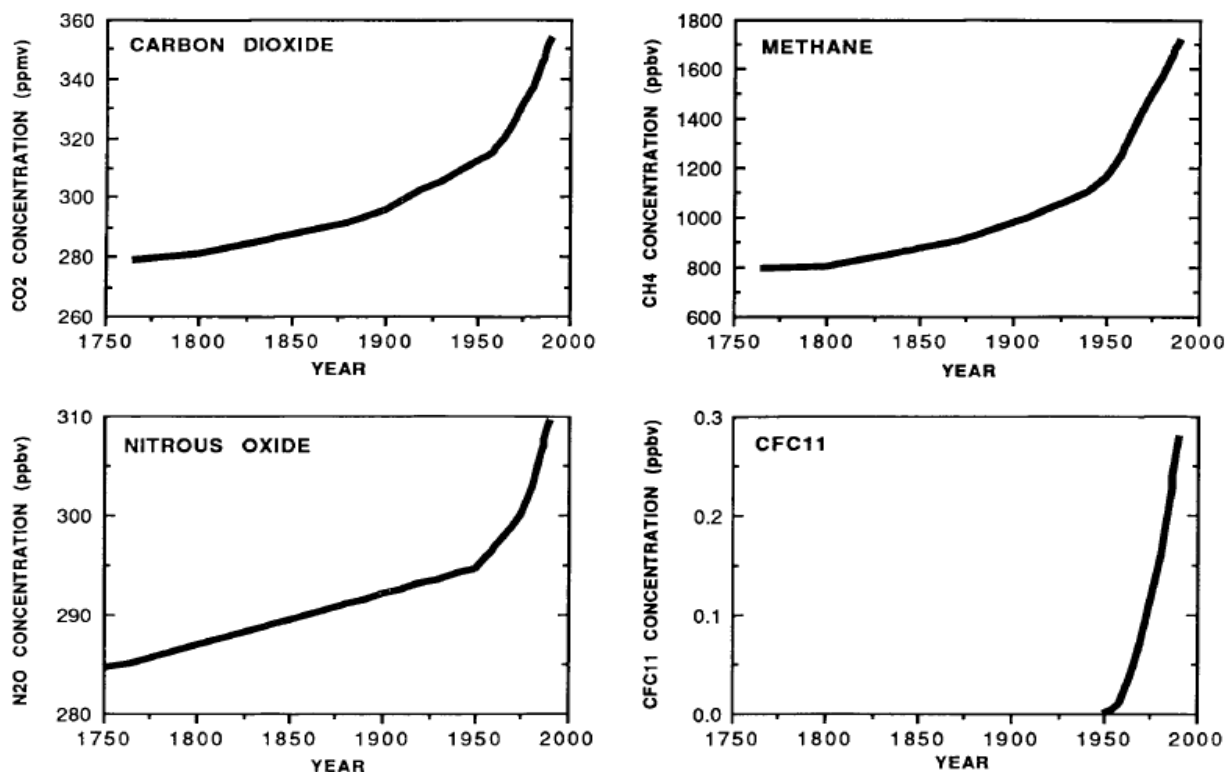


Figure 1: The trend of GHG Emissions

(Modified from IPCC 1990c)

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.

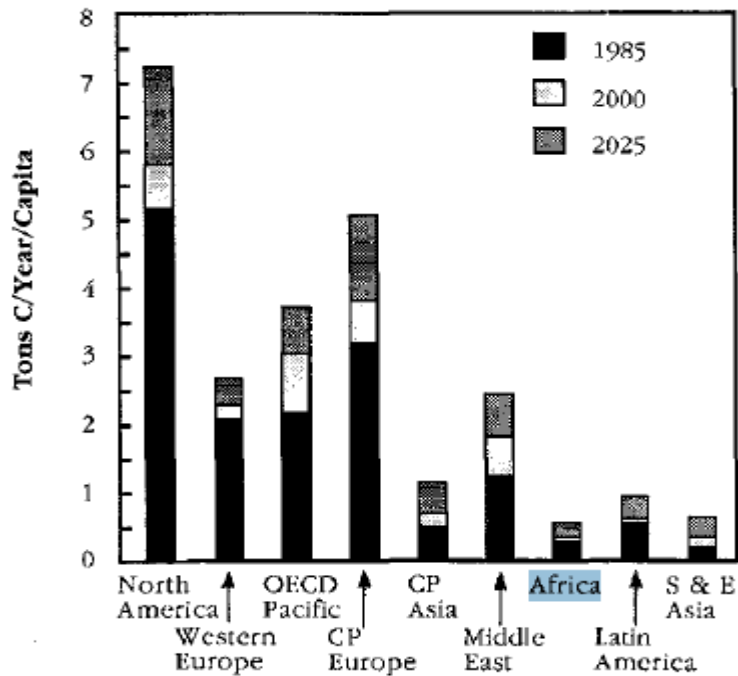


Figure 2: CO₂ emissions per capita

(Modified from IPCC 1990c)

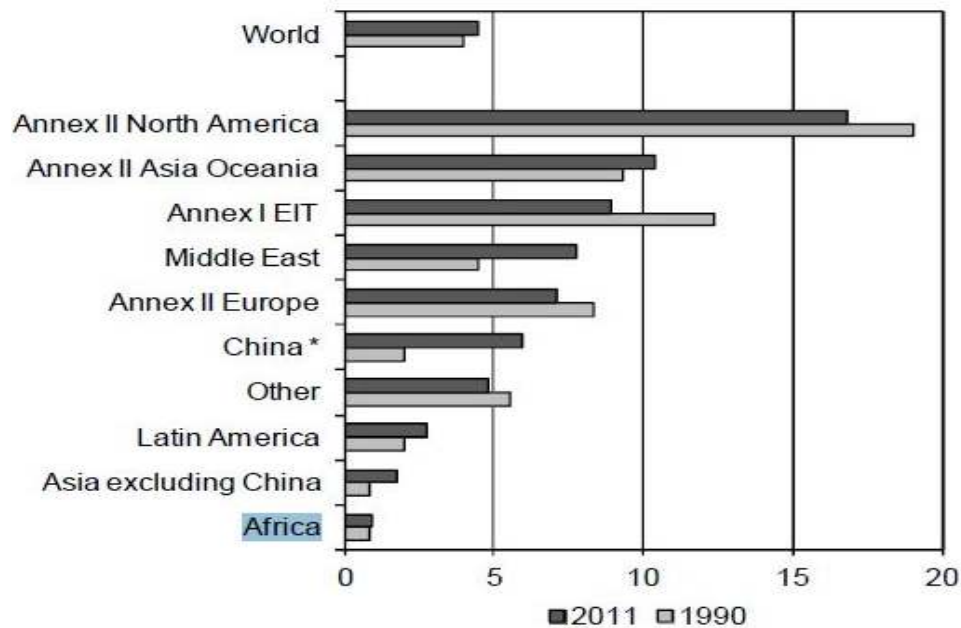


Figure 3: CO₂ emissions per capita by major world regions, tCO₂ per capita, (IEA 2013)

NB: China includes Hong Kong