“Development at the crossroad in the age of climate change in Africa: crises of adaptation and human security in the 21st century”

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Development at the crossroad in the age of climate change in Africa: crises of adaptation and human security in the 21st century

Abstract

It is likely that development in Africa has reached a critical stage with the turn of the 21st century. This is as a result of climate change and the lack of adaptive and mitigative means on the continent. Despite the fact that environmental crisis in Africa is not the making of the continent, but for the unsustainable technology that were environmentally unfriendly. This is evident when one examines the problem of food security where subsistence farming dominates food production. With these problems, the introduction of living genetically modified crops and animals (LMOs) by developed states brings about the displacement of cultural heritage among indigenous people, increases health hazards and by extension, pressure on the scarce financial availability for African governments in addressing challenges related to development. As maintained by many students of climatology and development studies, the exact impacts of climate change is not yet known but what is sacrosanct is the fact that it is caused mostly through anthropogenic of industrial revolution. The solution to this curse should be human, in the form of adaptation and mitigation.

Keywords: climate change, food security, mitigation and adaptation, Africa, conflict.
JEL Classification: Q54, Q57.

Introduction

Climate is the manifestation of a great complex system consisting of five interacting parts: the atmosphere (air), the hydrosphere (water), cryosphere (frozen part of the earth), the land surface, and the biosphere (part of the earth where life exists) (De Chavez and Tauli-Corpus, 2008). Shift of weather conditions over a period of time causes climate change. The average temperature on the planet has been growing in recent time; resulting in harsh and unpredictable climatic conditions across the globe. Climate change can impact on all natural systems, hence a threat to human development and survival (socially, politically and economically).

According to the Intergovernmental Panel on climate change Fourth Assessment Report (2007), about 75 to 250 million people in Africa may be exposed to increasing water shortage due to climate change in 2020. Water is life with all the implications on the very survival of humanity. Not only that water will be a scarce commodity for domestic use, it will impact on agricultural production as the length of growing seasons and production potentials are expected to decreases due to climate change. Proceeds from rain-fed agriculture in some countries are expectedly reduced to about fifty percent according to the report. Thus, climate change is likely to have serious impacts in developing areas because of the twin issues of adaptation and mitigation challenges. This implies that more than 800 million people would likely be malnourished.

According to the World Bank (2008), almost 75% of poor people in developing countries depend on agricultural activities for their livelihood. This is pertinent in the African continent where subsistence farming is the order of the day. The crisis of environmental degradation is compounded with the introduction of ultra-capitalist genetically modified crops and animals. For any improvement in terms of crop and animal yield, many farmers have been hypnotized to embark on highly subsidised seeds which ought to be a capital investment, but ironically reduced to recurrent expenditure.

Negative impacts of climate in the riverine areas through flooding accompanied with various types of associated water borne diseases have started affectting many littoral states such as Madagascar, Comoros, Nigeria, Cape Verde and other states on the continent. The United Nations Framework Convention on Climate change (UNFCCC, 1992) defines climate change as a change of climate directly or indirectly attributed to human activity that affects the composition of the global environment, which in addition to natural climate variability is noticed over a considerable period of time. The UNFCCC draws a line between climate change relating to human actions and climate variability relating to natural causes. The impact of this is global warming. According to De Chavez and Tauli Corpus (2008), global warming is the average increase of the earth's surface temperature and oceans compared to previous centuries. It is greenhouse gases (GHGs) such as carbon dioxide (CO_2), emanating from human use of fossil fuel that trap heat in the atmosphere that regulates our climate. The gases exist naturally, but humans have further polluted the atmosphere with

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additional CO_2 by burning fossil fuels for power (coal, oil and natural gas) and through deforestation.

Because more GHGs trap more heat, average temperatures around the world are growing. Even the oceans also absorb this additional CO_2 thereby making it acidic and less friendly for sea life. Other impacts include changes in soil erosion, storms, floods and drought. The results would be a deepening food crisis, deteriorating weather conditions, decrease in energy and general environmental breakdown.

1. Causes of climate change/variations

The major cause of climate change is the constant burning of fossil fuels – coal, oil and natural gas that constantly release of carbon dioxide, (CO_2) nitrous oxide (N_2O) and methane (CH_4) in the atmosphere as a result of the alarming activities of man in the atmosphere.

