



Review Article

Prospect of Sub-Saharan African Agriculture Amid Climate Change: A Review of Relevant Literatures

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Abstract: Sub-Saharan Africa is an important world region in terms of food and feed production. However, climate change is becoming more and more serious threat to agricultural production in the region. Various and relevant literatures were contacted aimed at finding the impacts, causes and possible solution to the threat of climate change in Sub-Saharan Africa. Declining agricultural productivity and farm incomes, occurrence of extreme weather conditions, soil degradation and proliferation of pests and diseases were some of the impacts of the Change. Deforestation, transportation, power generation, burning of fuel, poverty and agricultural practices were among the causes of climate change in the region. Poverty alleviation, adequate mitigation and adaptation campaigns, afforestation and incorporation of climate change into long-term developmental programs were some of the possible ways of dealing with climate change threat in the region. It is recommended that apart from provision of alternative sources of fuel, governments should also create job opportunities in the region as well as ensuring that fallen trees are replaced.

Keywords: Prospects, Agriculture, Climate Change, Sub-Saharan Africa

1. Introduction

Climate change is an evitable phenomenon, which is occurring in every part of the world. It affects people, plants, animals and other things in various ways. There is an escalating consensus among scientists that the earth is warming due to anthropometrically increases in greenhouse gas (FAO, 2009; Asfaw & Lipper, 2011). Sub-Saharan Africa (SSA) is an important world region in terms of crops and live stock production. Various agricultural commodities are produced in the region for consumption and exportation to different parts of the world, which are used as food and feed, as well as raw materials to numerous industries for processing into different types of finished products for human use. However, climate change turns to be a critical challenge militating against such important contribution the region is offering to the world. It is noted that its negative effects are threatening to reverse the developmental gains in many parts of the world, especially SSA where the overall impact of the

change has been negative (Dube & Phiri, 2013). The change brings about unpredictable and variable rainfall both in amount and timing, changing seasonal patterns and an escalating frequency of adverse weather events such as drought, cyclone, flood, soil erosion and so on.

Based on Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), warming in Sub-Saharan Africa (SSA) is expected to be greater than the global average, rainfall is projected to decline in certain areas and there will be reduction in the production for a range of cereal crops (Ringler, Cai, Koo and Wang, 2011). Experts predicted that climate change will make dry areas to become drier and wet areas wetter across West and Central Africa, which will bring about longer and more frequent dry periods as well as an increase in temperature which is likely to encourage proliferation of pests that are threat to staple crops (IFAD, 2011). Thus, there is strong warning that climate change is a critical threat to food security in the region.

Therefore, it is important to glance back and found out the

various effects of climate change on agriculture, especially in SSA as revealed by various studies. This will further give light to researchers, policy makers, donor agencies, governments as well as the farmers to further realize the significance of climate change effects and implications in order to take appropriate measures to tackle the menace of the change at this point in time as to check or at least suppress its future effects. The study tried to answer the following questions (a) what are the inter-relationships between agricultural and climate change (b) what are the causes of climate change in SSA (c) what are the effects of climate change in SSA, and (d) what are the possible ways of solving the problems of climate change in SSA.

2. Methodology

Sub-Saharan Africa: SSA is a region of the African continent south of the Sahara Desert, consisting of 42 African countries (Figure 1 revealed their names) situated on the Sub-Saharan African mainland, in addition to six island nations—Madagascar, Seychelles, Comoros, Cape Verde and São Tomé and Príncipe. The north and sub-Saharan regions (which are distinct culturally as well as geographically) of Africa were separated by the extremely harsh climate of the Sahara, forming a barrier interrupted by the Nile River (New World Encyclopedia, 2015). “The modern term *sub-Saharan* corresponds with the standard representation of north as above and south as below. Tropical Africa and Equatorial Africa are alternative modern labels, used for the distinctive ecology of the region” (New World Encyclopedia, 2015, p.3).

