



Causes of Climate Change and Its Impact in the Multi-Sectoral Areas in Africa-Need for Enhanced Adaptation Policies

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Authors' contributions

This work was carried out in collaboration between both authors. Author ACM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AA managed the analyses of the study. Author ACM managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2018/37276

Editor(s):

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Complete Peer review History: <http://www.sciencedomain.org/review-history/24569>

Opinion Article

Received 8th October 2017

Accepted 24th April 2018

Published 11th May 2018

ABSTRACT

Africa has experienced climate change since the late Holocene which intensified in the last century mainly due to factors such as the changes brought about by the colonial administration, which led to rapid population growth from improved healthcare systems and infrastructure, and organised agriculture. Recent studies on climate change and its impact on Africa indicate that the continent is more vulnerable to climate change than other continents because of inadequate resources. The effect of climatic change has worsened in the last fifty years, mainly due to heavy pollution and the greenhouse effect caused by the industries in the developed countries and in the newly industrialized nation such as India, China, Korea, Malaysia, Thailand and others. Recent studies on climate change in Africa has shown that population growth has led to decline of forest cover,

increased land and environmental degradation, leading to severe ecological disruption. This change has wreaked and continued to cause severe damage to Africa's infrastructure, health and economy. Global warming related floods have destroyed roads, crops, water sources, and killed both people, livestock and wildlife. Droughts too have caused similar problem if not worse destruction. Africa's poverty makes it difficult for the people to mitigate their losses and to adapt to the conditions. It is, therefore, necessary for African countries and its leaders to adopt policies and laws which deliberately aim at addressing the problems created by climate change. These policies should be tilted towards adaptation rather than mitigation since African countries generally lacks the capacity. The objective of this paper is to create policy awareness on the causes of climatic change and its impact on sectoral systems in order to prioritise timely knowledge-based policy decision for stimulated green growth development opportunities. The findings and the conclusion are based on the available literature.

Keywords: Climate change; adaptation; mitigation; Africa policies; poverty.

1. INTRODUCTION

The effect of climate change on livelihoods in Africa has been disastrous and this is expected to get worse rather than improve.

While there have always been climatic variations in Africa, past variations had always been insignificant compared to the changes recorded from the 19th century to date. Throughout Africa and especially in East Africa, "the nineteenth and twentieth centuries were also periods of marked political, cultural and socio-economic change, accompanied by accelerating population increase and changing agricultural practices [1]. These changes followed the arrival of the colonialists which led to the introduction of, among other things, centralized administration, cash crops, organised subsistence farming, farm machinery such as ox-ploughs and tractors, pesticides and infrastructure such as roads. The colonial healthcare system also brought improvements in malarial treatments, immunization, and maternal and child care. All these led to the population explosion. However, the greatest changes such as the industrial revolution and the assembly lines, which had taken place in the developed world and in the newly industrialised countries such as China and India, led to tremendous global warming or the so-called greenhouse effect.

"The average global surface temperature has warmed 0.8°C in the past century and 0.6°C in the past three decades. A recent report produced by the U.S. National Academy of Sciences confirms that the last few decades of the 20th century were, in fact, the warmest in the past 400 years. The Intergovernmental Panel on Climate Change (IPCC) has projected that if greenhouse gas emissions, the leading cause of climate

change, continue to rise, the mean global temperatures will increase 1.4 – 5.8°C by the end of the 21st century" [2].

