

A Review Of Impact Of Climate Change On Food Availability And Adaptation At Farm Level In Sub-Saharan Africa

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Abstract - Sub Saharan Africa is highly vulnerable to the impact of climate change. Since small holder agriculture is the main livelihood of SSA which is the most susceptible to the effect of climate change and this climate change worsens the food availability and food insecurity problem in Sab Saharan African countries. To conduct this review, manual searching/ narrative review method and Google scholar search strategies were used in this literature review. As the result of climate change and ever increasing temperature in Sub Saharan Africa is being change in to arid and semi-arid environments that has a significant impact on agricultural production and climate change will be more likely to shorten the period of growing season as well as force large regions of marginal agricultural out of production. Predictable reductions in yield in some countries could be as much as 50 percent by 2020, and crop net revenues could fall by as much as 90 percent by 2100, with small scale farmers being the most affected. This would badly affect food availability in SSA. Particularly in some cereal crops it is projected that by the end of the 2025, grain crops will be most affected with up to 72 percent decline in wheat yields and up to 45 percent yield reduction in maize, rice and soybean. Overall studies predicted that a decrease the yield of cereal crops in Africa through shortening growing season period, magnifying water stress and increasing occurrence of diseases, pests and weeds outbreaks. Coping strategies to climate change in SSA experienced various adaptive mechanisms which are different considerably among regions, countries and socio economic groups since the ability to adapt and cope with climate change is a combined result of governance and national security strategies, wealth and economic development, technology, information, skills, infrastructure, institution and equity. In SSA the agricultural adaptation measures such as the use of crop varieties, planting trees, soil and water conservation, changing planting dates, diverging from crops production to livestock keeping, and irrigation as the most used adaptation methods. To withstand the impact of climate change and to assure food security, developing crop varieties those are more resilient to drought, heat, and pest infestation exploring the wild relatives of common crops linked to agricultural biodiversity is expected to avoid 10 to 15 percent to the projected reductions in yield under changing climate conditions. Therefore, in SSA climate adaptation strategy accompanied by agricultural biodiversity using genetically engineered varieties and green development led policy is effective and sustainable to withstand the climate change and to assure food security.

Key Words: climate change, adaptation, food security

1. INTRODUCTION

In the 21 century climate change and global warming is a series problem of the world. There is a suggestion of an increase in extreme weather and climate events such as droughts, floods, cyclones and heat waves, which is having severe impacts on natural and human systems throughout the world. These extreme events, which may have adverse effects on water availability and supply, infrastructure, agricultural incomes and food security, are expected to disproportionately affect the world's poorest and vulnerable people who mostly live in rural areas [54].

The increasing spectra of soaring food prices and global warming have brought food security and climate change concerns to the top of the international agenda. Agriculture and fisheries sectors now faces the double challenge of dealing with the impact of climate change at the same time that it must increase production to meet the food demands of a global population projected to reach 9.1 billion by 2050. Looking ahead, FAO recognizes that these two challenges must be addressed together. Climate change adaptation, a must for the agricultural sectors, will require substantial technical and financial investments in order to achieve food and nutrition security, particularly in food-insecure developing countries [29].

Africa has been identified as one of the parts of the world most vulnerable to the impacts of climate change [79].

Agriculture is the most important sector in Sub-Saharan Africa (SSA) and is set to be hit the hardest by climate change. Indeed, this is confirmed by several studies [42]. Although climate change may affect the agricultural sectors of different countries in different ways, what is clear is that these changes will bring about substantial welfare losses, especially for smallholders whose main source of livelihood derives from agriculture. There is a need for nations to neutralize the potential adverse effects if welfare losses to this vulnerable segment of the society are to be avoided. Adaptation seems to be the most efficient way for farmers to reduce these negative impacts [34]. This can be achieved through the smallholder farmers themselves taking adaptive actions or by governments implementing policies aimed at promoting appropriate and effective adaptation measures.