The climate of the region is influenced largely by distance from the equator and altitude, whereby in the highlands, it can be temperate even close to the equator. Although precipitation is steadier in the humid forests, rainy and dry seasons alternate. Rocks that solidified during the early cycles of eruptions on Earth are the greatest source of economically important metals, particularly gold and diamonds. The great age of sub-Saharan Africa's rocks has made the region well endowed with these and other metals, including copper and chromium (New World Encyclopedia, 2015).

Generally, SSA is the world's poorest region, still suffering from the legacies of colonialism, slavery, native corruption and other vices. Many governments face difficulties in implementing policies aimed at mitigating the effects of the harsh situations (New World Encyclopedia, 2015).

The study reviewed relevant and reliable literatures such as that of FAO, IPCC, World Bank, WHO, UNFCCC, IFAD and other important ones.

3. Results and Discussion

3.1. Climate Change and Agriculture

Climate change can be defined as a change in weather patterns due to human activities (industrial, domestic and agricultural) and earth's natural processes (such as variations in solar radiation received by Earth, volcanic eruptions, etc.) over a long period of time. In other words, “Climate change

means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (United Nations Framework Convention on Climate Change, 2014, par. 2). Climate is the primary determinant of agricultural productivity, and thus, based on the vital role of agriculture in human welfare, there was concern regarding the potential effects of climate change on agricultural productivity, because climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems and the nature of these biophysical effects and the human responses to them are complex and uncertain. For example, crop and livestock yields are directly affected by changes in climatic factors such as temperature and precipitation and the frequency and severity of extreme events like droughts, floods, and wind storms (Adams, Hurd, Lenhart & Leary, 1998).

Climate change and agriculture are interrelated processes—whereas global warming is expected to have significant impacts on conditions affecting agriculture, agriculture has been shown to produce significant effects on climate change through the production and release of GHGs such as CO₂, CH₄, and N₂O (Wikipedia, 2014). It is reported that agriculture contributed 13% of total GHG emissions in the year 2000, and it is alarming that in developing countries, such emissions are projected to rise in the next decades owing to population and income growth, among other factors, and within the agricultural sector, fertilizer application, livestock and manure management, rice cultivation, and savanna burning are the main sources of emissions (Rosegrant, Ewing, Yohe, Burton, Huq & Valmonte-Santos, 2008).

The socio-economic impacts of climate change implications are already visible, especially in Africa and the world at large. The most alarming effects are the intensity and frequency of extreme weather events like droughts, floods and heat waves, which have already started to create innumerable disasters for economic activities and livelihood sources derived from the natural resource base of the countries, especially in Africa (Dube & Phiri, 2013). In West Africa, on average, temperatures have been rising faster than the overall rate of global warming and this will affect agriculture and could lead to flooding and erosion of low-lying areas, with negative consequences for crop and livestock production and for the rural communities that depend on agriculture for their livelihoods (IFAD, 2011).

Rosegrant *et al.* (2008) reported that global agriculture will be under serious pressure to meet the demands of growing populations using finite, often degraded soil and water resources that are predicted to be further stressed by the impact of the change. Vermeulen (2014) stated that, “Tropical crops, livestock and fisheries are most affected by current climate change; regions of major exposure to climate change coincide with high prevalence of poverty and food insecurity”. He explained that its negative impacts on crop yields and fisheries are more serious in tropical regions with the possibility of livestock in the regions having a greater risk of climate change owing to

(Isingoma, 2009).

Table 1 shows the effects of the changes of various climatic elements in different countries and regions of SSA, which have serious consequences on food security in the region. As can be seen from the Table, all countries in SSA experienced increase in temperature which led to increase evapo-transpiration thereby leading to decline in soil moisture, which in turn results in the destruction of arable and permanent crops in the region. It can also be seen from the

Table 1. Consequences of climate change on food security in SSA.

