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The Impact of Climate Change on Agro-Ecological Based Livelihoods in Africa: A Review

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Abstract

Several local studies have been carried out on the impact of climate change on livelihoods and development especially in developing countries. However, there is a general scarcity of literature that makes a comparative appraisal of the impacts of climate change on agro-ecological based livelihoods across the African continent. This paper seeks to address that gap by making a comparative analysis of the effects of climate change on agro-based livelihoods across the African continent, focusing on Eastern, Western, Southern Africa and the Sahel region. A cross continental perspective on this issue is important in informing current global climate change negotiations and response strategies both at global level and national levels. While some studies have been conducted at individual country levels about the projected and recorded impacts of climate change, there remains a dearth of literature that reviews and consolidates these findings to give an overall holistic picture about continental and sub-continental impacts in Africa especially as relating to local agro and ecological based livelihoods. This study finds out that the impact of climate change is invariably negative across the whole of Africa as it leads to failing agricultural yields and a reduction of bio-diversity. The paper recommends an intensification for the support of livelihood diversification strategies in rural development planning. It further recommends policy strategies that particularly targets the poor and vulnerable communities whose livelihoods hinge on agriculture and natural ecosystems as these will suffer the most from the impact of climate change.

Keywords: climate change, agriculture, ecology, livelihoods, Africa

1. Introduction

Several local studies have been carried out on the impact of climate change on development especially in developing countries (Mubaya, Njuki, Mutsvangwa, Mugabe, & Nanja, 2012; Osbahr, Twyman, Neil Adger, & Thomas, 2008; Paavola, 2008). However, there is a general scarcity of literature that makes a comparative appraisal of the impacts of climate change on livelihoods across the African continent. This paper seeks to address that gap by making a comparative analysis of the effects of climate change on agriculture and local ecology based livelihoods across the African continent, focusing on Eastern, Western, Southern Africa and the Sahel region. An understanding of the evolution of agro-ecological based livelihoods under the current climate change trends would cast some light on what future trends to expect across the continent on these livelihoods. Furthermore, this knowledge is important for informing current climate change response strategies at policy making level both at the global level and at national levels. While some studies have been conducted at individual country levels about the projected and recorded impacts of climate change they have tended to examine commercial farmers and to neglect smallholder farmers who are the primary focus of this paper (See Kurukulasuriya et al., 2006). Thus, there remains a dearth of literature that reviews and consolidates these findings to give an overall holistic picture about continental and sub-continental impacts in Africa. This paper seeks to fill that gap by reviewing literature on

climate change and its impact on agro-ecological based livelihoods in the African region. Understanding these impacts is key in informing response strategies. As Somorin (2010) notes, the vulnerability of any particular system to climate change will largely depend not only on system resilience but also on the nature of the impacts that the system is exposed to amongst a host of other factors. Mendelsohn (2008:5) further notes that 'understanding the impacts of climate change will also help direct where, when, and how adaptation should proceed'. Therefore in understanding climate change in Africa it is necessary to have an appreciation of the climate change impact that communities face.

2. Climate Change Science: A Synopsis

Although climate change is generally (and simplistically) referred to as global warming, in reality, it is much more complex than global warming. It is broadly accepted that the causes of global warming are anthropogenic, that is, the emission and increasing concentration of greenhouse gasses (GHGs) in the atmosphere caused by human activities (Boon and Ahenkan, 2012). The main human activities leading to the emission of greenhouse gasses include 'electricity generation, land-use changes (particularly deforestation, agriculture and transport….' (Stern, 2006:1).These gasses include carbon dioxide and methane primarily generated from the burning of fossil fuels. When these gasses are emitted into the atmosphere, they trap heat leaving the earth and thereby giving a greenhouse effect which increases atmospheric and ground temperature.

There are on-going debates as to the level of contribution of human activities such as fossil fuel burning in generating global warming (Sr., 2009). In spite of these debates about the contribution of human activities to global warming, the presence and reality of global warming is itself no longer a contested issue. Somorin (2010:903) points out that,

> …the warming of the climate system is believed to be unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.'

Climate change 'encompasses serious disruptions to the world's entire weather and climate patterns, including impacts on rainfall, extreme weather events and sea level rise, as well as moderate to extreme global temperature rises' (Duff, 2011:xxiii). It manifests itself through such incidences as frequent floods and droughts, hurricanes, heat waves and frequent erratic weather patterns (IPCC, 2007).

Oxfam (2011:3) argues that;

> …it is important to note that climate change impacts will vary across different locations and at different times into the future, as soil types, topography and other factors vary across the region. We can expect therefore, an assortment of climate change effects.