In support the above, Climate change has already significantly impacted agriculture [63] and is expected to further impact food production directly and indirectly. Increase of mean temperature, changes in rain patterns, increased variability both in

temperature and rain patterns, changes in water availability, the frequency and intensity of “extreme events,” sea-level rise and salinization, and perturbations in ecosystems all will have profound impacts on agriculture, forestry, and fisheries [39]. The extent of these impacts will depend not only on the intensity and timing (periodicity) of the changes but also on their combination, which are more uncertain, and on local conditions. Anticipating appropriately the impacts of climate change on agriculture requires data, tools, and models at the spatial scale of actual production areas. Since the last IPCC report in 2007, some studies have attempted to anticipate these impacts and provide projections at such a scale, enabling us to have a more concrete vision of projected changes.

Agricultural production in Sub-Saharan Africa is particularly vulnerable to the effects of climate change, with rain fed agriculture accounting for approximately 96 % of overall crop production [107]. Climate change exacerbates the existing food insecurity problem in Africa and will further undermine current efforts to reduce poverty and food insecurity, particularly in Sub-Saharan countries. The current drought in the Horn of Africa is probably an indication of what may come as such incidents become more commonplace, with extreme weather events having a higher probability of occurring as a result of climate change.

2. THE OBJECTIVES OF THIS PAPER IS TO:

Review the existing research and information on impact of climate change on food availability and mitigation strategies at farm level in Sub Saharan Africa.

3. SEARCH STRATEGY

Manual searching literature review was used from peer reviewed literatures, working papers, conference papers and reports from known organizations related to climate change, food security and malnutrition and Google scholar search strategies were used in this literature review from different databases. Lastly, the full text documents were considered to assess the relevance of the paper predominantly for this review.

4. RESULTS

4.1. IMPACT OF CLIMATE CHANGE

All Literatures reviewed in this paper indicated that climate change is happening now and it represents a major threat for the coming decades [82]. Climate change has environmental and human and socio economic impacts from a global down to a local level. Climate Change is considered the biggest predictor of and having the greatest impact on international development and food and nutrition security in the coming decades. The researches stated that climate change is more threat for the coming decades particularly in Africa than any other regions whose livelihood is dependent mainly on rain fed agricultural production system with limited access to capital, including markets, infrastructure and technology [97].

As reviewed from the most of the researches that the impact of the climate change in Sub Saharan African countries is summarized as climate change, shocks, seasonality and trends, climate change and water in Africa, climate change impacts on ecosystems and biodiversity, and migration, environmental refugees and social conflict in Africa are reviewed to see the impact of climate change.

4.2. CLIMATE CHANGE, SHOCKS, SEASONALITY AND TRENDS

Climate change and natural disasters Natural disasters and climate variability are major sources of vulnerability for the food insecure. They particularly affect those in countries that largely depend on rain fed farming and those highly dependent on agriculture. Poor people are also less able to cope with the impacts of climate shocks and variability. These events can result in massive crop losses, loss of stored food, and damage to infrastructure and consequent increases in food prices. Climate change is increasing the frequency and size of such events in most severs in Sub Saharan Africa [87].

Climate change scenarios generally indicate higher temperatures for most of Africa, up to 3.5 °C by 2050, in certain areas of Africa although regional projections for precipitation trends vary [104], [92], and [53]. A 1 to 2 °C increase in temperature may, in combination with more erratic rainfall patterns, already lead to sharp fall in yields for staple cereals [17], and [92]. Especially the effects of increasing variability of climate would likely result in increasing inter- and intra-seasonal droughts, flood events, uncertainty about the onset of the rainy seasons leads to increased risk of crop failure [19], [99], and [98].

In similar the above results; sever shocks, seasonality, and long term trends in climate impact on a household's access to assets and resources. According the data retrieved from the international disaster database 'EM-DAT' suggest that the total number of African people affected by droughts or floods has been steadily increasing. For instance if we look at the time from 1990-1999; 92,234,246 and 14,358,269 people are affected by droughts and floods respectively. To see the trend of climate change and its effect from 2000-2009; 158,508,578 and 23,331,733 people are became a victim of drought and flood respectively. This result indicates that in average within ten years the number of people affected by drought and flood is increased by 72% and 62.5% respectively as the results of climate change that is very significant impact. Therefore, from this result one can made a projection from the trend that the impact of climate change on drought and flood might be increased more than the above for the coming decades.