Climate Change Impacts	Country/Region	Direct Consequences for Food Systems
Average temperature increase Hot days and nights Warm spells/heat waves over most land areas	Countries of SSA	Increased evapo-transpiration, resulting in reduced soil moisture. Greater destruction of crops and trees by pests. Greater threats to human that reduce the productivity and availability of agricultural labour. Reduced quantity and reliability of agricultural yields. Greater need for cooling/refrigeration to maintain food quality and safety. Great threats of wildfires.
Extreme events Droughtst Floods	Semi-arid and sub-humid Africa (particularly the Sahel, Horn of Africa and Southern Africa)	Crop failure or reduced yields. Damage to forests. Destruction of agricultural inputs. Increase land degradation and desertification. Damage to crops and food stores. Soil erosion inability to cultivate land due to logging
Change in rainfall amount and patterns	SSA	Reduced quantity and quality of agricultural yields. Shortage of water and heavy reliance on irrigation
Sea-level rise	West Africa (Gambia, Gulf of Guinea, Senegal.), Southern Mediterranean (Egypt) and East Africa (Mozambique)	Loss of cropland and nursery areas for fisheries through salt water intrusion Salination of irrigation water estuaries & freshwater systems which will threaten Irrigated crops Aquaculture in low-lying areas Coral fisheries dependent on soawning grounds in mangrove swamps.

Source: Chijioke, Haile and Waschkeit, 2011.

It was projected that cereal production for a range of crops in SSA will decline by a net 3.2% in 2050 as a result of climate change which will increase the number of malnourished children in both 2030 and 2050, but without climate change, child malnutrition levels in SSA are projected to decline from 28% in 2000 to 24% in 2030 and 19% in 2050, while under climate change child malnutrition would increase by additional 0.5, 1 and 0.6 million children in 2010, 2030 and 2050 respectively (Ringler *et al.* 2011).

Even though, they face a world where climate change will increasingly threaten the food supplies, the less privilege in coastal cities and low-lying islands of SSA are among the most vulnerable to climate change in the world, as well as the least able to adapt to the change (World Bank, 2013).

3.3. Causes of Climate Change in Sub-Saharan Africa

Studies have shown that there are so many factors that lead to climate change in SSA. Stern (2006) reported that there is strong scientific evidence that human activity is causing global warming, GHGs being the main sources. He explained that in order of global importance are electricity generation, land-use changes (particularly deforestation), agriculture and transport, and the fastest growing sources are transport and electricity. According to Rosegrant *et al.* (2008), climate change results from the concentration of GHGs such as CO₂, nitrous oxide (N₂O), and methane (CH₄) as well as emissions from agriculture which comes from four principal subsectors: Agricultural soils, livestock and manure management, rice cultivation, the burning of agricultural residues and savanna for land clearing, among which N₂O is the largest source of

Table that changes in rainfall patterns and amount as well as occurrence of flood and drought had significant effects on the both the quality and quantity of agricultural products in the region. These are serious warnings about the negative effects of climate change on the food security of the region, which need urgent and appropriate measures to be taken by citizens and various governments of the region, Non-Governmental Organizations, donor agencies as well as international bodies.

GHG emissions, accounting for 38% of the global total, which is produced naturally in soils through the processes of nitrification and denitrification.

Even though some have argued that climate change is actually caused by natural occurrences, the Earth's average surface temperatures have risen by 0.4°C since 1970s, which is an irregular increase that is extremely difficult to explain by natural causes and thus, certain changes do occur in the sun's activity, volcanic eruptions, and other natural events which all contribute to changes in the earth's temperatures, but only an increase in GHGs can explain the abnormal increases. Therefore, human activities that result in the release of these greenhouse gases well beyond natural levels include things like deforestation, burning of fossil fuels, changes in wetland construction, and so forth (Ecolife, 2011). Some of the anthropogenic causes of climate change in Sub-Saharan Africa include the following:

(a) *Agriculture*: Sub-Saharan Africa cannot do without agriculture because it is one of the important occupations of the people in the region- ranging from crop and livestock production to processing and marketing of different agricultural commodities. However, in the course of carrying out their activities, Sub-Saharan African farmers engage in some farm practices such as bush burning, clean clearing, overgrazing, same cropping, etc., which exacerbate global warming.

