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# Implication of Climate Change on Crop Yield and Food Accessibility in Sub-Saharan Africa

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## ABSTRACT

*Climatic change, one of the drivers of globalization, is a growing concern not only in the global scale but also in Sub-Saharan Africa (SSA). This paper reviews the impact of climatic change on crop production and food accessibility in SSA. Reports have predicted that SSA is one of the regions that would have the most severe impacts of climatic change. The increasing climatic variability brought about by the increase in the extreme whether events, global warming, sea water rise and deficit in rainfall would obviously have serious implications for food production and availability in the region. Thus, climate change has threatened the food security in SSA. Climatic change would significantly affect the livelihoods patterns, the ability to access food and the socio economic lives of the majority of the people in the region. Prediction models that we reviewed, in relation to impacts of climatic change on the food systems, showed consistent predictions of decrease in crop productivity, increase in land degradation, high food prices, and negative impacts on livelihoods, and an increase malnourishment. Therefore, there is an urgent need to avert this trend which climatic change is plunging the entire SSA into through the adoption of robust adaptation strategies as a means of mitigating severe food insecurity across the entire region. The respective regional governments should embark on policies and investments that support sustainable agricultural/farming practices and technologically driven development. This can help to mitigate the impacts of climate change on crop production and food security and thus, increase the capacity of the people to adapt. The feasible adaptation programs that could be adopted include improvement in agricultural land areas, crop productivity, cropping intensity, consumption and strengthening of all aspects of the market structures. Climate change is indeed an unavoidable incident in SSA, but increasing food insecurity among the population needs to be avoided.*



***Key words:*** climate change; extreme weather events; food security; food accessibility; food price volatility; Sub-Saharan Africa

## 1. Introduction

Agriculture constitutes the backbone of most African economies and is a major contributor to the gross domestic product (GDP) of the region. It accounts for about a third of Africa's GDP, employs in many countries about 60 to 90 percent of the total labour force and is the main source of livelihood for poor people (EU, 2007). In addition, most of Africa's poor live in rural areas, where they depend, directly or indirectly, on agriculture for their livelihood. In Sub-Saharan Africa (SSA), about 60 percent of the economically active population works in the agricultural sector (WDI, 2006). Any improvement in this sector would amount to an increase in the rural incomes and the purchasing power of a large number of the population in the region and, this would reduce poverty and hunger and, ensures sustainable development (Irz et al., 2001). Therefore, to ensure that the region is food secure, actions geared toward higher agricultural production and increasing access to food should be vigorously pursued.

However, climate change is considered as posing the greatest challenge to agriculture and food security in SSA. This is because the region is vulnerable to climatic change and its coping capacity is perceived to be very low (Shah et al., 2008 and Nellemann et al., 2009). Reports indicate that food production, including access to food, in many African countries is projected to be severely compromised by climate variability and change (IPCC, 2007). This means that areas suitable for agriculture would be negatively affected by climatic change and the yield potentials of many high profile crops produced in the region, particularly along the margins of semi-arid, arid and coastal areas, are expected to decrease. And, it would further adversely affect food security and exacerbate malnutrition in the region. FAO (2008) estimates indicate that the number of hungry and malnourished people due to insufficient food availability and lack of access to food, have increased from about 90 million in 1970 to 225 million in 2008, and was projected to add another 100 million by 2015.

Therefore, the outlook for the coming decades is that agricultural productivity needs to be vigorously increased to provide more food to meet the demands of growing populations and ensuring adequate access to food and its benefits now and for future generations. This paper reviews current knowledge about the relationships among climate change, food production and food accessibility in SSA. Hence, it will assess the multiple effects that climate change could have on crop yield and food accessibility in SSA. The paper tries to answer three major research questions: How does climate change affect crop yield in SSA?; what are the various ways that climate change can affect food accessibility in SSA?; and what are the projected impacts of climate change on food crop productivity and food accessibility in SSA?

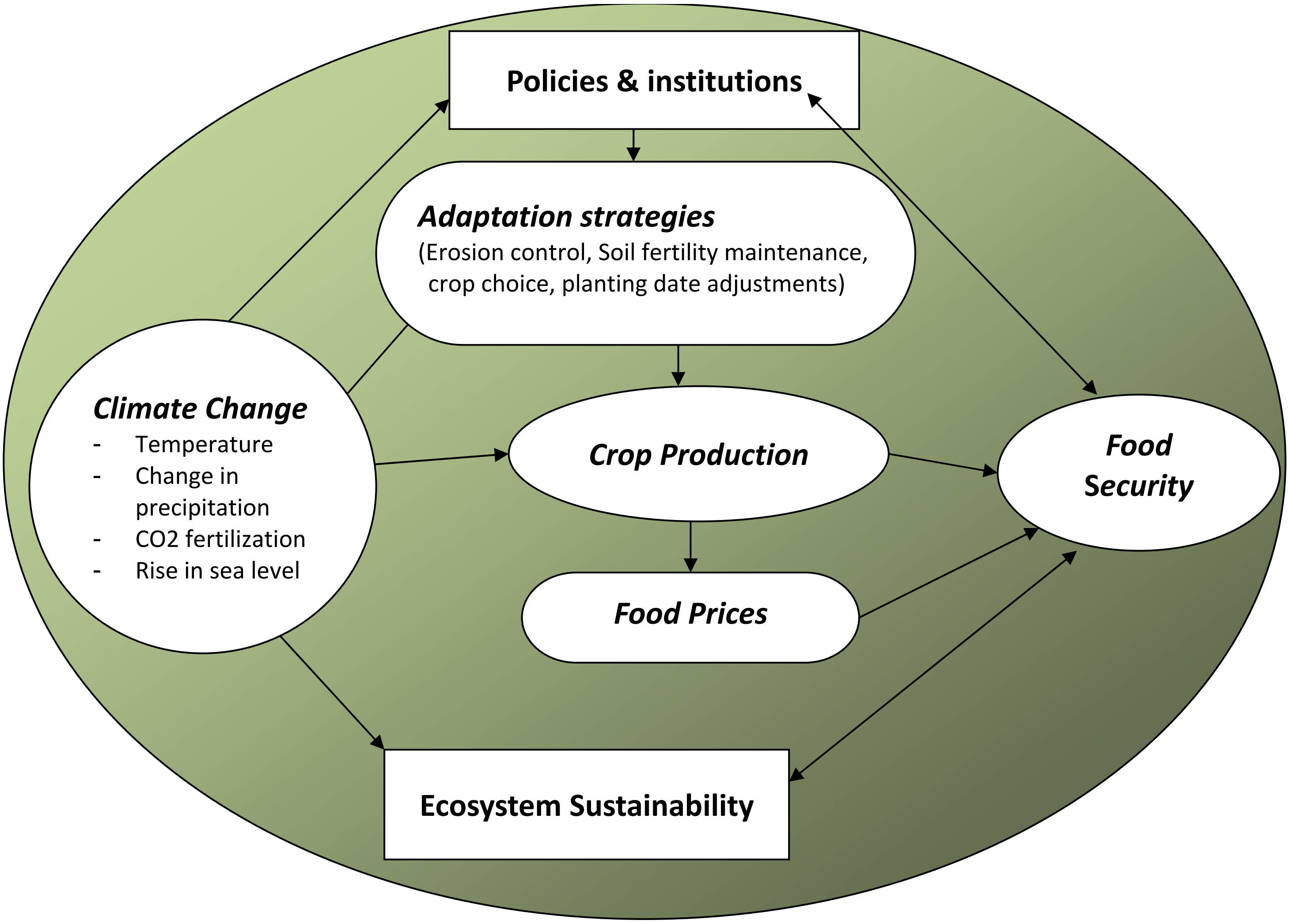
The remainder of the paper is organized as follows. Section two presents the conceptual framework and introduces the concepts, components, measurements and indicators of food security. The different ways how climate change affects crop production and how high food prices affect food accessibility are explained in section three, and the last section concludes.