4.3. CLIMATE CHANGE AND WATER IN AFRICA

The increasing demand of water in sub-Saharan Africa is a series intimidations and this is aggravated by climatic changes causal to higher irrigation water demand, disturbing river runoff, and affectation threats of shallow groundwater pollution due to intense rainfall [66]. The growing demand of water for irrigation and hydropower production is as a result of population and economic growth but are also affected by climatic changes through an increase in evaporative losses [8]. In most of the African country the variability of inter annual rainfall is found high. This is also strengthened that significant multi decadal rainfall unpredictability is predominantly prominence of Sahel region [47]. In Sub Saharan Africa region in the periods of 1970s and 1980s is a period of low rainfall compared to the 1900–1970 period caused severe droughts in the region. This is assured by the findings of [67], [48]. Descroix et al. (2009) and Amogu et al. (2010) found that decreasing of stream flows for rivers in Sudanian areas and increasing discharge for those in the Sahelian regions.

Most of Sub Saharan Africa has generally low permeability and minor aquifers [65]. Ground water recharge rates have been projected to decline by 30–70 % in the western parts of southern Africa and to increase by around 30 % in some parts of East and southeastern Africa for both 2 and 3 °C warming above preindustrial levels [25]. However, Sillmann et al (2013) stated that these increases may be overrated, as the result of increased occurrences of heavy rains, which are likely in East Africa that lowers actual groundwater recharge because of infiltration limits which are not considered in [25].

A further uncertainty relates to changes in land use because of agriculture, which responds differently to changes in precipitation compared to natural ecosystems [94], and with the hydrological model used and the lack of knowledge about groundwater aquifers [66] is associated to uncertainties about the climate change projection effects in the region.

Generally, even though the overall projections of impacts of climate change on water resources in Sub-Saharan Africa are associated with large uncertainties, it is obvious that about increases in groundwater pulling out in absolute terms resulting from population growth and growing demand particularly in semiarid regions due to projected increases of droughts and an expected expansion of irrigated land [94].

Therefore, living in an unsafe and uncertain projection of climate change on the environment contributes to food and nutrition insecurity, and climate change is likely going to aggravate these negative consequences [10].

The rate of evaporation and transpiration of water from land and plants increase as higher temperature in the environment that leads to dryer soils that have a higher saline content, increased erosion and water run-off, and decreased water quality [37]. So, the level of nutrient content and poor soil quality is particularly damaging to crop yields and crop health.

The water stress Africa facing and also projected according to Boko et al (2007) is for about 25% of Africa's population (about 200 million people) currently experience high water stress and the population at risk of increased water stress in Africa is projected to be between 75-250 million and 350-600 million people by the 2020s and 2050s, respectively.

Climate change has greater impact on water resources and agricultural sectors in Africa and heavily influences food availability [10]. On top of this there is also evidence that all over Africa of inter-annual lake-level fluctuations and volatility since the 1960s. Even during floods or heavy rains, changes in runoff and hydrology as a result of climate change have been observed in southern Africa, south-central Ethiopia, Kenya, Tanzania, and the wider continent, and are contributing to a decreased or stagnating food production [10].

4.3.1. Climate change impacts on ecosystems and biodiversity

It is obvious that biodiversity is expressed as our life insurance that contributes to our economic demand; educational demand, cultural and ecological services. Even though life is dependent on the existence of biodiversity, climate change is impacting the ecosystem and the biodiversity resources [30]. Large changes in ecosystem composition and function because of regional climate change would have cascading effects on species diversity [57]. In addition to this [53] assured that as climate change influences on the natural and human worlds, the biodiversity of Africa's ecosystems is being put at severe risk. Continuing deteriorations in rainfall have increased the escalation of deserts in southern and western Africa, resulting in shifting sand dunes and the loss of flora and fauna [53]. Studies showed and predicted that many species will become extinct, primarily due to loss of habitat and vegetation exacerbated by climate change, particularly in South Africa [68]. Based on a variety of circumstances, climate change is expected to cause losses of about 5,000 African plant species, over 50 per cent of some bird and mammal species, and decline the productivity of Africa's lakes by between 20 and 30 per cent by 2100 [53]. Additionally, it is estimated that by 2100, parts of the Sahara are likely to emerge as the most vulnerable agro-ecological zones as desertification spreads mixed rain-fed semi-arid systems will be affected in the Sahel by climate change. Similarly, mixed rain-fed and highland perennial systems will be affected the great lakes region and in other parts of East Africa [10]. In similar the above research findings about the impact of climate change on biodiversity resources, different literatures put as the following findings.