This also means that the effects of climate change themselves will also vary spatially and temporally thereby necessitating an understanding of the impact of climate change that is specific regions of the world, including Africa. Understanding climate change in Africa is particularly important because the highest temperature increases are going to be experienced in Africa since most of Africa lies in the tropical and sub-tropical altitudes.

3. Who Will Suffer the Most from Climate Change and Why?

Emerging evidence shows that the impact of climate change on global communities will not be experienced in the same way (Pricope, Husak, Lopez-Carr, Funk, & Michaelsen, 2013). Adger, Huq, Brown, Conway, & Hulme (2003) argue that 'the impacts of climate change are not evenly distributed'. The people that will bear the brunt of climate change are the poor from the Global South (including Africa) who are least equipped to adapt to the phenomenon and the risks associated with it (Bunce, Rosendo, & Brown, 2010). The vulnerability of people in the Global South is largely driven by lack of adaptation resources, poor governance, lack of information and the already hot and dry climatic conditions (IPCC, 2007). The irony of the climate change phenomenon is that it is the poor countries that have contributed little to the problem of global warming that are likely to suffer the most from climate change, since they have the least capacity to adapt to its effects. African countries contributed 4.6% of cumulative global carbon emissions from 1950 to 2000, and now emit only 3.5% of the total' (Reid, Sahlen, Stage, & MacGregor, 2008). Current evidence points to the fact that local peoples will suffer the brunt of the negative effects of climate change leading to severe complications in their livelihood patterns and a worsening of poverty levels (Devkota, Bajracharya, Maraseni, Cockfield, & Upadhyay, 2011).

Emerging evidence further shows that the bulk of the impact of climate change on livelihoods is likely to be felt by smallholder farmers who lack the requisite means for adaptation (Pricope et al., 2013:1525). Pricope et al. (2013) argue that yields from Africa's rain fed agriculture could decrease by as much as 50% in the next 30-35 years. These decreases in yields will largely be driven by droughts especially in the already dry and hot regions such as

Southern Africa and the Sahel. However, effective adaptation efforts might reduce the magnitude of the impact (Pricope et al., 2013). This point is further discussed under the section on climate change and livelihoods later in this paper.

(Garcia, 2008:3) highlights three key points that make Africa the most vulnerable continent to climate change. Firstly, the geographical positioning of the African continent gives it one of the warmest climates by virtue of its proximity to the equator. Secondly, most African countries depend on the agricultural sector which is sensitive to climate change. Third and lastly, socio-economic gaps in governance, government financing, high rates of poverty and growing populations all expose Africa as a region with high vulnerability to climate change.

The adaptation process requires a high level of both technology and resources that communities in the Global South are unable to afford. Duff (2011:xxv) argues that '…unlike the global public-good character of climate change mitigation, adaptation is a unique and costly policy challenge specific to each individual nation state.' While mitigation, if executed would result in a general global reduction of the dangers of climate change, adaptation has to be done at the local level meaning that the resources required are area specific. Better resourced communities stand a better chance to adapt and survive climate change challenges. Therefore the richer Global North and the poor Global South are differently vulnerable.

The IPCC (2007) thus emphasises the need to understand climate change in the context of what is called '…multiple stresses arising from the effects, for example, globalisation, poverty, poor governance and settlement of low lying coasts' (IPCC, 2007:78). This interaction of climate change and non-climate change factors is very important to acknowledge and highlight.

Stressors such as HIV and AIDS, the growth of local populations and the subsequent reduction of available land for farming as well as the impact of armed conflicts in Africa, amongst other things are seen as factors that contribute to the increased vulnerability of local communities to adverse weather conditions driven by climate change and variability (Morton, 2007). Commenting on the East African food crisis of 2011, Oxfam (2011:1) notes that 'beyond the debate on climate change's role in the current crisis in East Africa, one thing is clear. If nothing is done, climate change will in future make a bad situation worse.' While livelihoods in Africa might suffer from multiple stressors, climate change has become an important influencing variable in the management of these livelihood portfolios (Bunce et al., 2010). Mubaya et al. (2012:10) further argue that;

> …it is important to note though, that climate change amplifies already existing risks for farmers. This is the case as there are non-climatic risk factors such as economic instability, trade liberalisation, conflicts and poor governance that may also be faced by farmers….