# 2. Conceptual Framework and Background

## 2.1. Conceptual Framework

The conceptual model presented below depicts the linkage between climatic variables with livelihood outcomes such as agricultural production and food security. Climate change affects the type of policy measures that governments take and the adaptation strategies that the potential victims adopt. Existing policies and institutions also influence the severity of climate change in a country or region. Moreover, climate change affects crop yield and the livelihood patterns of households depending on the adaptation strategies put in place. According to Smit and Pilifosova (2001), adaptive capacity is defined as "the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change". The adaptation strategies determine the productivity of the ecosystem and the food security status of that household. A lower agricultural production and productivity due to climate change has implications for food prices, which in turn affect the livelihood and food security status of households in a country. In the absence of proper social security programs and where markets are not functioning well, which is the case in most of the countries in SSA, high prices will have severe short and long-term impacts on households. This term paper focuses only on the middle part of Figure 1 below, namely climate change, crop production, food prices and food security.

**Figure 1: Climate Change, Yield and Food Security**




***Source:*** Adapted from (Lautze et al*.*, 2003)

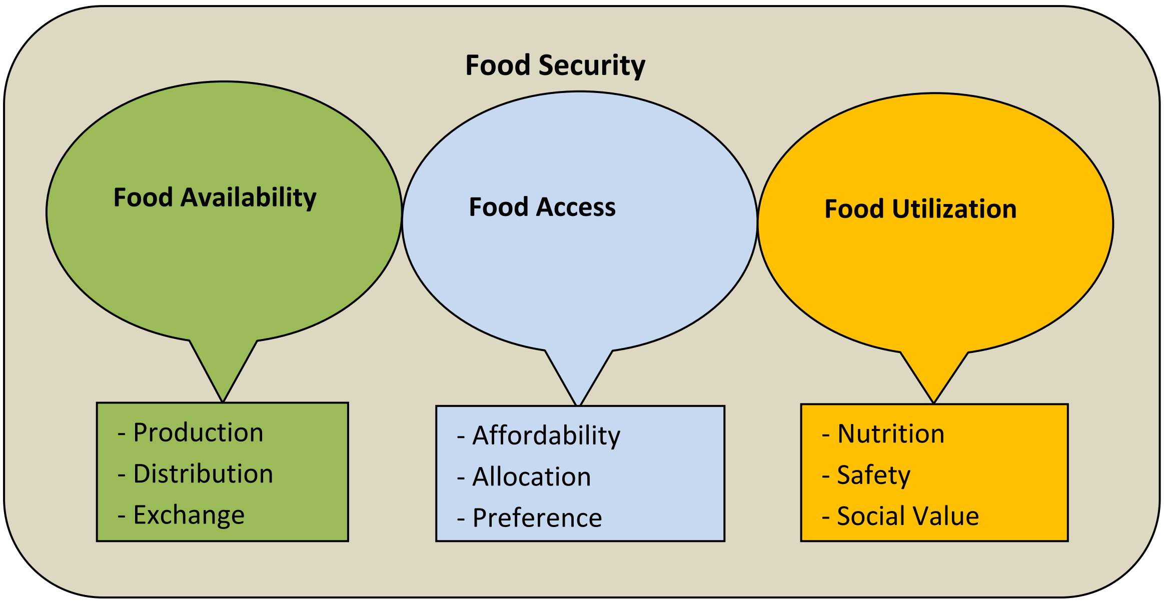
## 2.2. Food Security

As defined in the Rome Declaration on World Food Security 1996 food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996, p. 4). Food security depends on availability of food, access to food, and utilization of food (FAO, 2000). Food availability refers to the existence of sufficient quantities of food in appropriate quality, and supplied through domestic production or import. As indicated in Figure 2, food availability is a result of domestic production, distribution, storage, import and export. The comparison of available food to the estimated domestic consumption requirement gives estimation to the deficit or surplus of food availability in a certain country

(FAO, 2008a). Food availability is probably most frequently used as a measurement of food security. It is also the channel which climate change directly affects food security (Thompson et al., 2010).

Access to food is determined by physical and financial resources as well as social and political factors (Ericksen et al., 2011). Food access consists of affordability, allocation and preferences. Physical availability of food is not sufficient for an individual to have access to food. There may be food available in the market but some households may not access it for many reasons such as poverty, poor infrastructure, high prices, transaction cost, etc. The food available in the market may also be not the type that the households prefer. Thus, insufficient access to food could be a result of either high prices or lack of capacity to acquire food. The concept of access to food has been specially given emphasis since Amartya Sen's seminal book "Poverty and Famines" that shows famine can occur in spite of availability of food but due to failure of entitlement by a group of people to food (Sen, 1982).

**Figure 2: Basic components of food security**




Utilization of food depends on how food is used, whether food has sufficient nutrients and whether a balanced diet can be maintained. "Food utilization refers to the individual or household capacity to consume and benefit from food" (FAO, 2011, p.8). Although food availability and access to food are necessary for food utilization, they are not sufficient conditions. A household who has physical as well as economic access to food could be food insecure if it cannot get a balanced and nutritious diet. Food utilization has implications for a healthy and productive population in a country. Food utilization is determined, among other things, by food preparation, nutrition knowledge, health care, access to clean drinking water, women and child care and women's role (Negin et al., 2009). These are specially limited if not absent in most of the SSA countries where disease and malnutrition is widespread as a result.

It is the above three facets of the food system that need to be met in order for food security to be realized. Each of these facets can be impacted by climate variability. For the purpose of this term paper, we focus mainly on the components food production and food accessibility, as both are important for policy making in our time. The world has enough food supply but there are about a billion people who are not able to access this food supply. It is also worthwhile to mention that the three pillars of food security are hierarchical: food availability is necessary but not sufficient for access, and access is necessary but not sufficient for utilization (Webb et al., 2006). Therefore, food accessibility can be seen as an interface between people's nutritional well-being (utilization) and sudden shocks and long-term consequences of events like economic crises or climate change (Bloem, 2010).

Multiple factors play a role for households to access food. The most obvious ones are prices and employment opportunities, but factors as market integration, annual production cycles and the distribution of wealth can build obstacles to food accessibility and therefore can lead to food insecurity (Verdin, 2005).

**Measurement and Indicators of Food Accessibility:** Studies have shown that there exists a weak relationship between food availability and nutritional status which both, unlike accessibility, can be measured quite easily (Ericksen et al., 2011). Webb et al. (2006) state that purchasing power which varies with market integration, price policies as well as temporal market conditions, is the key to food access. The attempt to measure food accessibility is new and involves a lot of difficulties since households or individuals have many ways to react to a shock. To find proxies data have to be gathered on household or individual level, which is both time and resource consuming (Ericksen et al., 2011).