In the past, the atmospheric condition of the earth increased tremendously, as portrayed by geological evidence of ice ages, sea level changes and by the record of human history over hundreds of years. It is always very difficult to say with precision the causes of past changes in the climate, but what is certain is that it is related to changes in ocean currents, solar activity, volcanic eruptions and other natural causes. The difference now is that global temperature has risen tremendously over the past few decades. There is a very strong view of increases in average global air and ocean temperature, melting of snow and ice and rising global sea-level. The IPCC Fourth Assessment Report concludes that global warming is very clear. Atmospheric and ocean temperatures have been on the rise, more in the past five centuries, and probably for more than a millennium. Scientists have known long ago that the atmosphere's GHGs act as a 'blanket' that traps incoming solar energy and keeps the Earth's surface warmer, and that an increase in atmospheric GHGs leads to additional warming.

The burning of coal, oil and natural gas, as well as deforestation and various agricultural and industrial practices, are altering the composition of the atmosphere and contributing to climate change (www.gcrio.org). GHGs are chemical compounds such as water vapour (H_2O, CO_2, CH_4 and N_2O) found in the atmosphere (De Chavez and Tauli-Corpus, 2008). Other substances such as hydro fluorocarbons (HFCs) and per fluorocarbons (PFCs) result greatly from human industrial processes and contribute to GHGs. H_2O and CO_2 account for 90% of total GHGs emission. In terms of direct contribution of these GHGs, CO_2 contributes 55%, CH_4 (15%), CFCs (7%), and N_2O (6.5%) (www.undp.org). CO_2 is an end product of fossil fuel that produces the much needed energy essential for the transportation, manufacturing, heating, cooling and the generation of electricity among others. Fossil fuels presently account for about 80 to 85% of CO_2 released into the atmosphere. Deforestation from ranching, logging and agricultural practices also contributes to CO_2 emissions. Land use changes also contribute to about 15 to 20% of current CO_2 emissions (www.gcrio.org). CH_4 (natural gas) is the second most important of GHGs resulting from human activities (www.ecearth.org/article/causes_of_climate_change). It is produced during rice cultivation, cattle and sheep ranching and by decaying materials in landfills. It is also produced during coal mining, oil drilling and by gas pipeline leakage. N_2O is a product of agricultural and industrial practices. Chlorofluorocarbon (CFCs) is used in refrigeration, air conditioning and also as solvents.

Natural changes in the climate come from interaction between the atmosphere and ocean, referred to as internal factors, and from external causes such as variations in the sun's energy output which would externally vary the amount of solar radiation received by the earth's surface (www.eoearth.org/article/causes_of_climate_change), and in the amount of material injected into the upper atmosphere by explosive volcanic eruptions (www.gcrio.org).

2. Projections for climate change

The main projection of future climate patterns are largely based on computer-based models for climate systems that incorporate important factors and processes of the atmosphere and oceans, including the expected growth in GHGs from socio-economic scenarios for the coming decades. The IPCC looked examined results published by different researchers and on this basis, has projected that by 2100 (IPCC Fourth Assessment Report):

- The global average surface warming (surface air temperature change), will increase by 1.1 to 6.4^{o}C.
- The sea-level will rise between 18 and 59 cm.
- The oceans will become more acidic.
- It is most likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent.
- It is also most likely that there will be more precipitation at higher latitudes and is likely that there will be less precipitation in subtropical land regions.
- It is envisaged that tropical cyclone (typhoons and hurricanes) will be heavier, with larger peak wind speed and heavy precipitation associated with ongoing increases of tropical sea surface temperatures.

The projected changes in climate are likely to alter the health status of millions of people, including through increased deaths, diseases and injury due to heatwaves, floods, storms, fires, and drought. Increased malnutrition, diarrhea and malaria in some areas will increase vulnerability to extreme, public health and development goals will be threatened by long-term damage to health due to disasters.

Drought affected areas will likely become more widely distributed. Precipitations are most likely to increase the incidence of high flood risks as experienced in many parts of African states, most especially in arid regions where water scarcity have always been experienced. Dry tropics and other regions supplied by melt/thaw water from mountain ranges will increase water availability in the ocean with its negative impacts on mangrove areas of West African states and some Islands such as Cape Verde, Comoros, Madagascar and Seychelles. While some mid-latitude and high latitude areas will initially benefit from higher agricultural production, for many others, at lower latitudes, especially in seasonally dry and tropical regions, increases in temperature and the frequency of droughts and floods will likely affect crop production negatively, which can increase the number of people at risk of hunger and increased level of displacement and migration.