Mubaya et al.'s (2012) view underscores the importance of fully contextualising the impact of climate change on livelihoods. They note that these other intervening factors are also important in understanding climate change impacts on livelihoods. Pricope et al. (2013) argue that population growth is one of the factors that has fundamentally altered both ecological systems and livelihood patterns in East Africa. They argue that many countries in Africa have experienced unprecedented population growth since the 1960s. For example the population of Kenya is expected to have grown by over 400% since 1960 while neighbours, Somalia and Ethiopia are thought to have grown by 232% and 268% respectively. These increases of population are thought to have also had an impact on the environment alongside climate change. Any investigation of the impact of climate change should therefore not underestimate the importance of other multiple stressors especially in the African context.

4. Climate Change and Human Development

From the foregoing arguments it is clear that climate is a critical variable in influencing the development and evolution of livelihoods globally. The impact of climate change on the livelihoods of communities in the global south has been broadly documented (see IPCC, 2007); Boon and Ahenkan, 2012; Bunce et al., 2010). Adger et al. (2003) add that all human activities relating to livelihoods are sensitive to climate in some form or fashion. Livelihoods are generated in the context of the local climate which is an overall influencing factor. This view is further emphasised by Stern (2006:6) who argues that 'climate change has profound implications for the environment in which social and economic activity takes place, and can thus have similarly important effects on prosperity and human development.'

Pittock (2005) notes that natural ecosystems are dependent upon climatic conditions. 'At least until the advent of irrigation and industrialisation, climate determined the food supplies and where human beings could live' (Pittock, 2005:1). Sokona & Denton (2001) concur arguing that everywhere on the planet, people rely significantly on their ecosystems for food provision, medicine, shelter, energy, water and animal feed as well as to renew the fertility of the soil and to purify water. 'However, ecosystems are under threat from poor and unsustainable resource

management, on the one hand, and the impact of climate change on the other' (Sokona & Denton: 2001:119). While these authors are in agreement that climate affects livelihoods, Pittock's argument however suggests that the advent of industrialisation and irrigation might have reduced human beings' dependency on rain fed agriculture and thus liberating them from the vagaries of climate change. While this might be true for Developed countries, the same may not be said about Africa where limited industrialisation and irrigation technologies have been applied.

5. The Impact of Climate Change on Ecosystem Based Livelihoods

There is a very close link between ecosystems and the livelihoods of many people in the Global South. Assan & Kumar (2009:394) show that in Africa 'the poor are more dependent on the ecosystem and its services to cater for their various types of demands ranging from food, fuel wood and water to medicinal plants and services to enrich their cultural identity and social wellbeing.' The erosion of these ecosystems are likely to aggravate poverty in developing countries. There are questions about whether or not the overreliance of the poor on the local ecosystem does in fact also accelerate the degradation of the local ecosystems and thus setting in motion a cycle of destruction for the ecosystem and local livelihoods (Shackleton & Shackleton, 2012:278).

It has been projected that climate change is going to negatively affect natural ecosystems leading to biodiversity loss of up to 40% before the end of the century in some areas (Stern, 2007). A general evolution of ecosystems is expected to accompany climate change because the survival of ecosystems is closely tied up with local climatic conditions. The IPCC (2007:98) points out that 'plants and animals can reproduce, grow and survive only within a specific range of climatic and environmental conditions. If conditions change beyond the tolerances of species, then they may respond by:

- Shifting the timing of cycle events (e.g. blooming and migrating)
- Shifting range boundaries (e.g. moving pole ward) or the density of individuals within their ranges,
- Changing morphology (e.g. body or egg size), reproduction or genetics,
- Extirpation or extinction' (IPCC, 2007:98).

All such changes of the ecosystem are bound to initiate an inevitable chain reaction on local livelihoods (IPCC, 2007). It has been argued that,

> Human wellbeing and progress towards sustainable development are vitally dependent upon the earth's ecosystem services…Degradation of these ecosystem services would have an adverse impact on food accessibility, livelihood options and quality of life of local communities' (Boon and Ahenkan, 2012:1-2)

Most people living in rural areas derive a significant amount of their livelihood portfolios from the ecosystems around which they live (Pricope et al., 2013). These ecosystems provide a variety of goods and services integral to the livelihoods of locals known as ecosystem services (Shaw et al., 2011). According to Shaw et al. (2011) ecosystem services can be subcategorised into four important sections which include the following:

- Provisional services (this relates to food, timber, water and fuels)
- Regulating services (this relates to the natural systems by which the ecosystem regulates itself such as water purification and carbon sequestration)
- Supporting services (relating to climate regulation)
- Cultural services (aesthetic values and sense of place).