These climatic changes which have since intensified as a result of human activities' induced "greenhouse effect" such as the mushrooming of factories in China and India and the newly industrialised economies are affecting Africa the most, despite its low level of development characterized by few factories and other environmental pollutants such as nuclear tests. Africa contributes very little to greenhouse gas emissions, which are blamed for global warming, and which in turn adversely affect the weather conditions [3]. Africa's low level of development, further makes it difficult for it to mitigate damages brought on as a consequence of global weather changes, or even to adapt to these changes. Indeed "of all of the world's continents, Africa is the most vulnerable to the impacts of climate change. With so many Africans living close to the poverty line, climate change could roll back much of our hard-won progress on development." [4] Poverty further makes Africa "the most susceptible to climate change due to its vulnerability and inability to cope with the physical, human and socioeconomic consequences of climate extremes" [5]. While countries such as the United States of America and Australia have insurance covers for their citizens in the event of destruction by natural disasters such as wildfire or flooding, an African must end for himself in the event of such weather phenomena. Most international agreements and treaties on climate change mitigation are about the reduction of carbon emissions which are not a priority for Africa. As a result of an inability to carry out adaptive measures, Africa though a very low emitter of carbon suffers

more than the big polluters such as China or the USA.

2. EFFECTS OF CLIMATE CHANGE ON AFRICA'S LIVELIHOODS

The continent also relies heavily on direct consumption and exports to pay for the imported goods manufactured in the developed countries thus contributing to the problem of global GHG emission through the countries of origin of the manufactured goods. Indeed most manufactured items to Africa, are from heavy polluters such as China, South Korea, India and Malaysia. Although climate change is today a global environmental, economic, social, political and developmental problem, Africa's concern is quite different from that of other parts of the world:

"Africa's concern about climate change is more about the links between climate change and droughts, desertification, floods, coastal storms, soil erosion — contemporary disaster events that threaten lives and livelihoods, and hinder the continent's economic growth and social progress. Due to the limited relevance of past and current global climate change agreements to Africa's climate and environmental problems, the hardest hit region has benefited least from climate funding and investments for green, low carbon growth [5]. The effects of climate change manifest themselves through various aspects of Africa's livelihoods such as agriculture and so forth.

3. THE EFFECT OF CLIMATE CHANGE ON AFRICA'S AGRICULTURE

Africa, therefore, requires urgent adaptation measures as climatic change has adversely affected the continent in all aspects of life. One of these adverse effects is in the area of agriculture. Africa, especially Africa South of the Sahara, relies mainly on agriculture for both monetary income and subsistence. In a work on the Karamoja region of Uganda, Mubiru [6], notes that "agriculture is the backbone of Africa's economy and the livelihood of many people depend on it. However, most of this agriculture depends on rainfall and is therefore inherently sensitive to climate conditions. This makes agriculture one of the most vulnerable sectors to the risks and impacts of climate change and variability. It is projected that crop yields from rain-fed agriculture in some countries in Africa could be reduced by up to 50% by 2020 as a result of climate change."

The consequences of a reduction in crop yield alone would be catastrophic to Africa considering that:

"Africa has the highest fertility level, with around 4.7 children per woman. Even assuming a continued decline in fertility, given this high starting point, we should anticipate a continued rapid growth of the African population, which will roughly double in size between now and 2050" [7].

This could among other things, mean massive movements of people in search of food, farm invasions which would escalate Africa's conflicts, and widespread malnutrition with its associated maladies such as stunted growth in children and reduced immunity in both adults and children. Most importantly, climatic unpredictability may cause many investors to shy away from rain-fed agriculture which forms the backbone of food production in sub-Saharan Africa and yet this investment is vital if sub-Saharan Africa is to meet its future food requirements. Cooper, et al., [8] correctly observe that:

"Rain-fed agriculture will remain the dominant source of staple food production and the livelihood foundation of the majority of the rural poor in sub-Saharan Africa (SSA). Greatly enhanced investment in agriculture by a broad range of stakeholders will be required if this sector is to meet the food security requirements of tomorrow's Africa. However, production uncertainty associated with between and within season rainfall variability remains a fundamental constraint to many investors who often overestimate the negative impacts of climate induced uncertainty. Climate change is likely to make matters worse with increases in rainfall variability being predicted".

The most popular African food-grains such as maize, rice, millet and sorghum, are 89% rain fed [9].