Climate change projection in Africa is challenged by limited sources of information. While there is visible and growing evidence that climate change is widely known, regional and local trends are at times clouded by high yearly and inter-annually variability in climatic conditions. The inadequacy of meteorological data network and near difficult access to data in many areas of Africa represents an additional challenge to determining climate change. How to determine good and quality information on climate change differs across the continent. There are various types of global climate change model (GCM) simulation for various scenarios that are available, and they are being used to assess the effects that might be experienced in Africa.

The region will now have to find a way out of increase in temperature that will affect agricultural and natural ecosystem; increase water scarcity and regional variations on water availability; reduced agricultural growing duration in many parts of Africa and intensified precipitation events that might escalate the level and flooding time.

Table 1. Overview of climate changes projections for Africa

Change	Regions
Average conditions	
Temperature increase	Entire continent (medium projected increase in annual average temperature: 3 to 4°C (end of century to present)
Decrease in rainfall	West coast of Africa as far South as 15°N Southern Africa
Increase in rainfall	Northern parts of East Africa
Uncertain projections for rainfall	Sahel (already high variability) Guinean coast Southern Sahara
Sea level rise	Low lying islands and Coastal zones Delta regions
Extremes	
Increase in intense precipitation events	Entire continent (this applies also in regions of mean drying because there is a proportionally larger decrease in the number of rain days)
Cyclones	Uncertain changes in magnitude and frequency, and shifts in Cyclone tracks possible

Source: Based on IPCC (2007).

3. Projected temperature change

African continent has warmed by about 0.5% in the past century. Based on the available information, the projected annual average increase in temperature will probably rise by between 3 and 4 degrees Celsius by the end of the 21st century. From available data, the present degree of precipitation will likely increase in future. Given that global warming in dry areas is increasing, there will be tendency for dry areas to be drier and wet areas wetter. Areas with less rainfall will most probably experience lesser rain, while places that had already received substantial quality of rainfall are most likely to receive more. This will pose additional problems to lively-hood and economic activities that depend on natural resources. Increase in temperature will eventually lead to increase evaporation from the soil and water bodies. An anticipated change in annual average precipitation implies overall wetting and drying of annual climate. Changes in the timing and level of monthly rainfall, coupled with changes in temperature and other conditions, result in changes in run-off and groundwater recharge. Substantial amount of research is going on to manage the GCM stimulation result that helps manage changes in hydrological cycle and reshape river basins that gingered climate risk.

4. Projected changes in the length of growing (LGP)

As mentioned above, agriculture is the main source of employment for the teeming population in the continent. Majority of farmers practice subsistence farming as against mechanised farming practiced in developed areas. The implication of this, among others, is that lack of modern irrigation amounts to poor crop yield during failure of rainfall. In some instances, when there is too much rainfall, flooding may lead to displacement and poor crop production as well. As experienced in the delta regions of the Gulf of Guinea in Africa, the length of crop growing keeps on decreasing as a result of too much rain or too little available water from the pattern of rainfall. While the level of changes differs from one another, either because of the kind of the scenario and model applied, the general picture on how growing periods might look like across the region proves that the fall in the length of the growing period will be more visible in places where climatic conditions are already problematic to agriculture-based means of sustenance. A drop in the length of growing is also visible in places with projected rise in rainfall due to improved evaporation under climate change.

According to Zhu (2005), climate change has both positive and negative effects on farming. But there can be a worst scenario in the long run that might lead to food scarcity if nothing is done to arrest the current situation. Crop productions are affected by many factors linked with climate change. These factors are temperature, rainfall, extreme weather conditions, climate variability and CO_2 in the atmosphere that is envisaged to cause global warming which will likely affect the availabilityof food (USDA, 2007).

Temperature is an important factor that determines the rate at which a plant metamorphoses through various stages towards maturity. According to the International Fund for Agricultural Development (2009) a rise in temperature increases plant tissues thereby reducing the rate of digestibility and degradation of plant species. Temperature quickens plant maturity, especially in crop species, thereby reducing the growth stages during which pods, seeds and grains can absorb photosynthetic products. It determines the extent of growing and grazing seasons and usually has a strong impact on the timing of developmental processes and on the rates of expansion of plant leaves. Clearly temperature reduces the production of cereal grains that form the basis of much of the world's diet by 40 million metric tons per year (Lorraine, 2007).