Although all the types of services rendered by the ecosystems are very important for human survival, it would be noted that the most immediate needs for communities in the Africa are met through provisional services. Communities derive a variety of benefits from the ecosystem which include water, food and firewood amongst other things (Shaw, 2011 & IPCC, 2007). A degradation of these ecosystems would threaten the livelihoods of the people who depend on them. Boon and Ahenkan (2011:2) argue that,

> Any progress achieved in addressing the goals of poverty and hunger eradication, improved health, and environmental protection may be unsustainable if most of the ecosystem services on which humanity relies continue to be degraded.

Ecosystem provisional services play a key role as safety nets in times of difficulty for poor communities as they provide coping strategies in the face of shocks (Shackleton & Shackleton, 2012:279). Poor households have been noted to respond in three main ways to shocks using ecosystem provisioning services.

- There could be increased use of a resource that is already an integral component of livelihoods
- There could be adoption of a resource that is not commonly used.

- There could be temporary trade in wild products in order to overcome current shocks. This strategy may be permanently adopted as a livelihood eventually.

  (Shackleton & Shackleton, 2012:279)

In a study of the Sui River Forest Reserve (SRFR) in Ghana, Boon and Ahenkan (2011) observed that the '….livelihoods of the communities surrounding the reserve are very intimately linked to the availability of ecosystem services.' They further argued that ecosystem services were the main source of livelihood for the communities that lived around the reserve. They categorise three types of provisional services enjoyed by the surrounding communities to the forest. These are foods, medicine and what they call other goods. Food services include meat, fish, honey, fruits, mushrooms and cola nuts amongst others. On medicine services there are various types of products derived from the ecosystem which include animal products, roots, oils, leaves and barks used both for human beings and animal treatment. Other goods include timber, wood fuel and mortars. It should be noted that most of these products are highly dependent on climate and the environment as they depend on precipitation and temperature patterns. Boon and Ahenkan (2011) confirm this as they established that the forest area and the surrounding areas had experienced a general reduction in precipitation and an increase in temperature over the last thirty years. This had affected agricultural production and the general ecosystem wellness. It was noted for example that the harvest of cocoa had drastically been reduced due to unfavourable weather conditions. Cocoa trees were dying from drought. New pest strains were emerging probably associated with changing climatic conditions. The increased incidence of droughts and high temperatures also precipitated a higher frequency of bush fires that was devastating the forest, further reducing ecosystem services received by the communities in the area of study. Climate change was therefore a driving factor in 'habitat destruction and biodiversity loss.'

Boon and Ahenkan's (2011) arguments are supported by Somorin (2010) who notes that forests are particularly important in the context of Africa where the welfare of millions of rural people is dependent on ecosystem services from forests. Goods provided by these forests include wild game meat, fruits, and herbs that improve the health of local communities. In times of seasonal food insecurity, forests become particularly important as they provide several copying systems in the form of various types of wild food. Various goods derived from the forest are sold to provide income for local communities.

Biodiversity will also be affected by climate change. According to Stern (2007:65) 'ecosystems will be particularly vulnerable to climate change with one study estimating that 15-40% of species face extinction with 2◦C of warming.' Gosling et al. (2011:448) estimate that this loss of biodiversity would be between 20 and 30% if global temperature increases by about 2%. Changing climate patterns will cause particular species of plants and living organisms to either adapt or die because they thrive under particular ecological and climatic conditions. Those elements of the ecosystems that fail to adapt would eventually become extinct leading to further ecological destabilization and an alteration or destruction of community livelihoods in the affected areas.

The vulnerability of poor people in the Global South is particularly due to their over reliance on ecosystem based resources and rain fed agriculture (IPCC, 2007). Such livelihoods are susceptible to the effects of climate change. It has been suggested that a diversification of livelihoods into off-farm based livelihoods could be a viable option for these communities. However, the challenge of diversification is that it requires substantial capital which the poor are usually not in a position to command (Assan & Kumar, 2009).

It is important to note that while the impact of climate change might be negative on the ecosystems of Africa, elsewhere, the impact is positive. For example, the IPCC (2007) reports that due to global warming, Polar Regions are showing an increased rate of colonisation by plants who find the place increasingly suitable for growth. Ecosystems and forests in temperate regions will increasingly benefit from the lengthening of plant growing seasons as there will be longer warmer seasons favouring plant growth in previously too cold places.