Lovett et al., (2005) climate change is expected to significantly alter African biodiversity as species struggle to adapt to changing conditions.

He'ly et al., (2006) biome sensitivity assessments in Africa stated that deciduous and semi-deciduous closed-canopy forests may be very sensitive to slight reductions in rain fall during the growing season. This elucidates that deciduous forests may be more sensitive to reduced precipitation than grasslands or savannahs that could lead to species extinction as extended drought is occurred. The finding according Vanacker et al., (2005) is slightly seems as opposed with the above findings that illustrates in sub-Saharan Africa, which includes parts of East Africa, several ecosystems, particularly grass and shrub savannahs, are shown to be highly sensitive to short-term availability of water due to climate variability. Some studies also explained in Africa there is expansion of desert and reduction of the total vegetation cover [12].

Another finding showed that a multifaceted shifts in special spreading of the left over natural vegetation types with net decreases in woody vegetation in western Africa [38] and net increases in woody vegetation in central, eastern, and southern Africa [73].

Bond and Midgley(2012) stated in their finding as the vegetation cover change along a time in Africa is as a drivers of anthropogenic effects. This finding is also explained and widened up to correlate the different variables interactions like; natural climate variability, anthropogenic climate change, and interactions between these drivers and anthropogenic land use change have important additional and interacting effects [12], [38]. Due to these interactions of different factors that contribute to lose of biodiversity resources, it has been difficult to determine the role of climate change in isolation from the other drivers [69].

4.3.2. Migration, environmental refuges and social conflict in Africa

As the literatures reviewed; it seems as different researchers have a common findings and stands on the impact of climate change on migration and conflict. For instance, Chen et al, (2011) identified that migration, conflict, climate change, and the environment are correlated. The migration of the people to escape from the effect of climate change for search resources may increase the probability of conflict as groups compete for limited resources in a fluctuating environment. But, the conflicts do not necessarily lead to violence; it depends basically on the specific social and political context, and the policy responses undertaken.

Additionally, International Organization for Migration, IOM, (2011) support to the above interaction of the impact of climate change on migration and conflict that slow-onset disasters and gradual environmental degradation, including phenomena such as desertification, reduction of soil fertility, coastal erosion and sea-level rise, which may be associated with climate change, impact existing livelihood patterns and systems of production and may trigger different types of migration, conflict, and environmental degradation at the same time, war that leads to migration of refugees may damage the environment and their surrounding ecosystems. According to the IOM (2011) report climate change has been estimated to have displaced over 20 million people. Conflict has been estimated to have displaced over 4.6 million people. Each of these risk factors poses increased risk to subsequent climate and conflict interactions. Thus, climate change may contribute to increased wars, increased numbers of refugees, and increased competition for limited resources. By increasing the scarcity of basic food and water resources, environmental degradation increases the likelihood of violent conflict [92]. This implies that indirectly climate change could be as a cause for migration and conflict of people. According to UNEP also, the conflict in Darfur has been driven in part by climate change and environmental degradation, which threaten to trigger a succession of new wars across Africa [101]. Moreover, the interaction between environmental factors and conflict is queried. Gleditsch (2012) reviews a set of recent studies on the relationship between violent conflict and climate change and stresses that there is to date absence of confirmation for such interaction. Other meta-analyses by Hsiang et al. (2013) and Hendrix and Salehyan (2012) recommended that aberration from ordinary precipitation and slight temperatures escalates the threat of conflict. In Africa, (Hsiang and Meng 2014) have studied and repeated the doubtful result of (Burke et al. 2009) that the possibility of conflict is more in warmer years. The new findings of the report of the IPCC are the first to suggest an indirect fundamental association amid poverty and economic shocks augmented by climate change and intra-state violence [54].