In the Sahara region of Africa, the length of growing season has been greatly reduced by high temperatures with adverse effects on crops (IPCC, 2007). Extreme temperatures bring about damages in crops with vicissitudes on food security. Critical stages for high temperature damage includes seedling emergence in most crops, silking and tasseling in corn, grain filling in wheat and flowering in soya beans. It also leads to heat stress for plants, increasing sterility of lowering overall productivity, increases evaporation from plants and soils and growing water demands while reducing water availability (Brett, 2009).

Shifting in ecological zones and rainfall becomes unpredictable and unreliable both in volume and timing (Brett, 2009). The crop water time may be adversely affected by seasonal precipitation changes, within season pattern of precipitation and inter-annual variation of precipitation. Too much precipitation can cause infections on crops, while very little can be disastrous to crop production which will lead to a decline in agricultural productivity (IPCC, 2007), especially if the dry season occurs during the all-important developmental stages. For example, moisture stress during the flowering, pollination and grain-filling stages is critically harmful to maize, soya beans, wheat and sorghum. Even rice which is the staple food that feeds half of the world's population can also be jeopardized (Lorraine, 2007). According to Brett (2009), 75 to 250 million Africans are likely to be exposed to an increase in water scarcity due to unpredictable and unreliable rainfall patterns.

The quality and availability of water stored in the soil (that is a vital input to crop growth) will be affected by changes to both precipitation and seasonal annual evaporation respiration. Agricultural produce, with access to food in many African nations and regions are likely to be adversely compromised by climate variability changes in precipitation. The areas suitable for agriculture, the period of growing seasons and production capacity, particularly along the margins of semi-arid and arid areas are likely to decline. In some countries, production from rain-fed agriculture could be highly reduced by up to 50% by 2020 (Brett, 2009).

Nevertheless, the increase of atmospheric CO_2 and ozone that have been seen in the past century are likely to continue (USDA, 2009). As the levels of carbon emission changes, the optimal growth ranges for different species also changes; species also alter their competitive powers and the composition of mixed grasslands changes. The proportion of browse in rangelands will increase as a result of increased CO_2 levels (IFAD, 2009).

CO_2, apart from being a GHG, also impacts greatly on plant life because plants absorb CO_2 during photosynthesis to produce sugar that is necessary for growth. The level of the CO_2 fertilization consequences differs greatly among plant types and from variety to variety.

Further research reveals that the significant impact of climate change due to increased CO_2 is clearly seen in the production of both C_3 crops (plants types with three carbon atoms in their biochemical sequence of reaction such as: cowpea, wheat, soya beans, rice, potatoes, cassava and yam) and C_4 crops (plant types with four carbon atoms in their biochemical sequence of reaction such as: sorghum, sugar cane, millet and maize). Plants with C_3 photosynthetic pathway, excluding corn, can show productivity increase of about 20 to 30% even more when grown at twice present CO_2 level and at optimal conditions with C_4 crops (USDA, 2007). In addition, CO_2 fertilization effect cannot make up for the negative consequences from other environmental hazards. For example, studies on multi-year field and GHGs on potato and dry beans conducted in Ithaca, New York, showed significant production increase for both potatoes and beans at twice present CO_2 levels when day time maximum temperatures were allowed to occasionally reach 95°C during pod time formation, there was no production benefits from higher CO_2 (Peet and Wolfe, 2000; Jifon and Wolfe, 2005). The implication of this on food security is that LMOs will be an alternative with health effects on the developing states. There is *status quo* that developed states, mostly America, will not like to be altered in any form as a result of profit motive in the age of ultra-capitalism (Rautenbach, 2007). This approach in food security is also supported by adaptation and mitigation. The question raised is how can Africa embark on this when the problem of technology is unresolved as a result of the politics of its transfer remains unresolved between the North and the South? Attention is given to this issue below.

5. Climate change vulnerability, sensitivity and adaptation

IPCC defines vulnerability "as the degree to which a system is susceptible to, or unable to cope with the adverse effects of climate change, including climate variability and extremes. Vulnerability is seen as the function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity" (IPCC, 2001). Africa is poor, less developed, with income per capital very low, high rate of mortality and morbidity, sky-rocketing degrees of illiteracy because of the privatization of education caused by imposed the Structural Adjustment Programme (SAP). Africa relies on natural resource with weak and bad governance structures. The end result of this is low capacity to react effectively and efficiently in order to climate change. Violent armed conflicts and the sole dependence on foreign assistance further complicate the already fragile situation, which had reduced many countries to failing, failed and fragile states. The continent is tropical with hot and dry weather conditions and citizens live in sub-humid and semi-arid zones. As a result of the consequences of high climatic change, Africans have developed some strategies to manage and live with severe adverse conditions (Amusan and Jegede, 2014; Andah, 1993). The high level of low adaptive capacity contributes to high vulnerability, not necessarily climate change only. This is as a result of many factors: worsening ecology; high level of poverty; HIV/AIDS; uneven distribution of scarce land and too much reliance on the natural resource base (Hulme, 1996; Magadza, 2003; Ikeme, 2003). Adaptive capacity improvement is an essential factor to reducing vulnerability in climate change.