For the comparison of food accessibility across countries, Ericksen et al. (2011) use the following indicators:

- **GDP** (gross domestic product) **per capita** (in current USD)
  This indicator can help to show how well consumers are able to buy food and is therefore very important for the economic access to food (affordability).
- **Current poverty levels: % population living below USD 2 a day**
  Since the GDP per capita does not tell anything about the distribution of income within a country, it is necessary to see how many poor people do live in the respective country to make a statement about food security. This indicator does also reflect the affordability of food as the poorer a household is, the more of its income will be spent on food. Therefore, the share of money spent on food could be another indicator for food accessibility.
- **Transport time to markets**
  An indicator for the physical access to food is given by the time that food takes to reach markets. A region with a high level of urbanization would show a closer proximity to markets which would be an indication of higher food security. Nevertheless, of course, if a household does not have the money to buy food (affordability), a close market with food does not mean that the household is food secure. Increasing urban food insecurity seems to underline this point.
- **Monthly staple food prices**
  Besides the income, food prices and their volatility are very important indicators for food affordability. This paper will deal with this issue in detail later-on.

## 2.3. Methods

In the process of this review, we have employed a number of methods and resources. The climatic change and food security literatures were searched and reviewed for SSA with emphasis on the areas of impact of climate change on crop production, food accessibility and the implications of price changes on access to food.

**The boundaries of the review included:**

- Biophysical studies which recognized that crop farming is practiced within an economic and social context that is often location-specific;

- Studies that use climate projections, or those concerned with the underlying science of the response of crops to some climate factors;
- Studies that focus on crop productivity, omitting the forestry, fisheries, livestock and other non food crop agricultural sectors.

**Search strategy**

The main database sources and organization websites used in the review are summarized in Table 1. Academic database sources were sampled first, to avoid duplication later from less specialized databases. Regional terms (such as "Africa" or "Sub-Saharan Africa", "Tropical", and "Developing countries") were used as specific search terms, as these restrict the search and exclude studies that have a wider perspective. Articles were excluded if not published in English. Only peer reviewed journal articles and widely cited discussion and working papers were included.

Statistical data on prices and production was also used to see the trend in the level and volatility of prices overtime for selected staple crops in SSA. The indicators of food accessibility were taken from IFPRI and FAO sources.

**Table 1: Database Sources and Websites**

| **Database sources** | **Organization websites** |
|---|---|
| Journals | Science direct, Google scholar and others |
| FAO | www.fao.org, www.faostat.fao.org |
| IFPRI | www.ifpri.org |
| CGIAR | www.cgiar.org/publications |
| United Nations Economic and Social Council (UNESC) | Various sources |
| United Nations Framework Convention on Climate Change | Various sources |
| World Bank | www.worldbank.org |

# 3. Climate Change, Crop Production and Food Accessibility

## 3.1. Overview

Crop production and food accessibility are key elements for determining whether an individual, a household or even a given region is food secured. These elements are affected by climatic change. Thus, climate change is a critical element for assessing the household or regional food security. FAO (2008) stated that climate change will affect food security through its impacts on all components of global, national and local food systems. There is an overwhelming report that climate change will bring both impacts and opportunities with respect to crop production.

Crop production is one aspect of the food systems affected by climate change. It is very pertinent to look at how climatic change would affect crop production in SSA. This is because crop production does not only look at how the crops we consume are produced, but it is also an employer of labour especially in SSA where over 70 percent of the people depend on farming for their livelihoods. Thus, if the people are no longer able to make their living producing food crops, their ability to have the capital to access food may also be affected. Therefore, any change affecting the crop production in SSA will have significant ripple effects that results not only in the reduction of the available food but also increases market prices in the region. In this chapter, we will look at the interactions of climatic change with crop production and food accessibility in SSA.

## 3.2. Impacts of Climate Change on Crop Production

Climate change affects crop production through direct impacts on the biophysical factors such as plant and animal growth and the physical infrastructure associated with food processing and distribution (Schmidhuber and Tubiello, 2007). In this section, we will be exploring on how climate change will affect crop production in SSA directly.

Recent research has suggested that some impacts of climate change are occurring more rapidly than previously anticipated (Parry et al., 2007). Crop production in SSA is directly affected by many aspects of climatic change, stemming primarily from:

- Average temperature increase
- Change in rainfall amount and patterns

- Rising atmospheric concentrations of $CO_2$
- Change in climatic variability and extreme events
- Sea Water Rise

### 3.2.1. Average Temperature Increase

Increases in mean, maximum and minimum temperatures are forecasted for most regions of the world as a result of climate change. It is expected that countries in the low latitude (tropical and sub tropical) regions, where water availability is low, would generally be at risk of decreased crop yield at even 1 to 2°C of warming (Parry et al., 2007; FAO, 2008b). This is as a result of increased evapo-transpiration and lower soil moisture levels (Bals et al., 2008). Thus, the phenomenon would result in some of the agricultural lands in the SSA, which is located in the tropics, becoming unsuitable for cropping and some grassland becoming unsuitable for pasture (Bals et al., 2008). This would result in crop yield reduction in the region. The extent of these declines in yields is still unknown, but some analysts suggest they could be severe (Bals et al., 2008).

### 3.2.2. Change in Rainfall Amount and Patterns

It is expected that as a result of climate change, the temperate regions (wet areas) could become wetter and the dry areas in the tropics could become drier (FAO, 2008b). The intensity of rainstorms could increase (in some areas) and precipitation could become more variable and unpredictable. The change in rainfall can affect soil erosion rates and soil moisture, both of which are important for crop yields. SSA would experience decreased precipitation, which according to Parry et al. (2007) is about 20 percent. Thus, increase in temperature along with reduced precipitation will likely result in the loss of arable land in the region due to decreased soil moisture, increased aridity, increased salinity and groundwater depletion (Bals et al., 2008). Water shortages could lead to water rationing and higher water costs and will limit opportunities to maintain or extend these cultivated agricultural lands through the use of irrigation. FAO (2008) opined that reduction in available good quality water for crop at certain times of the year will negatively affect food supplies. SSA depends on rain-fed agriculture and, the distortion of the rainfall pattern would limit crop production and this would bring untold physical and socio-economic hardship to the rural farmers in the region.

### 3.2.3. Rising Atmospheric Concentrations of $CO_2$

The atmospheric $CO_2$ concentrations are estimated to be approximately 379 ppm at present but are projected to potentially rise to 550 ppm by 2100 under the IPCC Scenario under the lowest future emissions scenario and greater than 800 ppm under the business as usual scenario (Schmidhuber and Tubiello, 2007). Increasing atmospheric $CO_2$ levels is beneficial to plant: it acts as a fertilizer by enhancing the growth and development of crops. Increase in the atmospheric $CO_2$ levels would stimulate photosynthesis and improves water-use efficiency (Eamus, 1991, Bazzaz and Sombroek, 1996). Thus resulting in an increase in the crop biomass and yield. However, the increasing atmospheric $CO_2$ level does not only contribute to increased crop yields, but is also a major cause of the greenhouse effect.

### 3.2.4. Change in Climatic Variability and Extreme Events

Extreme events are not new phenomena in agriculture, but they are expected to increase in frequency and the areas subject to extreme events are likely to expand (Schmidhuber and Tubiello, 2007). Easterling et al. (2007) cited several studies that projected increased frequency of extreme weather events in SSA, which will have more serious consequences for food production and food security. This is becoming worrisome due to the high dependence of the region on rain-fed agriculture. Climate variability, particularly severe flooding and droughts, have been directly linked to declines in economic activity (Brown et al. 2008). Reports of Wassmann and Dobermann (2007) showed that the SSA region has experienced a series of extreme precipitation events that seem to be linked to changing climate. According to the report, the 2000 Mozambique flood had—apart from huge human losses a devastating effect on the agriculture of Mozambique with approximately 90 percent of the country's functioning irrigation infrastructure damaged and a significant loss in agricultural land that resulted many households without food.