Stern (2006:2) points out that 'most of the damaging consequences of climate change are associated with water in some shape or form, including droughts, floods, storms and sea level rise.' It is estimated that a third of the world's population lives in nineteen countries that are currently classified as water scarcity zones (Garcia, 2008:4). Literature generally shows that climate change will result in water shortages in Africa (IPCC, 2007). This will have far reaching social consequences because availability of fresh water '…is fundamental to economic growth and social development' (Kankam-Yeboah, Obuobie, Amisigo, & Opoku-Ankomah, 2013:773). For example, a study by (Davis & Hirji, 2014) in Zimbabwe showed that there was a very close correlation between precipitation levels (providing water) and the performance of the Gross Domestic Product (GDP). In years that precipitation was normal or above normal, the GDP performed well. Inversely, when precipitation was poor, the GDP also slumped. They argue in their study that 'the precipitation-GDP relationship occurs primarily because of the centrality of agriculture and electricity production within the economy … both are heavily dependent on precipitation' (Davis

and Hirji, 2014:1).

The global differences in water availability are underscored in the IPCC (2007:90) assessment that, 'at present no globally consistent trend in lake levels has been found.' Countries close to glacial melts such as Mongolia and China have had lakes that have gained water due to melting glaciers (IPCC, 2007). However, countries in drier and warmer environments like Zimbabwe, Zambia and Malawi have reported a lowering of water levels in lakes attributable to climate change.

In West Africa there is also emerging evidence of changes in stream flows. A recent study of selected rivers in Ghana by Kankam-Yeboah et al. (2013) shows that rivers in the White Volta Basin will experience a decline in stream flow of approximately 21.6% by 2020 and 50.1% by the 2050s. Rivers in the Pra Basin would experience 22.2% and 46.2% decreases in stream flows respectively during the dates mentioned above. Although the Ghana case study does not discuss the socio-economic effects of such changes, it is evident that there would be serious effects on the livelihoods of communities who rely upon the stream flows for their livelihoods (Kankam-Yeboah et al. (2013:783).

In view of the foregoing projections, it is estimated that Africa will see increasing numbers of water insecure people ranging between 75-250 million by 2020 and 350-600 million by the 2050s (Sr., 2009). This shortage will not only affect crop production but it will probably also threaten the health of the communities. A study conducted by Dube, (2012) on water and sanitation in Southern Zimbabwe concluded that communities with high scarcity levels of water tended to have greater incidences of diseases like diarrhoea.

Sea levels are also on the rise due to climate change (IPCC, 2007). They have been on the rise since industrialisation and are expected to have risen by approximately 50 centimetres by the year 2100 compared to 1990 levels (Kummsa & Jones, 2010). It is projected that the rise in sea level resulting mostly from thermal expansion and the melting of ice caps and glaciers in Greenland and Antarctica is going to have important implications for coastal communities globally and Africa in particular. Some island nations like the Seychelles and Maldives are expected to be submerged into the sea within the next century if the present rate of sea level rises continue (Kummsa & Jones, 2010). Furthermore, cities such as Maputo, Cape Town and Dar es Salaam are also thought to be threatened with partial submersion (Kummsa & Jones, 2010). Such a rise in sea levels would also mean that fresh water sources and water resources like fish along the coast lines would be destroyed through salination, coastal erosion and wetland flooding. Species that survive on fresh water such as particular kinds of fish would become extinct along the coastlines.

The livelihoods impact of climate change resulting from sea level rises will be aggravated by the fact that 'humanity is preferentially concentrated in the coastal areas of the world' (Nicholls & Mimura, 1999:5). Coastal areas are therefore generally of high population density because of the economic opportunities that they offer. In particular this concentration of the human population along coastal areas is driven by the fertility of land in low lying delta areas, transport opportunities and easy access to sea food amongst other things (Darwin & Tol, 2001). Coastal areas are thus naturally highly productive areas compared to inland areas. Dasgupta, Laplante, Meisner, Wheeler, & Yan (2008) have argued that because of the productive nature of coastal areas, they tend to have a relatively higher Gross Domestic Product share when compared to other inland regions. In view of the foregoing arguments, any negative changes that might affect coastal areas as a result of climate change and sea level rises might have far reaching livelihoods consequences.

Dasgupta, Laplante, Meisner, Wheeler, & Yan's (2008) study estimates that a one metre rise in the sea level would impact approximately 1.28% of the population of people in developing countries. A further rise by another meter to two meters would impact some 2.03% of the population of people in developing countries. However, it is important to note that Dasgupta et al. (2008) argue that the overall impact of sea level rises would be beyond the proportion of the population affected because, as noted earlier, coastal areas tend to have a higher share of the GDP. In other words a greater proportion of individual countries GDP would be affected by disturbances in the highly productive coastal areas. Major anticipated effects include the disappearance of wetlands, submersion of cities, and destruction of biodiversity and loss of farming land amongst other things (Dasgupta et al., 2008).