(b) *Deforestation*: Deforestation (indiscriminate felling of trees for various purposes) is a rampant phenomenon in SSA. This may be due the level of poverty couple with ignorant of the effects of such actions on global warming on the part of the citizens and/or improper planning and implementation on the

part of governments of the region. Figure 1 and 2 show the some of the reasons and ways of deforestation in SSA.



Source: FAO, 2009

Figure 2. Fuel requirement as a reason for deforestation.



Source: Cunningham, 2010.

Figure 3. Deforestation of forest for various purposes.

Deforestation causes lost of species and soil degradation which are important form of environmental degradation. Unfortunately, sub saharan Africans depend on subsistence farming as their means of livelihood and thus clear forests so as to expand their farms for feeding their growing population (Cunningham, 2010). From Figure 1 above, it could be seen that people in SSA rely on wood as a source of fuel for cooking and similar activities, leading to indiscriminate felling of trees. The fact is that majority of the people cannot afford to use kerosene for all their cooking activities talk less of natural gas, due to high cost couple with unavailability of the commodities. In Nigeria (the highest oil exporting country in the region) for instance, the price of kerosene at black market usually more than triple the official price and it is on rare cases that one can get it at official price even after wasting lots of energy and time. Thus, people were left with no alternative except to be felling trees for various domestic purposes.

(c) *Transport:* It was reported that Africa's emissions from the transport sector have grown 50% since 1990 – 2nd fastest growing source of emissions in the world after Asia. This will increase health effects and climate change impacts (UNEP, 2013). Thus, urban air pollution is escalating in SSA, mainly caused by use of fossil fuels in transport; yet, vehicle

emission standards are insufficient and inadequately enforced. Only eight countries in the region have operational routine air quality monitoring systems. Traffic congestion is of growing concern in many cities. The causes include ineffective public transport; lack of transport demand measures; poor quality of cycling and walking infrastructure; lack of integrated land-use policies, and poor road discipline (Stockholm Environment Institute, 2013). SEI revealed that no country in SSA has diesel sulphur content less than 50 parts per million, several have between 2,000 and 5,000 ppm of such content or even more, only five countries have emission standards for vehicles, and only eight have set air quality. SEI lamented that SSA countries have many old vehicles lacking emissions control, poor vehicle maintenance, and a lack of cleaner fuels as well as inadequate regulatory frameworks specific to vehicle emissions coupled with inappropriate monitoring equipment, and existing laws and regulations are inadequately enforced.

3.4. Possible Ways of Combating Climate Change in Sub-Saharan African

Conducting Adaptation and mitigation workshops, seminars, and panel discussions on climate change are efficient ways of dealing with the acute temperature and rainfall variability which leads to decline in agricultural yield, water scarcity, drought and flooding, occurrence of various diseases and increase in deforestation. Key stakeholders, public and private officials, university academicians and researchers as well as personnel from different sectors; should be participate (World Bank, 2015). This will pave ways in enlightening people and governments about the danger of some practices that cause climate change in SSA and how the practices can be checked adequately and appropriately. It was reported that it was the inability of SSA governments to treat climate change into long-term investment and planning risks that leave countries across the region vulnerable to droughts, floods, heatwaves and rising sea-levels (The Guardian, 2016).

There are various strategies that can be employ in response to climate change so as to retard its escalating nature in such a way to cope with its impacts to some extents, the process of adopting these strategies is known as mitigation. According to Wikipedia (2014), climate change mitigations are actions to limit the magnitude and/or rate of long-term climate change and it is generally involves reductions in human (anthropogenic) emissions of GHGs, which may be achieved by increasing the capacity of carbon sinks, such as through afforestation. The Wikipedia pointed out that mitigation policies can greatly reduce the dangers associated with human-induced global warming. It however argued that effective climate change mitigation will not be achieved if each agent (individual, institution or country) acts independently in its own selfish interest. Therefore, there is the need for SSA countries to join hands to address the problems of climate change. It is paramount to seek ways of improving productivity, via access to improved seeds, fertilizers, water management techniques, equipment, financing, and markets because, it is noted that only about 5%

of Nigerian smallholders use improved seeds due to its availability, quality and pricing, whereas fertilizer application rate is approximately 7 kg per hectare, which is a small fraction of the global average of 100 kg/ha, and only 18% of farmers receive extension services (Nwuneli, 2011).