### 3.2.5. Rise in Sea Water Level

Sea level is set to rise as a consequence of increasing global temperatures. Both will increase the vulnerability of coastal and low lying agricultural lands factoring in impacts such as coastal inundation, soil salinization and intense rainfall. Sea level has already risen by 15 to 20 cm due to the melting of glaciers and polar ice, as well as rising temperatures in the oceans (Douglas, 1997). There is significant uncertainty with regard to how much sea level could rise, but current projections suggest a sea level rise of about half a meter by 2100 can be expected and that it could possibly be significantly higher (Ibid). The countries that would be vulnerable to sea water rise in SSA include: Gambia, Gulf of Guinea, Senegal, Southern Mediterranean and Mozambique. Coastal inundation and soil salinization, will lead to a loss in agricultural land in the region. This would significantly affect crop production in the coastal regions, leading to regional loss in famers' income and food supply systems. Contamination of arable land through greater exposure to wastewater is also a possibility (ESCAP, 2009).

**Table 2: Consequences of Climate Change on Food Systems in SSA**

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

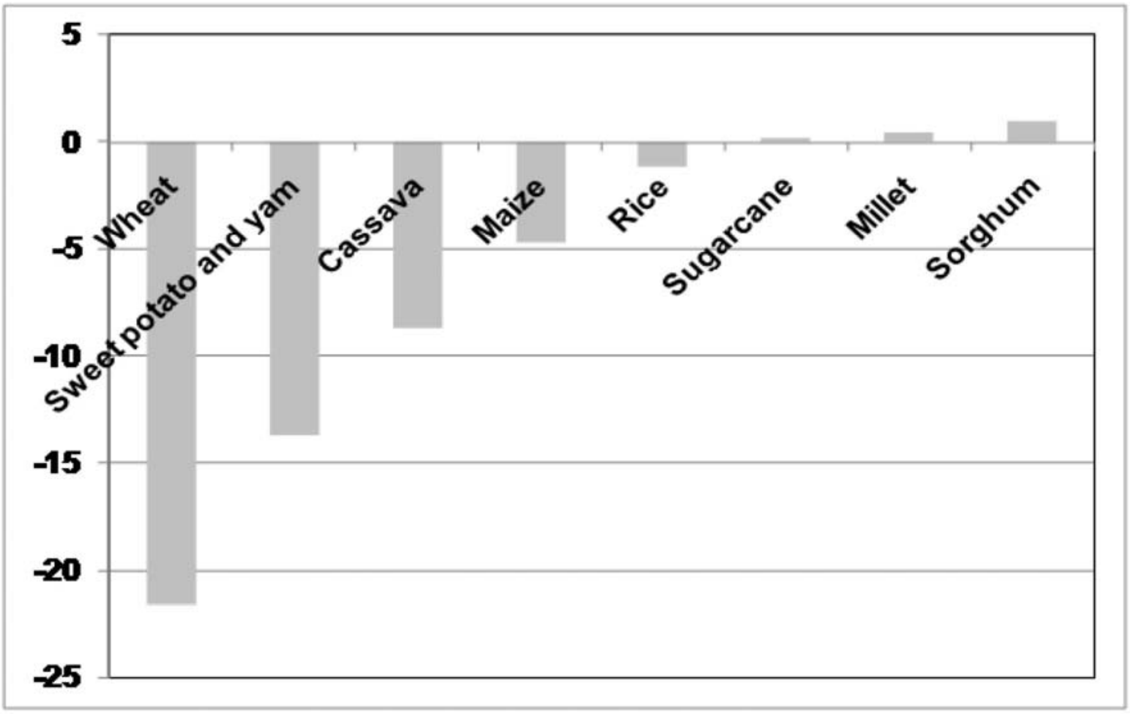
## 3.3. Yield Response in a Changing Climate

In SSA, climate models predict increased evapo-transpiration and lower soil moisture levels (Rosenzweig et al., 2002). This would result in drought, some agricultural lands becoming unsuitable for cropping, and some tropical grassland becoming increasingly arid. Lobell et al. (2011) exploited historical data from over 20,000 field trials of maize conducted in Africa over the past decade and, they found out that each 'degree day' that the crop spends above 30 °C (a unit that reflects both the amount and duration of heat experienced by the plant) depresses yields by 1 percent if the plants are receiving sufficient water. They also revealed that water availability has an important effect on the crops sensitivity; with yields decreasing by 1.7 percent for each degree day spent over 30°C under drought conditions. Thus, they indicated that under non-drought conditions 65 percent of the land area in Africa that is under maize cultivation at present would experience yield losses from a uniform 1 °C warming. Under drought conditions, 100 percent of the present cultivated area would experience yield losses, with 75 percent of this area suffering yield losses of at least 20 percent. Temperature rise will also expand the range of many agricultural pests and diseases by increasing the ability of pest populations to survive and attack crops thereby causing yield reduction. The climate change will exacerbate drought and land degradation, with estimations of 5 to 8 percent increase (60 to 90 million ha) of arid and semiarid land in Africa (Parry et al., 2007). This means that about two-thirds of arable land in Africa is expected to be lost by 2025, land degradation currently leads to the loss of an average of more than 3 percent annually of agriculture GDP in SSA (UNESC, 2007). In addition, decreased rainfall would impact negatively on the yields from rain-fed agriculture, with estimations of up to 50 percent in some countries by 2020. Maize, for example, could be discontinued in some areas in the region.

## 3.4. Projected Impacts on Crop Yield

The projected change in yields as a result of climate change in 2050 for selected crops grown in SSA is shown in Figure 3. IFPRI (2007) reported that negative yield impacts are projected to be largest for wheat, followed by sweet potato, whereas overall yields for millet and sorghum are projected to be slightly higher under climate change. Although negative impacts are largest for wheat, the region grows very little of it (about 4.3 million ha in 2000).