Despite low adaptive strength, Africa has engaged customary patterns to deal with adverse climate conditions. The communities who hitherto faced adverse climatic conditions have discovered and adopted different ways of coping with climatic catastrophes. Constant droughts in all intent and purposes increase people's vulnerability in the short-run, but will encourage adaptation in the medium and long-run (Mortimore and Adams, 2001).

It is instructive to note that the local population has developed better, effective and efficient early warning systems than developed agencies where critical decisions are made at the level of households (Rahmato, 1998). For instance, remedies against droughts have been adopted by the nomadic pastoralists in the Desert Margins Programs (DMP) of Kenya (Langill and Ndathi, 1998). Local farmers have also fashioned out a coping device and tactics, in places where drought occurs frequently. Methods of evaluating the chances for successful household or village seasonal food production are also in place to ensure sustainable farming and herding systems (Downing et al., 1998). Rural Senegal and Burkina Faso have improved their adaptive capacity by adopting pruning and fertilizer doubling methods of free densities in semi-arid areas. This has helped to glue soil together and turn around desertification.

Other methods are:

- Diversification of herds and incomes, for example, the introduction of sheep in the place of goats in the Bara area of Western Sudan (Osman et al., 2005).
- Reliance on forest products as a buffer to climatic induced crop failure in climatically marginal agricultural areas (De et al., 2005).
- Manipulation of land that leads to land use conversion (changing from livestock to game farming in Southern Africa).

However, due to the fact that sizeable numbers of Africans were reported dead and affected by climate change and related illness and diseases in the continent between 1993 and 2002, it is estimated that about 136,590 and 250,000 people were reported dead during the Soudano-Sahelian drought of 1968-73, alongside with about 12 million cattle that died as a result of starvation. The implication of this is that traditional methods on adaptation and mitigation are not to full prove to the negative impacts of climate change and climate variability (Tarhule and Lamb, 2003).

6. Planned future adaptation

According to the IPCC Third Assessment Report, climate change is visibly glaring, and will ever continue even if global gas emissions are reduced considerably in the short to medium term (Adger, 2004). Considering this fact and with regard to Africa's vulnerability to climate change, planned adaptation becomes crucial and inevitable. Some adaptation options are adopted routinely by the system in question as part of its normal operation. These adaptation responses are "autonomous" (Parry and Carter, 1998) to show the potential internal adjustment of a selected sector. Autonomous adaptation can follow three main categories: inbuilt adjustments, routine adjustments and tactical adjustments. Inbuilt adjustment allows for the physiological or even unconscious adjustment to changed climate conditions such as a plant stomata reacting to a change in environmental conditions. Routine adjustments are more conscious adjustments that occur within the system to variations in climate conditions such as farmers altering a sowing date to take advantage of the most favorable soil moisture conditions for that season. Tactical adjustments represent a more pronounced response to climate variations that are outside the normal expectations of climatic variability. For example, a grower may decide to change crops from maize to sorghum in response to a hotter and drier environment. Autonomous adjustments represent many of the responses within a specific sector of society. More strategic adaptation responses may be formulated across societal sectors as part of a specific government plan for climatic effects.

Most adaptation measures have their own limitations as discussed above. Despite these; there is still a need to embark on it in order to avoid self-annihilation. This position has received academic discussion elsewhere (Amusan, 2009). Management of water resources through diversification of agricultural practices is one of the means of enhancing water sustainability. This is through development of resourceful systems of seasonal predictions or diversification of means of livelihood by engaging in different economic activities, one of the cogs in this system is the gestation period and technicalities that this demands (Amusan, 2014). Utilizing forest products as a buffer to climate-induced crop failure from farming in climatically marginal areas are also necessity for the present circumstance to serve short run demands with all its lapses (De et al., 2005).