6. Climate change and agricultural production in Africa

At a global scale, evidence of the impact of climate change on agricultural production remains somewhat mixed with global projections suggesting that there might be no significant losses at the global level (IPCC, 2007; Mendelsohn, 2009; Hassan, 2010). The main reason for this trend is that losses in drier African regions will be compensated for by increased production in high latitude regions where global warming will raise temperatures and extend planting seasons by reducing the risk of frost in many places (Hassan, 2010). (Thornton, van de Steeg, Notenbaert, & Herrero (2009) point out that at mid- to high latitudes, it is envisaged that crop productivity could

increase reasonably due to local increases in mean temperature of up to 1-3 °C. However, this would partly depend on crop types. The opposite can be expected for regions in lower latitudes where modest increases in temperature will reduce crop yields as crops become intolerant of high temperatures. It is interesting to note that these findings show that although climate change would have negative results for agricultural production in sub-Saharan Africa, this would not necessarily be the case with other developing countries. This makes Africa a special area of interest of study (Barrios, Ouattara, & Strobl, 2008).

It should be noted that the negative impact of climate change comes against the background of an already precarious food security situation in parts of Africa. It is estimated that over 800 million people are currently malnourished in Africa and the population is growing (Barrios et al., 2008). This means that within the next 35 years food production should be doubled. Yet projections show that there will be a decline due to the impact of climate change (Barrios et al., 2008). Sub- Saharan Africa agriculture, relative to other regions of the world, is more sensitive and susceptible to climate change due to reasons already alluded to.

In Sub-Saharan Africa, agriculture is the main engine for economic growth contributing in excess of 40% of the Gross Domestic Product for most countries and employing over 50% of the people in those countries. Furthermore, agriculture serves as the main base for food security in the region as the majority of people grow their own food (Barrios et al., 2008). It is estimated that 95% of Africa's agriculture is rain fed (Kummsa & Jones, 2010). This makes the sector highly vulnerable to climate change. The increasing frequency of droughts due to climate change expected to reduce agricultural productivity by up to 50% in Africa by 2020 (Kummsa & Jones, 2010). The UNDP (2007) estimates that drought affected areas could expand by between 60 and 90 million hectares by the year 2060. This would complicate the already critical food insecurity situation in Southern African countries such as Zimbabwe.

Oxfam (2011) predictions show that if the current trends of global warming continue and if the world warms by 4 degrees Celsius, changes in temperature and precipitation in the East African region could mean that there is a marked reduction in the production of staple foods. This would largely be driven by a decline in the growing season of crops which could go down by up to 20%. It is projected that this decline would also adversely affect the production of maize by about 20% of the current levels of production. Bean production would be the most affected at about 50% (Oxfam, 2011). Cereal production is expected to reduce significantly in countries such as Zimbabwe, Ethiopia, Sudan and Nigeria. By 2050, crop yields are expected to have fallen by up to 20%, and by 2100 crop revenues in South Africa are projected to have dropped by up to 90% (Hope, 2006).

It is also projected that some regions especially in Southern Africa will become more prone to floods as has already been experienced in the last couple of decades. For example, the floods that hit Mozambique in the year 2000 leading to an estimated 800 deaths, the destruction of infrastructure and the outbreak of water borne diseases have largely been attributed to climate change effects (Patt & Schroter, 2008). It is anticipated that the Southern part of Mozambique will experience more frequent heavy rains and flooding as a result of climate change.

As noted above, a study of the impact of climate change would not be sufficient without emphasising regional differences even within the African continent. As Hein, Metzger, & Leemans (2009:466) emphasise, 'climate change is a global phenomenon, but people will be affected by its local impacts.' It is local impacts that are critical in the climate change adaptation discourse because adaptation must be suited to the local conditions which have proven to vary widely across geographical regions with some regions reaping benefits while others have increasing vulnerability.

6.1 The Sahel Region

The Sahel region in Africa is one of the regions that is expected to be hardest hit by climate change. The Sahel covers nine countries close to the Sahara desert. These include Burkina Faso, Mali, Guinea Bissau, Mauritania, Niger, Chad, Cape Verde, Senegal and Gambia. The region borders the Sahara desert to the north. The region has been identified as one of the most vulnerable regions to climate change due to its proximity to the equator, its already high temperatures and low rainfall, the high reliance of local populations on rain fed agriculture, high population density and low adaptive capacity (Mohamed, 2011; Hein et al., 2009). Sissoko, van Keulen, Verhagen, Tekken, & Battaglini (2011) note that the impact of climate change has largely been negative in the Sahel region. They add that more than 50% of the population in the region is employed in the agricultural sector, and agriculture contributes in the range of between 35% and 60% of the national economic output measured in terms of the Gross Domestic Product. As in other parts of Africa, agriculture has suffered from a variety of factors in the Sahel which include the pressure of growing populations on available land resources and diminishing soil fertility. These factors in combination with climate change, are projected to have a telling effect on agricultural production and livelihoods in general.