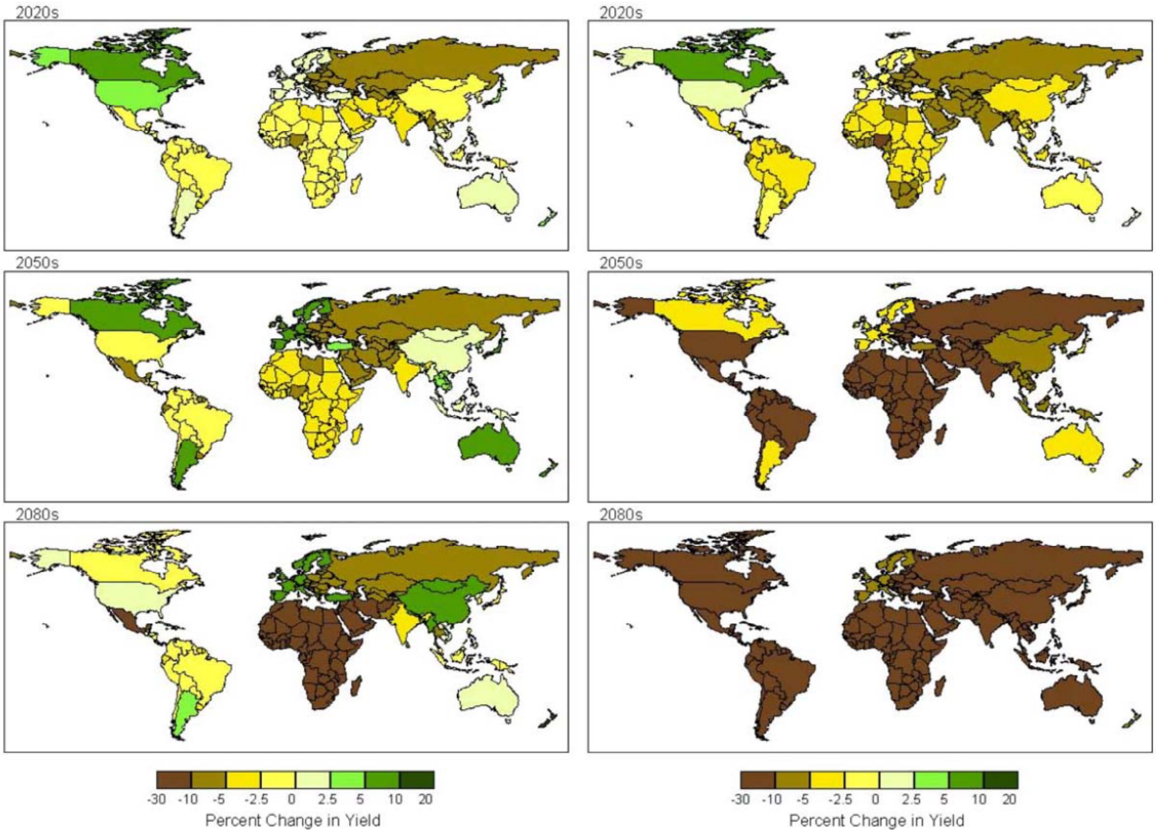
**Figure 3: Yield Changes by Crop as a Result of Climate Change, 2050, SSA (percentage change)**




***Source:*** IFPRI, 2007

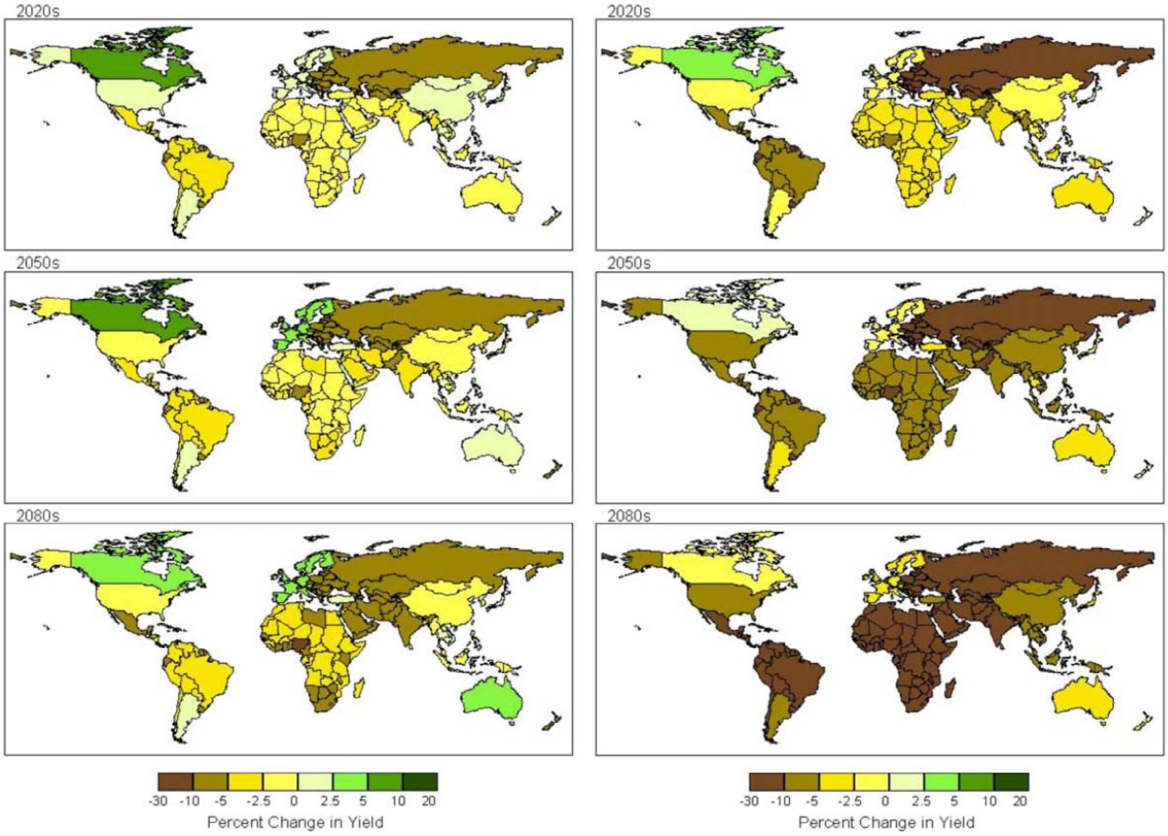
Changes in temperature and precipitation associated with continued emissions of $CO_2$ gases will bring changes in land suitability and crop yields. The IPCC Special Report on Emissions Scenarios (SRES, 2000) grouped the socio-economic development and associated emissions into four scenarios, namely; A2, B2, A1 and B1. The A1 scenario (the "business-as-usual scenario") is the scenario of the highest $CO_2$ emissions, while the B1 category corresponds to the lowest $CO_2$ emission. The A2 and B2 scenarios are intermediate between the A1 and B1 scenarios. Depending on the SRES emission scenario and climate models considered, global mean surface temperature is projected to rise in a range from 1.8°C (with a range from 1.1°C to 2.9°C for SRES B1) to 4.0°C (with a range from 2.4°C to 6.4°C for A1) by 2100 (IPCC, 2007). Changes in the regional crop yields under each of the IPCC (2000) SRES scenario are the result of the interactions among temperature and precipitation effects, direct physiological effects of increased $CO_2$, and effectiveness and availability of adaptations. Figures 4 and 5 show the potential changes in world and regional wheat, rice, maize, and soybean production for the 2020s, 2050s and 2080s (compared with 1990) under SRES scenarios with and without elevated atmospheric $CO_2$ concentrations. The model predicted that by 2020, small changes in cereal yield will be evident in all scenarios (FAO, 2002), and the differences in the mean impacts of the SRES scenarios will depend on the range of the spatial variability. Generally, the SRES scenarios result in grain yield decrease in SSA. The A1 scenario, as expected with its large increase in global temperatures, exhibits the greatest decreases in the grain yields, especially by the 2080s. Decreases are significant in SSA with expected losses up to 30 percent (Figure 4). This is an indication that effects of temperature and precipitation changes on the yields are beyond the inflection point of the beneficial direct effects of $CO_2$. However, the B1 scenario will result in smaller cereal yield decreases that never exceed 10 percent (Figure 5).