Rosegrant *et al.* (2008) stated that, "Even with sufficient mitigation measures the current scientific consensus holds that GHG emissions and atmospheric concentrations are set to increase for some decades. Consequently, global mean surface temperature will continue to rise long after an emissions peak has passed". Thus, in this context scientists should be encouraged to conduct research to come up with improved varieties of crops and breeds of animals that can resist adverse effects of climate change such as insufficient rainfall, high temperature, strong wind and so on. Such varieties and breeds should continuously be upgraded and made available to the farmers at affordable price or even free of charge. Adequate extension activities should be carried out in every nook and corner of SSA to enlighten farmers about the existence and technical knowhow of the varieties and breeds for possible utilization by the farmers of the region.

It is suggested that there is a very strong connection between deforestation and poverty and thus argued which causes the other. Whatever the case may be both are very important related problems that need to be addressed (Cunningham, 2010). Governments in SSA need to provide their citizens with alternative sources of fuel at affordable prices so that people can be restricted from indiscriminate felling of trees for firewood and other purposes. Without such alternatives no matter how much effort such governments put to stop the people from such acts, will be in vain. There is also need for SSA governments to devise ways of improving the welfare of their citizens such as creation of jobs opportunities, provision of social amenities, etc., as well as awareness campaign about the danger of deforestation. Cunningham also explained that targeting and fixing poverty are considered to be conventional ways to deal with deforestation and thus, governments together with various organizations, sees development as the main key to solution of the problem. Nonetheless, industrialization is also one of the causes of deforestation. This never ending circle of frustration leave many people wondering if there solution to the problem of deforestation, apart from letting the nature and the economy to deal with it. He pointed out that planting trees to replace the fallen ones and establishing orchard may help greatly.

To avoid climate change disaster, it is necessary to reduce the GHGs emission of our modern energy systems, which have adverse impact on our planetary boundaries (The Guardian, 2016). Here SSA leaders should collaborate with the rest of the world leaders to tackle the problems of GHGs emission from modern energy sources such as electricity generation. Because, Sub-Saharan Africa is still facing some of the earliest, most severe and most damaging effects of climate change. Thus, Africa's leaders need to support international efforts to address climate change. But they have to immediately deal with the alarming reality behind Africa's struggling and insufficient modern energy (The Guardian,

2016).

African countries are busy investing in long-lived investments such as ports, large dams, and social infrastructure, such as hospitals and schools which will probably last beyond 2050. But by then, Africa's climate may seriously change from what it is today. For instance, the Overseas Development Institute (ODI) and Climate and Development Knowledge Network (CDKN), revealed that governments and businesses across SSA are not considering long-term climate data in their investments and planning decisions. This includes studies from Zambia, Malawi, Rwanda, Ghana and Mozambique. It is alarming that poor use of climate data could put societies into conditions that make them very vulnerable to droughts, floods, high temperatures or sea-level rise in the future. Thus, putting climate change into long-term investments and planning decisions is vital for supporting climate-resilient development, but it's not happening in SSA (The Guardian, 2016). Therefore, SSA leaders should be considering climate change in their long-term investments and planning decisions so that its impacts can be suppressed at the long-run.

Perhaps, the preliminary point is to enhance the quality and quantity of African climate observation networks and scientific capacity in SSA. This will not only help in establishing information about past and current climates, as well as 'ground-truth' climate science through generating domestic knowledge, perspectives and skill but will also serve as a link between scientists, policy-makers and practitioners and help with presenting climate information in a format that decision-makers can act upon (The Guardian, 2016).