4. CHANGES IN AFRICA'S LAND USE

Climatic variation and decline in agricultural output are promoting changes in land use; especially in areas closer to urban centres, which ironically, require even more food production. In these areas, people are giving up agriculture for housing estates, shopping malls or amusement centres. The farmers find the climate too unpredictable to continue with agriculture. For example in the Kenyan county of Kiambu which

is close to the capital Nairobi, the following observation has been made 10:

“Years ago, Kiambu was an agricultural zone with green lush vegetation of coffee and tea plantations, but the region has lately opened up for development with developers invading prime land to build homes for either sale or rent to an already bulging Nairobi population. The booming housing business is now threatening the area’s economic activity,; agriculture as many farmers are now selling off their land to developers with others cutting down their coffee and tea bushes to pave way for the now booming construction business” [10]. This phenomena has reduced the carbon sink potential of the area.

5. ERRATIC WEATHER PHENOMENON

Although the Kiambu example is a recent trend, it is being replicated in all peri-urban areas of all sub-Saharan cities. This accounts for the rising costs of food and other agricultural products in African cities. It also worsens the climatic degradation as in most cases, the crops being destroyed such as coffee, tea bushes and banana plantations would contribute towards the mitigation of global warming [11]. These developments entail removal of different plant species, both natural and man-made which protect ecosystems’ vitality and human health.

In Africa, the effect of rising temperature due to climate change means that it rains in the periods which used to be dry and which were used for harvest and transportation of food and other agricultural produce to the market. This unpredictable weather phenomenon has three adverse effects on the agricultural outputs: one is that the harvests are disrupted as the farmers find it difficult to harvest in the rain; secondly, the food crops harvested such as groundnuts, maize, millet, sorghum and cash crops such as cotton, cocoa, coffee or tea cannot dry properly and therefore have lower qualities; and finally, the crops cannot be transported to the market centres due to flooded roads, landslides, and so forth. Food prices too are adversely affected due to weather changes. Ojok’s [12] observation concerning Uganda is applicable to the whole of Sub-Saharan Africa.:

“Uganda’s agricultural sector heavily depends on physical structures such as roads, bridges, communication networks, storage, and market places that are essential to support the production of goods and services, the distribution

of finished products to market, and people’s access to basic social services. Climate change has and will continue to have significant direct and indirect impacts on agricultural infrastructure in Uganda. It is predicted that Uganda will continue to experience rising temperatures, which will increase by more than 2°C by 2030. Additionally, the growing variability of inter-annual rainfall is projected to continue and is likely to cause an increase in rainfall during the dry season as well as an increase in the frequency of extreme events such as floods and landslides. Infrastructure is critical to economic performance, growth, and development. ...during weather-related emergencies, the damage to transport, storage, bridges, fuel supplies, and other vital agriculture-related infrastructure can be a bigger constraint on food availability and a bigger driver of food price increases than the direct impacts on food production”.

6. CLIMATE CHANGE ON INFRASTRUCTURE AND FOOD SUPPLY SYSTEM

The impact of climate change is seriously being felt in Kenya. In May 2016, more than 700 people comprising about 620 children and 48 expectant and lactating mothers were stranded in Isiolo County villages after heavy rains cut off road. The stranded people were threatened with starvation and diseases because they could not access food and health care [13]. The issue became worse considering that Isiolo area of Kenya is semi-arid and is usually dry in the month of May. This also meant that there was no prior preparation for the floods since the locals and the administration did not expect rains around the month of May.

Due to its semi-arid condition, the majority of the people could not swim and were adversely affected by the floods. The food distribution system was disrupted due to the flood.

In this era of climatic change, floods alone can cause havoc in both the food production and the food supply systems [14] as was seen in the Isiolo incident.