**Figure 4: Potential Changes (%) in National Cereal Yields for the 2020s, 2050s and 2080s (compared with 1990) under the HadCM3 SRES A1 Scenario with and without CO2 Effects**




***Source:*** Parry et al., 2004

**Figure 5: Potential Changes (%) in National Cereal Yields for the 2020s, 2050s and 2080s (compared with 1990) under the HadCM3 SRES B1 Scenario with and without CO2 Effects**

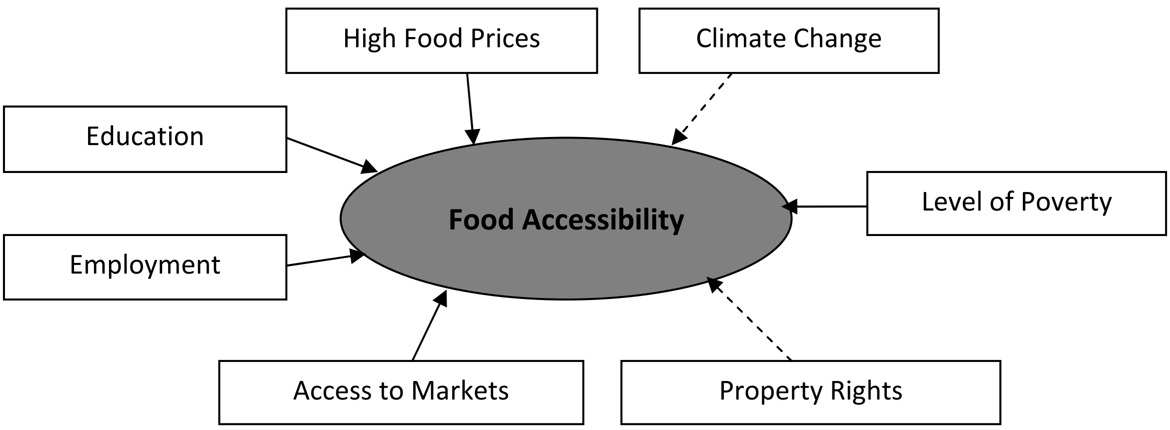



***Source:*** Parry et al., 2004

## 3.5. Factors Affecting Access to Food

Households in SSA countries fail to access food for many reasons. Figure 6 shows the most common drivers of food insecurity for households in developing countries.

**Figure 6: Determinants of Food Accessibility**




***Source***: Gregory, 2005. The arrows in dotted lines are for factors that primarily affect food availability whereas the others primarily influence food accessibility.

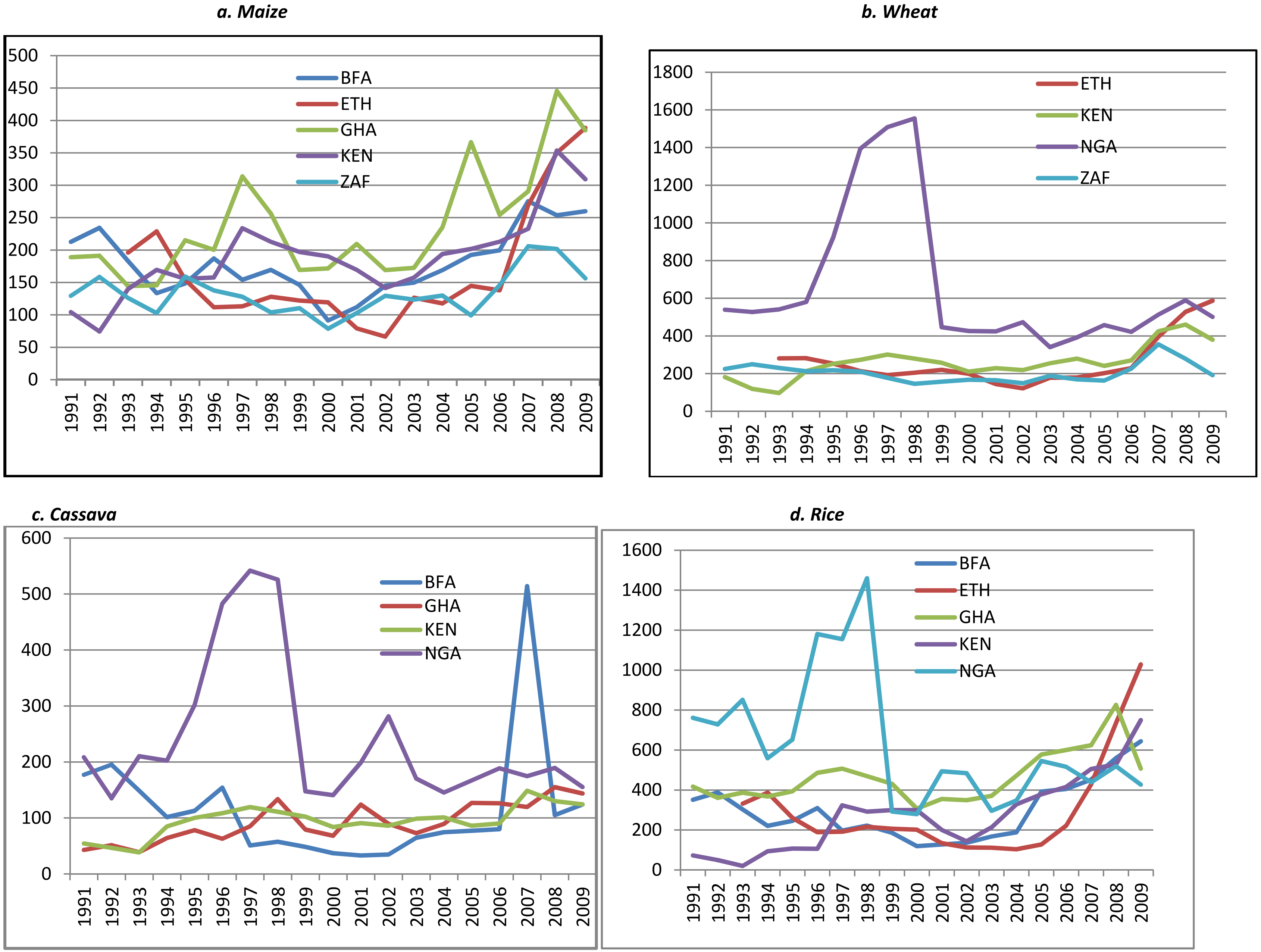
The factors in figure 6 are not entirely independent. As discussed in the previous section, the impact of climatic change could result in failure of farmers' crops which would give rise to a greater reliance on purchased commodities. For a farmer with small asset base such a loss in production would, obviously increase his/her poverty status, lead to rise in the prices of crops and high rate of unemployment. Lack of education may result in sub-optimal decision making by households about investments, credit, sale of outputs, etc. High food prices and unemployment deteriorate the purchasing power of the households which may potentially lead them to food insecurity. Poor access to infrastructure and markets may result in an exclusion of rural households from markets where they can earn better prices for their surplus produce. Thin markets and high transaction costs force farmers to gain less for their produce but to spend more for purchased commodities. Property rights and climate change have an indirect effect on food accessibility via their effect on food availability. The following sections go more into detail about these drivers of accessibility to food.

### 3.5.1. Food Prices (Volatility)

#### 3.5.1.1. Causes and Trends

After about three decades of low and relatively stable level, international agricultural commodity prices experienced a dramatic rise from late 2006 until they surge as large as the all-time high in June 2008. The World Bank Food Price Index rose by about 50 percent from June 2010 to February 2011 and attained its 2008 hike. Several studies addressed the potential causes (e.g. von Braun and Torero 2009) and consequences (e.g. Ivanic and Martin 2008) of high level and volatile food prices. Climate change (extreme weather events) is one of the root causes for the recent high and volatile food prices. An increase in price volatility has implications for resource allocation, investment decisions of farmers and thus on their welfare and future livelihoods. Although food prices have increased in almost all countries and for many agricultural commodities, the impact of the rise in prices differs across countries for many reasons. Many SSA countries are affected negatively by the rise in prices. This is because most of these countries are net food importers and they are more vulnerable than the developed countries. The major negative impact of high food prices rests on smallholder farmers in SSA since they have little or no social security from the state.