Generally there is little impact of agricultural research across SSA on improving the living standard of wet season farmers under the existing climatic conditions. Thus, a comprehensive strategy is needed if the challenge of adapting agriculture to future climate change is to bear fruit. It is useful to consider the criteria by which current successful initiatives should be judged. Success will be measured by the way that farmers are better able to cope with climate-induced risk and adapt to future climate change. But for that to happen and for agricultural research to have made a considerable contribution, in the shorter term there are key 'foundation stones' that must be in place upon which such research must be built (Cooper, Stern, Nogueira and Gathenya, 2013).

Climate change adaptation and mitigations are essential instruments to save the life of the vulnerable communities particularly in African continent. Integration of adaptation measures into sustainable development strategies is an efficient way of tackling climate change impacts. This will help to reduce the pressure on natural resources. After adequate environmental education and awareness campaign, stakeholders should do their best to bring change through adaptation and mitigation options. Through adaptation and mitigation workshops, the attitudes of peoples towards climate change solutions will be changed (World Bank, 2015).

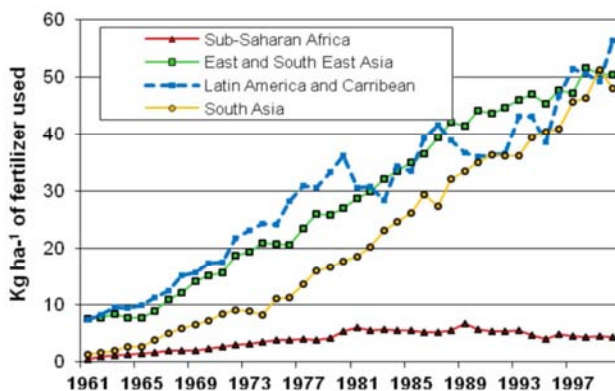
A key factor to implement is to encourage the community to participate in all adaptation and mitigation plan. In general, to minimize the impacts of climate change on Africa all

governmental and non-governmental organizations, private sectors and individuals should participate in afforestation, re-afforestation and forest conservation, and there should be concern from all organizations (private and individual) for water and soil conservation as well as wise use of water. The culture of water harvesting and storage techniques, livelihood diversifications and enhancing the use of climate resilient green economy are vital practices (World Bank, 2015).

Conducting research on climate change and dissemination of the finding to decision makers and stakeholders is another way of minimizing the impacts of climate change. Therefore, educational institutions, research centers and meteorological organization should focus on climate change researches. The data for such researches should be made available to researchers free of charge in order to encourage such researches and publication of the findings. The people of Africa should be educated and made aware of their role and how they can deliver such role in climate change adaptation and mitigations. It is noted that any governmental plan without the recognition of the people is difficult to implement and be unsuccessful. (Gemed and Sima, 2015).

Increase in Population worldwide, increase food demand, thus there is need for higher crop yields, leading to more intensive land use, which in turn result in nutrients depletion and soils degradation. Such nutrients depletion can only be immediately reversed with the help of chemical fertilizers thus, fertilizer use trends can act as a useful investment in agriculture. However, it is noted that Average rates of fertilizer use have risen ten times, that is from 5 to 50 kg/ha in many parts of Asia and Latin America during the last 50 years whereas in SSA they remain at about 5 kg/ha from 1980 onwards as can be seen in figure 4 (Cooper, Stern, Noguier and Gathenya, 2013).

Therefore, SSA governments should try as much as possible to ensure adequate supply of fertilizers to every parts of the region at prices that are affordable to farmers. When this happened, the farmers could be able to produce more food to meet the demand of the escalating population of the region.



Source: Cooper, Stern, Noguier and Gathenya, 2013.

Figure 4. Fertilizer use trends (kg/ha) in Africa, Asia and Latin America: 1960-2003.