7. EFFECT OF CLIMATE CHANGE ON CASH CROP PRODUCTION

Another area of concern is cash crops. Nearly all of the sub-Saharan African countries, with the exception of a few such as South Sudan, Angola

and Nigeria, sustain their economies through cash crops such as tea, coffee, cocoa and cotton. The economic dependency of sub-Saharan Africa on agricultural crops is up to 90% and on natural resources such as timber, fishing, minerals and so forth is up to 85% [15]. Changes in climate are therefore threatening the backbone of many African economies. A clear example is the case of the Kasese area of western Uganda where coffee is the dominant cash crop. To the Ugandan farmers of Kasese:

"Droughts were becoming longer, rainfall during the rainy season was becoming more erratic, and that the rains were shorter. This has impacted the coffee production patterns and therefore negatively impacted coffee yield in general. Furthermore, certain pests and diseases (e.g. leaf miners, coffee berry borers, mealy bugs, and leaf rust) seem to be increasingly higher altitudes as climate changes" [16].

As "the productivity of food crops is inherently sensitive to variability in climate", [9] the diseases do not stop with cash crops only but are also spreading onto food crops such as bananas, cassava, potatoes, maize, millet and others. Some experts have even gone as far as recommending that certain communities should abandon their staple food such as maize in preference of drought resistant varieties such as millet and sorghum [17].

8. CLIMATE CHANGE AND SOCIAL LIFE

Unfortunately, the effects of climate change are not limited to agriculture alone. They pervade all aspects of African life. The United Nations Development Programme/United Nations Environment Programme [18] a study on the Lake Kyoga catchment areas of Uganda listed the adverse effects of climate change as:

1. "Food insecurity
2. Landslides and soil erosion
3. Water shortages and quality changes
4. Energy insecurity
5. Biodiversity loss
6. Climate-related disasters
7. Conflict due to resource scarcity and forced migration
8. Disease pattern shifts."

Food insecurity is mainly due to droughts or changes in weather patterns, therefore, bringing confusion to the planting and the harvesting seasons. Food storage also becomes a problem

with the unpredictable weather patterns. Perhaps the best statement about this comes from Tirado et al. [19] where he states that:

"Climate change and variability affect stages of the food chain, from primary production through to consumption. Due changes in temperature and precipitation patterns, increased frequency and intensity of extreme weather events, ocean warming and acidification, and changes in contaminants' transport pathways among others. Climate change may also affect socio-economic aspects related to food systems such as agriculture, animal production, global trade, demographics and human behaviour which all influence food safety".

The severity of landslides has since increased all over Africa. In Uganda, Kenya and Tanzania, landslides have become biannual events. There are floods and landslides leading to deaths during every rainy season. The event of weekend of 7-8th May 2016 is still memorable:

"El Nino-induced rainfalls have wrecked havoc in Kenya, Ethiopia, Tanzania, and over the weekend, Rwanda. Southern Africa has also not been spared with the output of the staple maize crop cut by nearly half." [20].

Apart from both cash and food crops, farmlands and livestock, over 49 Rwandese lost their lives in the landslides that followed the rainfalls of May 2016; and many more lives were lost over the same period across Kenya, South Sudan, DRC Congo, Ethiopia and several other African countries. One intriguing aspect of global warming is that while it is raining in one area, causing death of people, livestock and farm destruction there is always drought in another area causing death and loss of resources. This was also the case in 2016 for, Somalia and other Eastern African countries as well as in Madagascar. For Madagascar it started towards the end of 2015.

"In Madagascar, 700,000 people are thought to be affected by the drought in the south, whereas in the north 30,000 people have been affected by heavy rain that has brought a high risk of flooding and landslides. In Mozambique, over 40% of this season's crops in the south have been lost to drought. In the north, storms and heavy rains have left 45 dead and destroyed over 1,000 homes since the start of the rainy season in October 2015." [21].

9. AFRICA'S CLIMATE CHANGE AND WATER AVAILABILITY

It is also true that water shortages and declining quality are being experienced in nearly all African cities as well as in the rural areas. According to Urama and Ozor [22]:

"Climate change is having a multitude of immediate and long-term impacts on water resources in African countries. These include flooding, drought, sea-level rise in estuaries, drying up of rivers, poor water quality in surface and groundwater systems, precipitation and water vapour pattern distortions, and snow and land ice maldistribution. These effects, when compounded together, have devastating impacts on ecosystems and communities, ranging from economic and social impacts to health and food insecurity, all of which threaten the continued existence of many regions in Africa".