The climate trends in the Sahel region are in line with the rest of West Africa where rainfall data shows a marked decline of precipitation from the 1960s. The decrease in precipitation has generally meant that the region has encountered more droughts since the 1960s. Sissoko et al. (2011) estimate that between the 1960s and 1990, there was a decline of between 20% and 40% in precipitation in the region. This led to a re-classification of some regions in the area from semi-arid to arid and from sub-humid to semi-humid. It should be noted that the reduction in precipitation quantity has critical implications for water availability and livelihoods in the region. Reduced water availability affects nearly all livelihoods that depend on water including cropping and livestock rearing.

Another study by Mohamed (2011) shows that a systematic water shortage problem is expected to emerge in the Sahel region by the year 2025 as a result of the new climatic trends. The water shortage will be compounded by the pressure of increasing populations in the region over and above the effects of climate change. Mohamed (2011) further projects a decrease of between 11% and 26% of millet and groundnut production by 2025 due to reduced precipitation and shortened cropping seasons.

6.2 East Africa

A study by Oxfam (2008) examined the impact of climate change on the livelihoods of pastoralists in Eastern Africa, focusing on Kenya and Uganda. It found out that notable climatic changes had taken place. It further noted that the length of rainy seasons had been reduced particularly in North Eastern Uganda. The rains that used to fall in the month of March through to August were frequently now starting in April. These findings are comparable with Mubaya et al.'s (2012) findings in Southern Africa which showed that the region was getting shorter wet seasons with unpredictable rainfall patterns. This reduction of the amount of rain was negatively impacting on livestock pasture as there was less time for it to mature. The Oxfam study further notes that increasing successive poor rainfall seasons were not giving cattle sufficient time to recover from drought years. The return rate of droughts was increasingly becoming more frequent. Estimates show that drought related shocks used to occur every ten years. However, they were now occurring every five years or less at the time of the study.

6.3 West Africa

The effects of climate change in West Africa appear to generally mirror most of what happens elsewhere in Africa. Jalloh, Nelson, Thomas, Zougmoré, & Roy-Macauley (2013) undertook an extensive study covering the whole of West Africa to understand the impacts of climate change on agriculture in the region. The region known as West Africa covers countries that include Burkina Faso, Benin, Gambia, Cape Verde, Guinea Bissau, Guinea, Niger, Mali, Togo, Sierra Leone, Liberia, Senegal, Ghana, Cote D' Ivoire, Nigeria and Niger.

The study by Jalloh et al. (2013) individually examined the potential impacts of climate change for each of these West African countries. Several important issues were raised in the study that are worth noting here. Firstly, it was noted that, like most of other African regions, the agricultural sector still plays a very critical part in the economies of the countries mentioned above. It is estimated that the agricultural sector employs over 60% of the total labour force of West African countries, and that agriculture contributes approximately 35% of the total regional Gross Domestic Product (GDP) (Jalloh et al., 2013).

In general, the study by Jalloh et al. (2013) concluded that climate change poses a great threat to agriculture based livelihoods in the West African region. According to model simulations of climate change scenarios, climate change will impact the region through changes in precipitation patterns, increasing extreme weather events and a general shift in farming seasons. In line with the general global warming trends, the study projects that increasing temperatures will negatively affect the growth of particular crops including sorghum, while reduced precipitation is also expected to worsen the situation (Jalloh et al., 2013). Crop yield losses of between 5% and 25% are projected for the region by 2050 according to simulation models. This reduction in food security is against the backdrop of one of the fastest population growth rates in the world found in West Africa.

Jalloh et al. (2013) note several factors that make West African Agriculture susceptible to climate change. One of the factors is that most of the agricultural activities are rainfall dependent. In countries like Ghana, only 4% of potential land is under irrigation. High poverty levels also contribute to a general inability to invest into adaptation procedures by farmers. Lastly, some of the countries are involved in general political conflicts that also affect farming. The study by Jalloh et al. (2013:385) therefore makes the overall observation that 'The challenges to the agricultural sector and its stakeholders from a changing climate are growing and pose a serious threat to the welfare of people in the region, particularly farmers.'

In the assessment of Sr. (2009:452) 'in West Africa, a decline in annual rainfall has been recorded since the end of the 1960s, with a decrease of 20-40% observed during the periods 1931-1960 and 1968-1990.' As a result of the continued decline of rainfall and an increase in temperatures, by 2080, it is expected that the volume of arid and

semi arid regions would have increased by between 5% and 8% and thereby reducing suitable land for agriculture (Hope Sr., 2009).