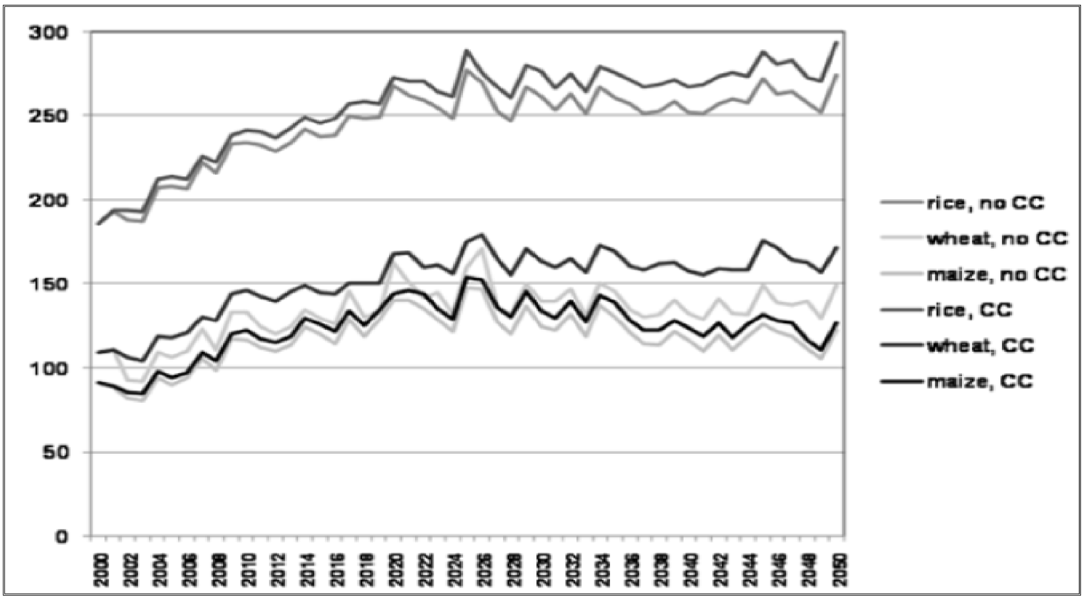
**Figure 7: Prices ($/MT) of Staple Crops in Selected SSA Countries** (Source: FAOSTAT)



Price trends for selected staple crops (maize, wheat, rice and cassava) are shown in Figures 7 a - d. In general, the figures showed three facts, that: prices of these crops have been increasing for the last decade; the price increases have become more volatile in recent years; and there is substantial correlation among prices across commodities. Both the increase in the level and volatility of prices for the crops shown in the figures vary across countries and among crops. The transmission of international prices to domestic prices in these countries does also differ depending on government foreign trade policies, infrastructural development, etc. SSA households face significant intra- and inter-annual variability in food prices. Poor macroeconomic policies, social unrest, increasing population and variation in production, market and infrastructure are some of the factors for local food price variability in these countries. A reduction in production due to extreme weather events in many areas of the region does also cause a significant rise in local food prices. Local prices of major staple crops in SSA also show seasonal variability. Since farmers have limited access to infrastructure and since they cannot afford storage facilities, they are forced to sell their produce after harvest at low prices. Storage capacity and better integration to market of producers (which lack in SSA) in many developed countries are some of the reasons that intra-annual prices are relatively stable in these countries.

Climate change is one of the factors driving prices in Africa. A 15, 7, and 4 percent rise in prices of wheat, rice and maize, respectively is projected for 2050 due to climate change in the continent (Ringler et al., 2010). High prices imply a deterioration of real income for consumers. Thus, in SSA where the majority of the households rely on rain-fed agriculture and pastoralism, high food prices would make the realization of a robust food security in the region more challenging. This is because households in this region do not have good asset base and, hence have considerable financial constraints. This would exacerbate the sensitivity of the households to climate change, and in combination with high food prices it limits their access to food (Cooper et al., 2008). The effect of climate change on prices can be observed from Figure 8, which shows the global price projections of staple crops with and without climate change. World rice, wheat, and maize prices are projected to increase by 48, 36, and 34 percent respectively during 2000 to 2050. This increasing trend has a devastating impact on food net-importing African countries which will be reflected in increasing level of food and nutrition insecurity in the region.

**Figure 8: International Staple Crop Prices ($/MT) with and without Climate Change**



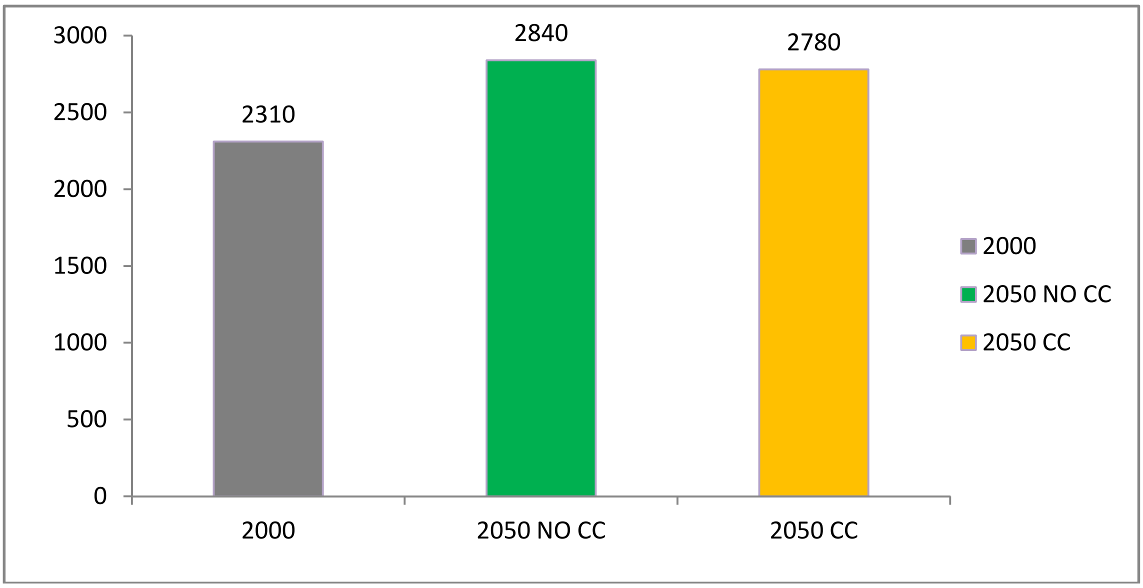

***Source:*** Ringler et al., 2010

#### 3.5.1.2. Consequences

The impact of an increase in agricultural prices on farmers is not obvious: it depends on whether the farmer is a net seller or a net buyer of food. While the net seller, a farmer who produces a surplus, benefits from a rise in food prices, the net buyer loses. The majority of the farmers in SSA are net buyers and an increase in price has a welfare reducing impact. However, the impact of high prices on consumers is unambiguously adverse. Low purchasing power of households as a result of high prices leads to a failure to access food, which in turn reduce individual's calorie availability. Households may be forced to reduce the quality and/or quantity of the food they consume, consume less preferred food, and allocate food to certain household members because of high prices. High food prices also have long-term human capital effects. Households may be forced to withdraw children from school or spend less on health and nutrition in order to compensate the loss in purchasing power due to high prices. Studies show that undernourished people in their early childhood have more than 10 percent lower life time earning capacities due to physical and mental impairment (World Bank, 2011). This is especially true since the majority of consumers in the SSA region spend a substantial share of their income on food.