While the common slogan in Africa is that 'water is life', the Intergovernmental Panel on Climatic Change (IPCC), warns that the whole of the impact of climatic change shall be felt through water. According to the Panel:

"...the impacts of climate change on humanity will be felt 'mainly through water', via shifts in rainfall and extreme events, and that the poor and vulnerable – particularly in Africa – will suffer most. These climate impacts include both impacts on the water sector (e.g., damage to water supply and sanitation infrastructure from floods) and impacts from water on other sectors (e.g., flood damages to agriculture)." [23].

The water availability in Africa is already a problem and this is expected to worsen.

10. CLIMATE CHANGE AND ENERGY IN AFRICA

As far as energy is concerned, from Cape Town to Cairo, power cuts are no longer the exception. Some cities such as Blantyre in Malawi and Dar es Salaam in Tanzania can go for days without power supply. Enete [24] concludes that:

"...climate change undermines power and energy production by increasingly depleting renewable and non-renewable sources, creating resource scarcity as well as damage to infrastructure".

11. LOSS OF BIODIVERSITY

As for loss of biodiversity, the list of African endangered species keeps growing and despite biodiversity being vital to the survival of African people.

"Biodiversity is an important resource for African people. Uses are consumptive (food, fiber, fuel, shelter, medicine, wildlife trade) and non-consumptive (ecosystem services and the economically important tourism industry). Given the heavy dependence on natural resources in Africa, many communities are vulnerable to the biodiversity loss that could result from climate change." [25].

12. RESOURCE CONFLICT AND DISEASES

The available literature concludes that nearly all African countries are facing resource conflict due to the changing weather patterns. These conflicts have resulted in fragility in areas such as north and north-east Kenya, eastern Uganda, Sudan and South Sudan, large swaths of Ethiopia and Eritrea, and northern parts of Nigeria, among others. It is generally agreed that these conflicts intensify during extreme weather patterns such as during extreme flooding or droughts [26]. This is a common occurrence in areas such as Karamoja of Uganda, and north and north east Kenya, where precious human life and resources are lost, leading to the missed opportunities for socioeconomic development of Africa.

Climate change is also increasing the spread of human diseases as well as the emergence of new ones. For example, the East African El Nino event of 1997/9 is blamed for "induced floods and landslides. One thousand people were reported to have died in flood related accidents while 150,000 people were displaced from their homes. Damage to trunk and rural road infrastructure was estimated at US 400 million and infiltration of water resources and flooding of some water pumping stations [27]. The cholera outbreak cumulatively caused 41,857 cases and 1,682 deaths from December 1997 to July 1998" in Uganda alone [28]. The older diseases such as yellow fever, malaria and tuberculosis which had disappeared or were effectively contained re-emerged with deadlier strains. The ballooning African urban slums such as Kibera in Kenya and Soweto in South Africa have exacerbated the conditions. These slums with their open sewers,

blocked drainages and stagnant pools of water have become the breeding grounds for these diseases. Austin [29] correctly asserts that:

“The economic dependency and environmental decline lead to increased urban slum populations in less developed nations, and nations with larger urban slum populations have higher rates of TB and malaria”.