Although global warming is indeed a universal phenomenon, climate changes at local levels have varied greatly regionally. Within Africa alone, significant variations in terms of changing climate patterns can be noticed. As noted earlier on, between 1960 and 1998, the West African region has had a reduction of precipitation of between 20% and 40% with particular reference to the Sahel region. However, the tropical rainforests have experienced a marginal decline of between 2% and 4% in terms of precipitation. The Guinean coast is estimated to have gained 10% in terms of average annual rainfall.

6.4 Southern Africa

Countries in this region include South Africa, Zimbabwe, Botswana, Tanzania, Mozambique, Malawi, Namibia, Angola, Lesotho, Zambia and Swaziland. The Southern Africa region is generally projected to become hotter and drier as the next decades unfold. Furthermore, studies already show that rainfall patterns will become unpredictable and volatile (Mubaya et al., 2012). Rainfall seasons have already shown significant signs of shortening, thereby affecting cropping seasons (Mubaya et al., 2012). Other projections include more intense droughts and floods, reduced farming productivity and increasing water scarcity in general (Shackelton & Shackelton, 2011).

Furthermore there is expectation (and there is evidence already) that there will be a shortening of the wet season and increased variability of rainfall patterns from season to season. This will greatly affect farming seasons with serious consequences for agricultural production. In their study focussing on Zimbabwe and Zambia, Mubaya et al. (2012) conclude that **'**there appears to be an increasing trend towards a late start to the rain season, prolonged mid-season droughts, and shorter growing seasons in Southern Africa.'

Reid et al. (2008) examined the actual and potential impacts of climate change on Namibia's natural resources and the economy. They note that Namibia's economy depends substantially on the contribution of agriculture and fisheries to the Gross Domestic Product. The combined contribution of these two sectors to the GDP is 15%. These two sectors combined employ approximately 50% of the Namibian workforce. The impact of climate change on these sensitive sectors is therefore likely to have remarkable effects in the whole economy. Long term temperature records in Namibia show an approximate warming rate of about 0.2C per decade (Reid et al., 2008). This equates to three times the global mean rate of increase. Rainfall in Namibia is expected to not only be reduced in amount in the future but to become more variable in terms of timing. This will lead to a generally drier environment which is difficult for rain fed agriculture. The combined net effect of warming temperatures and reduced rainfall will be water shortages since evaporation rates would increase for already limited water. These climatic changes are also likely to lead to increasing desertification and a disappearance of grasslands and shrubs for cattle grazing endangering livelihoods based on these resources (Reid et al., 2008).

Reid et al. (2008) further note that much of the land used for grazing in Namibia is already marginal. Any negative pressure from climate is likely to further deteriorate the land. 'Namibia's rural economy depends heavily on extensive ranching activities, which are underpinned by the productivity of grassland, savannah and shrub-dominated ecosystems' (Reid et al., 2008:456). Very significant agricultural losses will result from the noted climatic changes as the carrying capacity of rangelands will be severely reduced. Projections of between 20% and 50% are expected in the commercial cropping sector (Reid et al., 2008). Losses in the traditional farming sector are projected to be higher ranging between 40-80% because of the low adaptive capacity. Adaptation through irrigation is expected to be limited because ground water levels will be lowered by increased demand and reduced precipitation.

7. Conclusion

This paper reviewed literature on the impacts of climate change on agro-ecological based livelihoods in Africa. It finds out that evidence from different parts of Africa shows that the impact of climate change on livelihoods is invariably negative on agro-ecological based livelihoods. Hotspots in terms of the severity of the impact of climate change were noted to be the Sahel region and Southern Africa. While Africa and other developing regions will suffer the brunt of climate change, regions in high latitudes and temperate zones stand to gain at least marginally from the warming trends as the regions will become more colonisable by species previously unable to survive. Agriculture and biodiversity are projected to suffer the most from warming temperatures and reduced precipitation in Africa. Livelihoods that are closely linked to agriculture and local ecosystems will suffer as a result of increasing temperatures and reduced precipitation. Incomes may be lost as particular species of trees and animals that are income sources either become extinct or migrate to more favourable regions climatically. While mitigation and adaptation efforts intensify globally, it is recommended that development players in Africa should intensify

efforts to diversify the livelihood portfolios of poor rural farmers who will suffer the most from these climatic changes. A move away from livelihoods purely dependent on agriculture and local ecological systems would reasonable buffer local communities from the full impact resulting from the projected reduction of precipitation and increase in temperatures.

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