The above studies complement to the established entitlement that, on both long and short timescales, depletion of a diminishing supply of, as well as uneven access to, resources has the probable to lead to rivalry between different groups and strengthen the risk of conflict [44]. The causative linking also works in the contrary direction, with conflict often leading to environmental degradation and increasing the susceptibility of people to a range of climate-generated stressors [9], [54]. The collapse of authority due to civil war can also aggravate poverty and cause ecosystem preservation measures to ruin; both of these factors can possibly cause more misuse of natural resources [74].

It is clear that how these dynamics play out is complex and not uniform, with the environment figuring as only one of several interrelated drivers of conflict [58]. That is similar with the Hailu A. (2012) who stated that climate change creates socio-political instability with in a community and a country at large and the relationship between climate change and security is complex [101]. However, given that unprecedented climatic conditions are expected to place severe stress on the availability and distribution of resources, the potential for climate-related violent conflict constitutes a real risk in some situations [7].

Generally, Sub-Saharan Africa is expected to be particularly affected by migration associated with climate change-related drivers, including sea-level rise and declining or disrupted availability of resources due to shifts in climatic conditions or extreme weather events [35].

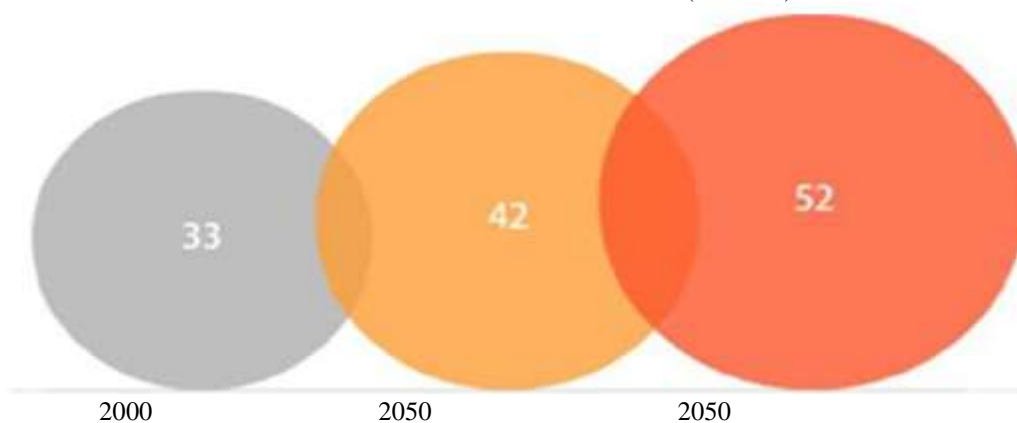
4.4. IMPACTS OF CLIMATE CHANGE ON FOOD AVAILABILITY

Different studies attested that many African countries and regions are probable to be strictly bargained on agricultural production and productivity by climate change and climate variability. Many countries in Africa is being changed in to arid and semi-arid environments that has a significant impact on agricultural production and climate change will be more likely to shorten the period of growing season as well as force large regions of marginal agriculture out of production. Predictable reductions in yield in some countries could be as much as 50% by 2020, and crop net revenues could fall by as much as 90% by 2100, with small-scale farmers being the most affected. This would badly affect food availability in the continent [10].

In addition UNICEF (2000) stated that Africa is exposed to food insecurity and low in food production, both seasonally and long-term. As the severity of climate change is increasing, numerous African nations experience bigger drought and unstable climate conditions harmfully affecting food production. Moreover as a result of global climate changes; Changing hydrology, reduced land productivity, a lack of economic inputs, and water stress account for the majority of the decrease in local production and supply channels in the local and international markets, and consequences in the instability of the food supply [100].

According to the IPCC AR4, if the existing situations of climate change continue, it is projected that 200–600 million more people will suffer from hunger by 2080 [109]. Food security in 2050 is likely to decline throughout the third world resulting in an extra 24 million malnourished children, 21% more relative to a world with no climate change, almost half of which would be living in SSA [75], [82]. .Look at Fig. 1.