Climatic change appears to be blamed for the outbreak of diseases in Uganda in 2000 that are not confined to diarrhoea, cholera Ebola and Rift Valley Fever (RVF) for example RVF disease afflicts domestic animals and humans with symptoms ranging from mild to severe, mild symptoms include haemorrhagic fever, muscle pains and headaches whereas severe symptoms range from loss of sight within weeks of infection to brain inflammation, which can lead to headaches and seizures was confirmed for the first time in Uganda in 2016 [30] Another disease blamed on the climatic change is, Dengue Fever, which hit the region in 2014. In Uganda the alarming headline was that “health experts have confirmed a strange viral infection known as, Chikungunya, virus which is transmitted by mosquitoes and its signs and symptoms are similar to those of malaria, has no known vaccine or cure at the moment [31], Chikungunya virus caused health havoc in Mandera County in north east Kenya. In Tanzania it was reported that climate change induced diseases and did not confine itself to new ones only but also to the immigration of old ones:

“Climate change can affect human health and well-being through mechanisms. The risk of emerging diseases may increase due to changes and survival of pathogens in the environment, changes in migration pathways, carriers and vectors and changes in the natural ecosystems. Infectious agents are in a state of perpetual adaptation to their new host (s) or vectors, which can lead to the emergence of ‘new’ diseases or the spread of known diseases to previously unaffected areas.” [32].

Due to the tragedy being wrought by climate change, African countries must, therefore, think of and work towards a coordinated measure that can lead towards seamless adaptation. This should be a multi-pronged approach involving all aspects of the economy including the sciences. The donors, as well as the lenders, should make activities that lead to climatic adaptation their key conditions for development assistance

or lending. Already a major German bank which funds many activities in Africa has recognized adaptation as one of its key goals:

“At DEG we consider climate change to be one of the fundamental challenges of our times. Climate change will affect people and their lives in established and in emerging markets. Our partners in the developing world will be hit hard by its consequences. Massive efforts will have to be initiated to adapt lifestyles and economies quickly to these changes in order to be able to at least alleviate these impacts...The promotion of ecological, economic and social development forms a keystone of our mandate. Consequently, DEG has elevated climate protection and adaptation to be a strategic goal. Projects with a positive climate effect are given a high priority. We have formulated clear investment targets and defined focus sectors, where we see specific growth potential”. [33].

13. CLIMATE POLICY

African countries must therefore refrain from projects that exacerbate climate change such as clearing off forests and destroying wildlife habitats to make way for infrastructural developments. While north and Central America has stable wildlife and forest covers, Africa, South America and Oceania have registered net loss [34]. The sciences such as engineering should also play their role in the process of climatic adaptation by declining to undertake projects that may compromise the process of adaptation or endeavour to explain to clients very clearly the consequences of such undertakings [35]. Clear policy frameworks in respect to adaptation too must be developed and adhered to. Developed countries such as the United Kingdom [36], Australia [37] and many other countries which are even less prone to climatic variations have since developed comprehensive policy frameworks towards climatic adaptation and mitigation. In Australia, the Climatic Change Act, 2010 of Victoria makes it clear that in matters touching on or could have effect on the environment or climate:

A decision should be based on:

- (a) Careful evaluation of the best practically available information about the potential impacts of climate change to avoid, wherever practicable, serious or irreversible damage arising from climate change.

- (b) An assessment of the consequences of each of the options in making a decision having regard to the risks of each of those options.
- (c) Managing and allocating the risks associated with the potential impacts of climate change in a manner that is easily seen and understood and endeavoring to achieve best practice.

A decision should not rely on a lack of full scientific certainty as a reason to postpone appropriate measures to prevent serious or irreversible loss or damage as a result of climate change." [38].

Thus all attempts must be made to avoid acting in favour of the "benefit of the doubt" instead of taking such doubt broadly and overruling any actions that may be detrimental to the climate in the near or distant future. It is therefore wise to follow Von Schomberg's [39] advice that:

"Where, following an assessment of available scientific information, there is reasonable concern for the possibility of adverse effects but scientific uncertainty persists, provisional risk management measures based on a broad cost/benefit analysis whereby priority will be given to human health and the environment, necessary to ensure the chosen high level of protection in the Community and proportionate to this level of protection, may be adopted, pending further scientific information for a more comprehensive risk assessment, without having to wait until the reality and seriousness of those adverse effects become fully apparent."