Considering that the vast majority of actions on climate change are funded by developed countries, the slow release of

funding for adaptation projects is a significant cause for alarm. Regrettably, the principle of common but differentiated responsibilities and respective capabilities has not been consistently applied in relation to funding for climate change programmes in Africa (FAO, 2009). The FAO explained that the window of opportunity for investment in agriculture is restrained due to the potential impact of climate change in minimizing viable options for rural development. For example, investment in productivity can be optimized in conditions where natural and labour resources are undamaged by the disruption to crop cycles caused by climate change. This would mean governments and key stakeholders would be required to accelerate their efforts on expanding production capacity to maximize results. Thus, strategies for agricultural intensification and resilience of food production systems should be fortified through the creation of key synergies between mitigation and food security.

Renewable energy is an ideal option to complement large-scale hydro-power generation. Geothermal, small hydro, biomass cogeneration and wind energy options are attractive since the resources are widely available across the continent. These renewable energy options are not only environmentally friendly, but are more suitable adaptation responses to the adverse impacts of climate change (Ibingom, 2009).

4. Conclusion

Climate change has been causing a lot of problems to agriculture in Sub-Saharan Africa leading to decline in productivity due to extreme weather conditions such as high temperature, drought, flood, cyclones, etc. This gives an important signal about food security in the region. It was found that climate change and agriculture are inter-related, causing significant effects on each other.

Deforestation, agricultural activities, power generation, transportation and level of poverty are some of the anthropogenic causes of climate change in Sub-Saharan Africa.

Improvement of the welfare of the people through provision of social amenities and job creation, power generation through renewable energy, enlightening people about the danger of climate change and provision of alternative sources of fuel to people at affordable prices are some of the solutions to climate change threats in Sub-Saharan Africa.

Recommendation

It is recommended that:

- Sub-Saharan African governments should collaborate with the rest of the world to seek sustainable solutions to climate change threats.
- Sub-Saharan African governments should provide social amenities to their citizens.
- Kerosene and other cooking fuel should be made available by the government to people in the region at affordable prices to control indiscriminate felling of trees.

- d. Renewable energy should complement large-scale hydro-power generation across the region.
- e. Research should be conducted on climate change and the findings be properly disseminated to decision makers and stakeholders.
- f. Adequate environmental education and awareness campaign should be carryout and all stakeholders should be made to participate.
- g. People should desist from indiscriminate felling trees, where inevitable should be replaced with new ones.