Figure 1: Number of Malnourished Children in Sub-Saharan Africa (Millions)



Without climate change (Population growth, etc.)	with climate change (Business as usual scenario)
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Source: Nelson et al, 2009; Graphics by WFP.

In similar with the above finding it is forecasted that by the 2080s, there will be a substantial decline in suitable rain-fed land for cereals. The same predictions also directed that the arid and semi-arid land in Africa could increase by 5-8 percent, impacting wheat production and maize production extremely [92].

The highly dependent rain fed agriculture of Sub-Saharan African agriculture; in combination with observed crop sensitivities to maximum temperatures during the growing season are more vulnerable to climate change [6], [63], and [88]. Similarly, climate change as the result of increased temperature strongly will adversely affect crop yields in sub-Saharan Africa [103].

Generally, the effect of climate change will continue negative for most crops in SSA [87]. Several studies tried to show that the impact of climate change on the production and productivity of the main crops of SSA. For instance, IPCC suggests that the overall effect of climate change on yields of major cereal crops in the African region is very likely to be significantly negative, with strong regional variation [79]. "Worst-case" projections indicates to support the above findings that losses of 27–32 % for maize, sorghum, millet and groundnut for a warming of about 2 °C above pre-industrial levels by mid-century [87].

Maize, which is one of the most common crops in Sub-Saharan Africa, has been found to have a particularly high sensitivity to temperatures above 30 °C within the growing season. Each day in the growing season spent at a temperature above 30 °C reduces yields by 1 % compared to optimal, drought-free rain fed conditions [63]. Realistic confirmation suggests that rises in temperature in the period 1980–2008 have already resulted in average global maize and wheat yield decreases of 3.8% and 5.5% respectively, paralleled to a non-climate scenario [63]. Taking as evidences of the above findings studies projected that by the end of the 2025, grain crops will be most affected with up to 72% decline in wheat yields and up to 45% yield reductions in maize, rice and soybean [1].

More over a study of the impact of climate change on food production of a 2020 outlook indicated about two thirds of arable land in Africa is expected to be lost by 2025 due to decreased rainfall and reduce yields with an estimations of up to 50 percent in some Sub Saharan countries [61]. But another study alternatively stated that this projection of declining of food production could be compensated by increased area expansion of 2.1 percent partially rewards for an overall yield growth decline of 4.6 percent. The largest negative yield impacts are projected for wheat of which the region grows very little followed by sweet potatoes [18]. Generally the overall impact of climate change on food production and food security affects significantly and negatively in the coming decades. For example according FAO(2008) cereal production growth for a range of crops in SSA is expected to deteriorate by a net 3.2 percent in 2050 as the effect of climate change. By 2080, agricultural production in developing countries (Africa) may decrease by 20 percent due to climate change [28]. Similarly climate change is predicted to overall decrease the yields of cereal crop in Africa through shortening growing season period, magnifying water stress and increasing occurrence of diseases, pests and weeds outbreaks [79]. Furthermore, climate extremes can change the biology of plant pathogens, and higher soil temperatures can stimulate fungal development that destroys seedlings [84]. Such effects are as yet not embodied in modeling studies.

Similarly, the effect of CO₂ fertilization remains undefined but significant: Depending on crop type and region, assuming positive CO₂ fertilization may even converse the trend of effects. Conversely, major crops in West Africa are C₄ crops, such as maize, millet and sorghum, which benefits less from higher CO₂ concentration, so that the positive effect may be overvalued [85].

Nevertheless, all hopes are not vanished, some regions in SSA are estimated will experience improved agricultural production. Calzadilla et al. (2013) showed that in some areas of SSA agricultural production will increase by 25 per cent. This will be linked with anticipated rise in precipitation in some parts of eastern Africa including the Horn of Africa and central Africa [21]. For example maize yield is projected to increase in Kenya and Rwanda in 2030 and 2050 by 15% and 11% in 2030 and 18% and 15% by 2050 respectively.

4.5. MITIGATION AND ADAPTATION STRATEGIES

In Africa particularly in Sub-Saharan countries the people experiences high erraticism in precipitation and other climatic extremes, which will be worsened by climate change. Resilience in much of sub Saharan Africa is inhibited by fragile ecosystems, weak institutions, unsuccessful administration, and poverty; those most exposed are the poor who have the minimum adaptive ability [62].