The benefit of the doubt, if any, should be in favour of environmental protection rather than degradation such as hiving off rainforests for shopping malls, tea and coffee plantations [40] or the destruction of national parks for roads or railways [41]. This should be the key guiding principle of African policy towards climate change and adaptation.

14. CONCLUSION

Due to human activities, climate change has worsened in the last few years. This change has adversely affected Africa in areas such as food security health, infrastructure and economy. Africa's vulnerability such as rampant poverty makes climate mitigation unsustainable. Africa should therefore concentrate on the adaptive measures to climate change and the international

community should help Africa towards this end. The adaptive measures should be hinged on effective climate policies such as reforestation, conservation of wetlands, introduction of crops and livestock suitable to changing the climate and other suitable adaptive measures.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Lamb H, Darbyshire I, Verschuren D. Vegetation response to rainfall variation and human impact in central Kenya during the past 1100 years. *The Holocene*. 2003;285-292.
2. Case M. Climatic change impacts on East Africa: A review of the scientific literature. Gland, Switzerland: WWF-World Wide Fund for Nature; 2006.
3. Hepworth N. Climate change vulnerability and adaptation preparedness in Uganda. Nairobi: Heinrich Böll Stiftung Regional Office for East and Horn of Africa; 2010.
4. Bank AD. Africa' climatic opportunity: Adapting and thriving. Abidjan: African Development Bank; 2015.
5. Besada H, Sewankambo N. CIGI Special report: Climate change in Africa Adaptation, Mitigation and Governance Challenges. Waterloo, Ontario, Canada: Centre for International Governance Innovation; 2009.
6. Mubiru DN. Climate change and adaptation options in karamoja. Kampala: EU/FAO; 2010.
7. Connor S. Global population will soar to 11.2bn by 2100 - with Africa accounting for much of the growth, says UN forecast. *The Independent*; 2015. DOI:<http://www.independent.co.uk/news/world/africa/global-population-will-soar-to-112bn-by-2100-with-africa-accounting-for-much-of-the-growth-says-un-10448880.html>
8. Cooper PJ, Dimes J, Rao K, Shapiro B, Shiferow B, Townlow S. Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? *Agriculture, Ecosystems and Environment*. 2008;126:24-35.
9. Challinor A, Wheeler T, Garforth C, Craufurd P, Kassam A. Assessing the