Adaptation of forestry includes the decentralization of local management of resources. This is the form of local-based natural resources management approach to promote the use of ecosystems goods and services as opposed to a reliance on agriculture (in climatically marginal areas for agriculture) and manipulation of land use as a common practice in Botswana (De et al., 2005).

However, home gardens and sheep fattening have greatly contributed to enhancing the resilient capacity know-how of small local farmers in Kordofan and Darfur regions of Western Sudan (Osman et al., 2006). In many areas, food crops have replaced cash crops and various types of resilient crops have been introduced (DFID, 2000). Migration and local forced movements are presumed to be an adaptation option, but with crises of the concepts of *we* and *them*, and xenophobic attacks as displayed in South Africa in April 2015, which eventually attracted international attention. Migration as one of the best options is not a perennial solution to the problem, but introduction of mitigation and scientific adaption through appropriate technology transfer will play a major role. As discussed elsewhere, politics behind technology transfer is beyond Africa's power (Amusan, 2014, pp. 103-4).

In coastal areas, the anticipated adaptation options include fisheries management. To improve livelyhood in the Seychelles, there is closed season control agreement between foreign fleets/trawlers and the establishment of marine reserves. In West Africa, the options include the development of a sustainable Fisheries Livelihoods Programme (FLP). In the Delta area of Egypt, a system called dyke which means building a barrier to prevent flooding from sea option is used as it will prevent worst cases of flooding. However, it might probably cause serious groundwater salination and aggravate wave action. At the same time, it brings about improvement in the quality of food supply and arrests hunger in the states that introduced these systems (UNEP, 2004).

Conclusion and recommendations

Adaptation is defined as "the adjustment in a natural or human system in response to actual or expected climate stimuli or their effects, which moderates harm or exploit beneficial opportunities" (IPCC, 2007). Therefore, adaptation with impacts of climate change in essence has become an important feature of global discourse on climate change (Amusan and Jegede, 2014, p. 53). Examples of adaptation include preparing risk assessments, protecting ecosystems, improving agricultural methods, managing water resources, building settlements in safe zones, delivering early warning systems, instituting better building designs, improving insurance coverage and developing social safety nets (ibid, p. 53).

Adaptation is widely recognised as an important part of policy response to climate change because it helps farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socioeconomic conditions, including variability, adverse weather conditions such as droughts and floods, and sensitive short-term changes in rural and large-scale markets (Kandlinkar and Risbey, 2000).

Although climate is changing and climate variability is due to increase in very high magnitude and intensity (IPCC, 2001), it is likely that the present adaptation strategies may be considered inadequate in the future. Serious considerations are therefore needed if adaptation is to be perceived as an essential dynamic, continuous and non-linear process (ILRI, 2006). Correct and acceptable early warning forecast is considered a necessary element of adaptation, especially in predicting and cushioning the effects of floods, droughts and tropical cyclones and also for indicating the planting calendar to coincide with the beginning of the rainy season as well as see if there will be the outbreak of diseases in areas likely to suffer from epidemics (Kovats et al., 2002; Tarhule and Woo, 2002). According to Githeko and Ndegwa (2001), malaria epidemics in the highlands of Western Kenya can be predicted between two to three months before their occurrence through the information of Climate Outlook Forums (COF) in order to find out malaria related climate change risk and warning against malaria outbreaks.

Education, information and training should be considered and encouraged as necessary tools among governments, institutions and individuals in promoting adaptation to climate change in Africa, since the continent is considered to be one of the poorest continents likely to be exposed to the worst global warming scenarios.

Studies have revealed that without adaptation, climate change is generally bad for the agricultural sector, but with adaptation, vulnerability will be highly reduced (Easterling et al., 1993; Lemon, 2012; Rosenzweig and Parry, 1994; Reilly and Schimmelpfennig, 1999; Smit and Skinner, 2002).

The degrees of impact of climate change on the agricultural sector depend largely on its adaptive strength. Adaptive strength simply means the ability of a system to adjust to adverse condition – climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with consequences (IPCC, 2001).

Ideally, adaptation and mitigation should be considered together as some adaptation measures can help reduce GHGs emissions, while alternatively, mitigation measures can also be planned to reduce, and not inadvertently escalate risks of disasters.

Adaptation and mitigation are aimed at ensuring food security and political stability in Africa. As discussed elsewhere, the linkage between stability and climate change appears to be inseparable. The continuous crises in some part of Africa such as Mali, Libya, Nigeria, South Africa and DRC can hardly be explained without looking into environmental politics holistically.

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