It is proved by so many studies that, Africa's agriculture is extremely adversely affected by climate change [71], [81]. Therefore, coping the climate change SSA experienced various adaptive mechanisms which are different considerably among regions, countries and socioeconomic groups since the ability to adapt and cope with climate change is a combined result of governance and national security strategies, wealth and economic development, technology, information, skills, infrastructure, institutions, and equity [51].

Since 2007, Africa has developed experiences in conceptualizing, planning, implementing and to support adaptation activities, from local to national levels and across a growing range of sectors. Some farmers have already started to use this information distributing climate data regarding seasonal climate forecasts based on short term and long term forecasts to and are preparing themselves for dry conditions by planting drought-tolerant crops [83].

Many literatures directed that how to cope and mitigate the climate change in SSA giving a comprehensive support from different institutions. For instance food production can be improved intensely in dry areas when governments and organizations use climate forecasts and prepare accordingly by potentially distributing drought tolerant seeds [83]. Farmers can be also benefited in line with the climate forecasts by planting less drought tolerant and higher yield, long season maize when wetter than usual growing seasons are forecasted [83]. Over the last four decades, agricultural development policies and innovation have not only aimed to achieve increased levels of farm productivity, but have also sought to promote innovations that help farmers better cope with

climate induced risk; many of these innovations have been brought to scale in SSA. They include such improvements as drought resistant varieties, index based crop/livestock insurance, and soil management techniques that help conserve soil moisture in dry seasons and mitigate runoff and erosion in wetter seasons [22]. One particularly useful initiative that is rapidly gaining momentum in SSA aims to bring weather information to farmers in a format that is understandable and useful for them in making timely farm level decisions.

However, more recently it has become widely accepted that for resource poor and risk prone farming communities, risk mitigation must also be an integral component of strategies for adaptation to climate change, and that a two pronged approach sometimes referred to as the 'twin pillars' of adaptation to climate change is needed [14], [105]. Such an approach recognizes that both shorter and longer term strategies are required.

The above mentioned approaches are just a few of the many examples that governments, organizations, and communities need to consider in order to adapt to the challenges of subsistence food production and assure future food security [83], [104].

Many African countries, often with the assistance of international organizations or development agencies, have responded to the impacts of climate change. What is apparent immediately is the variety of responses, the lack of coordination and the highly experimental nature of some approaches [41].

Moreover, in concern to adaptation, there is a critical need to develop crops that are more resilient to drought, heat, and pest infestations to assure food security. In order to find these genetic keys, scientists need to explore the wild relatives of common crops. For this reason, it is important to maintain traditional plant varieties. In fact, adaptation linked to agricultural biodiversity is expected to avoid 10 to 15 per cent of the projected reductions in yield under changing climatic conditions [3].

As a result, many countries in Africa started to use genetically engineered varieties to tolerate the unpredicted climate change and climate variability. However, most countries in Africa are yet to accept this useful technology. Africa needs to identify specific biotechnology priority areas that offer high potential for contributing to the economy and people's livelihood, alleviating poverty, enhancing food security, reducing impact of biotic and abiotic stresses which will mitigate the effects of climate change and seek to promote Africa-focused biotechnology [102].

In reaction to changing rainfall patterns and in shorter growing seasons, some farmers are shifting to drought tolerant crops and fast maturing varieties in order to adapt to shorter growing seasons [96], [93]. These shifts are sometimes aided by social capital such as government programs and extension, or communication and support among farmers [108].

In fact, several studies reported that agricultural adaptation measures such as the use of crop varieties, planting trees, soil conservation, changing planting dates, diverging from crops production to livestock keeping, and irrigation as the most used adaptation methods in African countries [23], [56], [72], [2], [12]. However, it is clear that, for various reasons, not all farmers will adapt. In this study, the reasons for failing to adapt mentioned by farmers included lack of funds, shortage of water, poor planning, and shortage of seeds. Ogalleh et al. (2012), in analyzing perceptions and responses in Kenya, find that smallholders' perceptions are that climatic variability is increasing. In dealing with the negative impacts of this variability, the smallholders in this community use diversification of crop varieties, migration and sale of livestock. In addition, West et al. (2008) analyzed that the local perceptions and regional climate trends on the central plateau of Burkina Faso and found that rural households in the study area vary their agricultural practices, for example, integrating different crop varieties in their agricultural activities and implementing a host of soil and water conservation practices in order to respond to drought.