- vulnerability of food crop systems in Africa to climate change. *Climatic Change*. 2007;381-399.
10. Olingo A, Ayodo H. Property whirlwind in Kiambu County. *The Standard*; 2011. (Retrieved July 14, 2016)
Available:<http://www.standardmedia.co.ke/lifestyle/article/2000037208/property-whirlwind-in-kiambu-county>
 11. Somorin OA, Visseren-Hamakers IJ, Arts B, Tiani AM, Sonwa DJ. Integration through interaction? Synergy between adaptation and mitigation (REDD+) in Cameroon. *Environment and Planning C: Government and Policy*. 2016;415-432.
 12. Laker-Ojok R. An overview of climatic change and agriculture infrastructure in Uganda. Burlington, Vermont: USAID; 2014.
 13. Psirmoi D. 700 people stranded in Isiolo villages after floods. *The Standard*; 2016. Available:<http://www.standardmedia.co.ke/article/2000201753/700-people-stranded-in-isiolo-villages-after-floods>
 14. Mwaura FM, Okoboi G. Climate variability and crop production in Uganda. *Journal of Sustainable Development*; 2014.
 15. University, Gothenborg. Poverty and environment in Uganda. Gothenborg: PEAP 2004.
 16. Jassogne L, Laderach P, Asten PV. *Climatic change on coffee in Uganda*. London: Oxfam; 2013.
 17. Shongwe P, Masuku MB, Manyatsi AM. Cost benefit analysis of climate change adaptation strategies on crop production systems: A case of Mpolonjeni Area Development Programme (ADP) in Swaziland. *Sustainable Agriculture Research*; 2014.
 18. UNDP/UNEP. *Uganda Policy Brief: climate change, the environment and human welfare lessons learned from the Lake Kyoga catchment area*. Nairobi: UNDP/UNEP; 2004.
 19. Tirado MC, Clarke R, Jaykus LA, McQuatters-Gollop A, Frank JM. Climate change and food safety: A review. *Food Research International*. 2010;1745-1765.
 20. Jalloh AB. *El Nino-induced floods ravage East Africa*. Deutsche Welle; 2016.
 21. Davies R. *Poor Distribution of Rainfall Leads to Floods and Droughts in Southern Africa*. Floodlist; 2016.
 22. Urama KC, Ozor N. *African Technology Policy Studies Network*. Retrieved from African Technology Policy Studies Network; 2010. Available:http://www.ourplanet.com/climate-adaptation/Urama_Ozorv.pdf
 23. Doczi J, Ross I. *Oxford Policy Management*; 2014. (Retrieved from Oxford Policy Management)
Available:[http://www.opml.co.uk/sites/default/files/Doczi%20%26%20Ross%20\(2014\).pdf](http://www.opml.co.uk/sites/default/files/Doczi%20%26%20Ross%20(2014).pdf)
 24. Enete CI. Potential impacts of global climate change on power and energy generation. *Journal of Knowledge Management, Economics and Information Technology*. 2011;6. (Retrieved July 18, 2016)
Available:<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.674.5945&rep=rep1&type=pdf>
 25. Desanker PV. *WWF UK*. Retrieved from WWF UK; 2002. Available:http://www.wwf.org.uk/filelibrary/pdf/africa_climate.pdf
 26. Raleigh C. Come rain or shine: An analysis of conflict and climate variability in East Africa. *Journal of Peace Research*. 2012; 51-64.
 27. Tumwine C. *National identity development. Promoting Pluralism Knowledge in Uganda*. Kampala: Makerere University; 2009.
 28. Namanya DB. *An assessment of the Impact of climate change on the Health Sector in Uganda: A case of Malaria and Cholera epidemics and how to improve planning for effective preparedness and response*. Kampala: Ministry of Health, Uganda; 2009.
 29. Austin KF. *Dependency, Urban Slums, and the Forgotten Plagues Tuberculosis and Malaria Prevalence in Less Developed Nations*. *Sociological Perspectives*. 2015; 286-310.
 30. Ayebe AL. *Uganda: Government Confirms Rift Valley Fever Outbreak*. *The Observer*; 2016.
 31. Agaba J. *Strange malaria-like disease hits Uganda*. *The New Vision*; 2014.
 32. Mboera LE, Mayala BK, Kweka EK, Mazigo HD. *Impact of climate change on human health and health systems in Tanzania: A review*. *Tanzania Journal of Health Research*; 2011.
 33. Group, Deg. Bank. *Addressing climate risk: Financial institutions in emerging markets*. Cologne: DEG Bank Group; 2009.

34. Okia CA, Ed. Deforestation: Causes, Effects and Control Strategies, Global Perspectives on Sustainable Forest Managemen. Intech; 2012.
35. Board CE. (Undated). Priciples of Climate Change Adaptation for Engineers. Ottawa: Canadian Engineering Qualifications Board.
36. Government, Her. Majesty. UK climate change risk assessment: Government report. London: The Stationery Office; 2012.
37. Government, Australia. Canberra. Climate change vulnerability assessment framework for infrastructure. Canberra: Policy and Cabinet Division, Chief Minister and Cabinet Directorate; 2012.
38. Government of Victoria, A. The Climatic Change Act, 2010. Act No 54 of 2010. Government of Victoria, Australia; 2010.
39. Howden D. UGANDA: African forest under threat from sugar cane plantation. The Independent (UK); 2007.
40. Kushner J. Controversial Railway Splits Kenya's Parks, Threatens Wildlife. National Geographic; 2016.
41. Achen T. (Ed.). Microscopic modification and big politics. Vadstena, Sweden: Linköping Studies in Arts and Science; 2004.

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