References

- [1] Adams, R. M., Hurd B. H., Lenhart S. and Leary, N. (1998). Effects of global climate change on agriculture: An interpretative review. *Climate research*, 11: 19–30.
- [2] Asfaw, S. and Lipper, L. (2011). Economics of PGRFA management for adaptation to climate change: A review of selected literature. *Background study paper, no. 60*. Retrieved from <http://www.fao.org/docrep/meeting/023/mb695e.pdf>.
- [3] Chijioke, B. O., Haile, H. and Waschkeit, C. (2011). Implication of climate change on crop yield and food accessibility in Sub-Saharan Africa. Retrieved from http://www.zef.de/fileadmin/downloads/forum/docprog/Termpapers/2011_1_Oyiga__H_aile_Waschkeit.pdf.
- [4] Cooper, P. J. M., Stern, R. D., Noguier, M. and Gathenya, J. M. (2013). Climate Change Adaptation Strategies in Sub-Saharan Africa: Foundations for the Future. Retrieved from <http://dx.doi.org/10.5772/55133>.
- [5] Cunningham, M. (2010). Deforestation and poverty in Sub-Saharan Africa. Retrieved from <http://www4.ncsu.edu/~mtcunnin/World%20Forestry/>.
- [6] Dube, T. and Phiri, K. (2013). Rural livelihoods under stress: The impact of climate change on livelihoods in South Western Zimbabwe. *American International Journal of Contemporary Research*, 3(5): 11 – 25.
- [7] Ecolife (2011). Definition of climate change. Retrieved from <http://www.ecolife.com/define/climate-change.html>.
- [8] Food and Agricultural Organization (2009). Climate change in Africa: The threat to agriculture. Retrieved from http://ecoagriculture.org/wpcontent/uploads/sites_3/2016/08/ClimateChangeinAfrica_FAO.pdf.
- [9] Gemedo, O. D. and Sima, D. A. (2015). The impacts of climate change on African continent and the way forward. *Journal of Ecology and the Natural Environment*, 7 (10): 256 – 262.
- [10] Rosegrant, M.W., Ewing, M., Yohe, G., Burton, I., Huq, S., & Valmonte-Santos. R. (2008). Climate change and agriculture. Retrieved from http://ccsl.iccip.net/gtz_climatechange-agriculture.pdf.
- [11] International Funds for Agricultural Development (2011). Conference on new directions for smallholder agriculture, 24-25 January 2011, Rome, IFAD. Retrieved from <http://www.ifad.org/events/agriculture/doc/proceedings.pdf>.
- [12] Isingoma, B. J. (2009). Climate Change and energy in Africa. In Besada, H. and Sewankambo, K. N. (eds). *Climate Change in Africa: Adaptation, Mitigation and Governance Challenges*. CIGI Special Report, p. 36 – 40.
- [13] New World Encyclopedia (2015). Sub-Saharan Africa. Retrieved from http://www.newworldencyclopedia.org/entry/Sub-Saharan_Africa.
- [14] Nwuneli, N. (2011). A look at agriculture and agribusiness in Nigeria. Retrieved from <http://www.inter-reseaux.org/publications/revue-grain-de-sel/51-special-issue-nigeria/article/a-look-at-agriculture-and>.
- [15] Ringler, C., T. Zhu, X. Cai, J. Koo and Wang, D. (2011). Climate change impacts on food security in Sub-Saharan Africa. Insights from comprehensive climate change modeling. *International Food Policy Research Institute (IFPRI)*. Retrieved from www.cosv.org/.../climate%20change%20impacts%20on%20food%20security.pdf.
- [16] SciDev.Net (2016). Bringing science and development together through news and analysis. Retrieved from <http://www.scidev.net/global/climate-change/news/african-hunger-policy-climate-risks.html>.
- [17] Stern, N. (2006). The Economics of climate change. Retrieved March 12, 2015, from http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/destaques/sternreview_report_complete.pdf.
- [18] Stockholm Environment Institute (2013). Transport and environment in Sub-Saharan Africa. Retrieved from <http://www.sei-international.org/publications?pid=2197>.
- [19] The Guardian (2016). Sub-Saharan African countries are failing to plan for climate change. Retrieved September 6, 2016 from <https://www.theguardian.com/environment/2015/feb/13/no-sub-saharan-african>.
- [20] United Nations Environmental Protection (2013). Towards sustainable transport in Sub-Saharan Africa. Retrieved from <http://www.unep/transport/shareroad>.
- [21] United Nations Framework Convention on Climate Change (2014). Definitions. Retrieved from http://unfccc.int/essential_background/convention/background/items/2536.php.
- [22] Vermeulen, S. (2014.) *Climate change, food security and small-scale producers*. CCAFS Info Brief. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Retrieved November 21, 2014, from www.ccafs.cgiar.org.
- [23] Wikipedia (2014). Climate change. Retrieved from http://en.wikipedia.org/wiki/Climate_change.
- [24] World Bank (2013). What climate change means for Africa, Asia and the coastal poor. Retrieved from <http://www.worldbank.org/en/news/feature/2013/06/19/what-climate-change-means-africa-asia-coastal-poor>.
- [25] World Bank (2015). CO₂ Emissions (metric tons per capital). Retrieved September 14, 2016, from <http://data.worldbank.org/indicator/EN.ATM.CO2E.PC>.
- [26] Worldmap (2011). Sub-Saharan Africa. Retrieved from <http://worldmap.org/region.php?region=Sub-Saharan%20Africa>.