Similarly, Legesse et al. 2013 stated that crop diversification together with soil and water conservation and water harvesting practices were commonly used climate change adaptation strategies in eastern Ethiopia. Adaptation strategies vary from region to region and/or from place to place depending both on the extent and range of climate change or the exposure of the area to climate change, and the socioeconomic background of the people in the area [86]. But in some cases also, similar adaptation strategies have been reported in different areas [31], [60].

In SSA, large scale irrigation schemes have proven to be expensive and environmentally unsustainable [76]. Furthermore, the construction of large scale irrigation projects is limited by both natural and social constraints such as water source availability geography, and conflicting interests among stake holders [32]. This has made the development of large scale irrigation schemes implausible in SSA. However, the development of small scale irrigation schemes is a more feasible option for maintaining future crop productivity.

For smallholders, shallow and hand dug wells could supplement water limitations, especially during the dry season [76]. Rainwater harvesting and storage from ground surfaces and rooftops for use during the dry season is another option to cope with rainfall variability [26].

Promoting broad-based agricultural development to lift rural communities out of poverty is probably the effective adaptation strategy available [55].

Smit and Skinner (2002) grouped agricultural adaptation options to four main categories, but observed that they are not mutually exclusive, namely technological developments, government programmes and insurance, farm production practices, and farm financial management.

According to Smit and Skinner (2002) farm production practices adaptations could include; diversification of crop and livestock varieties, changes in the intensity of production, changes in the land use practices which involve altering the location of crop and livestock production (i.e. land fragmentation), conservation of moisture and nutrients, implementation and intensification of irrigation practices, and changes in the timing of farming operations.

Generally cropping practices that are often used to mitigate the effects of variable rainfall includes [4]: planting mixtures of crops and cultivars adapted to different conditions as formal or informal intercrops, using crop landraces that are more resistant to climate stresses, using crop trash as a mulch, planting starvation reserve crops and variety of low cost water saving measures.

Moreover, review of different literatures indicated that common adaptation methods in agriculture in SSA include use of new crop varieties and livestock species that are better suited to dry conditions, irrigation, diversifying crop varieties, adoption of mixed crop and livestock farming systems and changing planting dates [78],[81].

5. CONCLUSION

Climate change is a real and is impacting now African agriculture and it is a serious threat for the coming decades especially its impact is more severe for farmers whose livelihood dependent in small farming system mainly those who dependent in rain fed with limited adaptation accesses.

The impact of climate change is multidimensional in economic, social, political and environmental impacts.

In Africa particularly in SSA, as the result of climate change the arid and semiarid land could increase more than projected in the coming four decades. In line with this as many studies assured that the escalation of aridity and by magnifying water stress as the result of climate change could contribute to decline the food availability by 20% in 2050s. Besides climate change affects the plant pathogens and higher soil temperatures to rouse the fungal development that damages seed lings which are not yet included in the modeling studies of impact of climate change. However, climate change in some SSA countries especially in east African and central Africa could experience high amount of precipitation which contributes to increase the agricultural production in that particular regions.

In sub Saharan countries the ability to recover from the impact of climate change is restricted by fragile ecosystems, weak institutions, unsuccessful administration and poverty. Therefore, these different factors contributed to experience different coping strategies in SSA depending on the countries' governance and national security strategies, wealth and economic development, technology, information, skills, infrastructure and institutions. The most common adaptation strategies which are applied in SSA are the use of crop varieties, planting trees, soil & water conservation, changing planting dates, diverging livelihood system and irrigation. These adaptation strategies are effective in the presence of climate data information regarding seasonal climate forecasts. Moreover, climate adaptation strategy accompanied by agricultural biodiversity using genetically engineered varieties and green development led policy is effective and sustainable to assure food security.

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