Climate change will also slow the improvement in caloric consumption in SSA. The figure shows the improvements in caloric consumption in SSA with and without climate change (Figure 9).

**Figure 9: Food Calorie Availability under Climate Change and no Climate Change Scenarios (kilo calorie per capita per day)**

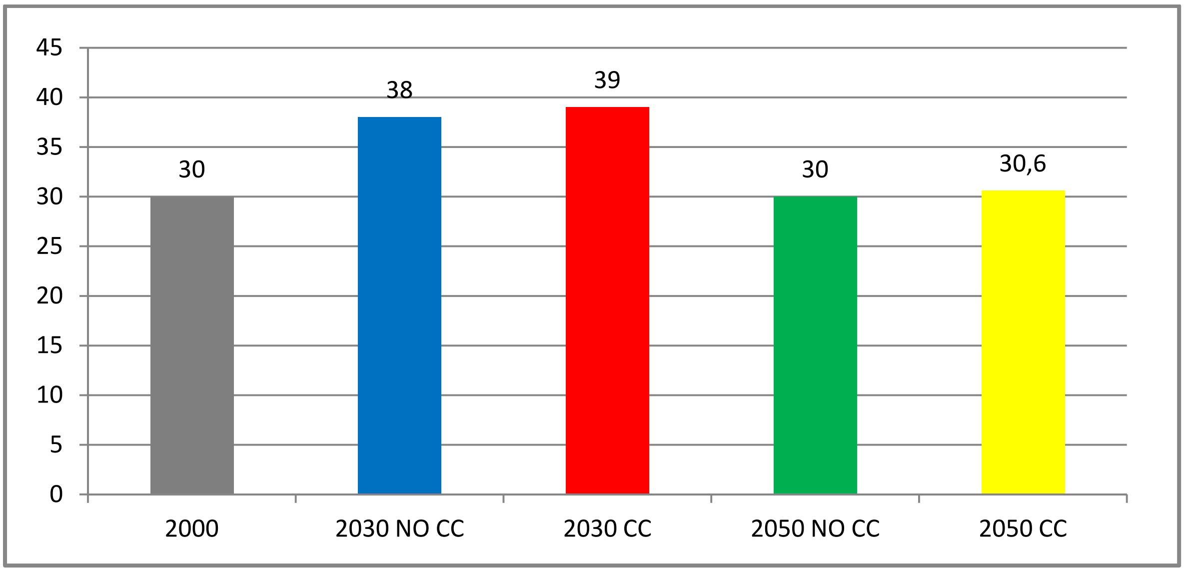



***Source:*** Own calculations from Ringler et al., 2010

Figure 9 shows that climate change will reduce the daily food calorie intake of households in SSA by about 60 kilo calories. The caloric consumption varies across different agro-ecological zones in SSA. Whereas the gulf of Guinea region has the highest per capita caloric availability, the Central African zone followed by Eastern Africa has the lowest per capita daily caloric consumption. Furthermore, according to the projection the Central African zone shows slow improvement in per capita caloric availability in 2050.

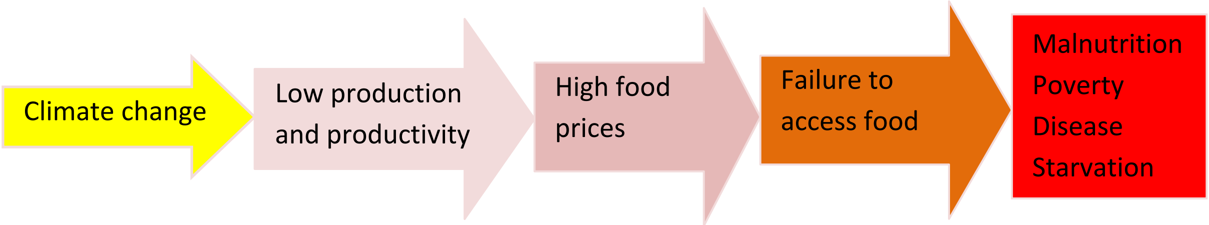
An improvement in economic growth and development implies a progress in food security, and hence a decrease in mortality rate and malnutrition prevalence. However, climate change offsets some of the benefits of economic growth in the SSA region. For instance, simulation models by IFPRI's IMPACT model show that climate change increases the size of malnourished children by 11 percent in low income developing countries (in comparison to no climate change or perfect mitigation scenario) in 2050. The number of malnourished children in SSA has also worsened due to global climate change. Figure 10 shows that the number of malnourished children in SSA is projected to be about 1 million more in 2030 and 600,000 more in 2050 due to climate change relative to no climate change scenario.

**Figure 10: Impact of Climate Change on Child Malnutrition in SSA (Million children)**




***Source:*** own calculations from Ringler et al., 2010

In general, the following process shows how the effect of climate change is channeled to food accessibility problems which could in turn lead to food insecurity.




### 3.5.2. Factors beyond Food Prices (Volatility)

Access to food by poor households in rural SSA is not solely limited by the too high food prices that they have to pay in the market. A set of other factors such as poor infrastructure, poor markets, on-and off-farm unemployment and access to credit may lead to a failure of entitlement by some households to food. This entitlement failure as Sen (1982) already explained could potentially lead to food insecurity.

***Access to Markets:*** Markets play an important role in the lives of the people in Africa. Even though a large number of the African population practices subsistence agriculture, markets serve as a secondary source of food. Especially in the so-called 'hungry season' from June to August, when crop yields are low, large amounts of the needed food have to be bought from markets. This holds also for drought years, where people purchase more goods from markets (Thompson, 2010). According to Thompson (2010) people will be more dependent from markets due to the climate change. The 'hungry season' will get longer and drought years will become more frequent because of continuously lower crop productivity. Reduction of marketing costs by improving the functioning of markets does much better than reducing food prices for consumers (Jayne et al., 1995). This is true for at least two reasons: one, it has the same effect as reducing food prices and hence improves the purchasing power of consumers; two, it improves production incentives that will bring about a change in cropping patterns and that increase the real income of both rural and urban households.

***Access to infrastructure:*** Infrastructures generally improve the poor's access to other assets including human, social, financial, and natural assets. Although they have the financial capacity, the net buying rural farmers are not able to buy food from markets far away from their village without access to roads. Neither are the net-sellers of agricultural products able to sell their outputs in the market. Small microenterprises and factories which employ many people in many urban areas of SSA cannot expand without electricity. Extreme weather events like flooding are serious threats for poor rural roads in Africa. Hence, access to infrastructure is important for households to be gainfully employed and thus, have access to food.

***On- and off-farm employment:*** Rural households in many SSA countries earn income from on-farm and off-farm employment. Both farm and off-farm activities can contribute to better food security and nutrition (Babatunde and Qaim, 2010). However, climate change can slow down the opportunity especially for on-farm employments that may result in deterioration of real incomes for the landless in SSA. The loss of both on-farm and off-farm jobs could lead to poverty and food insecurity of households in SSA where there are poor safety net programs.

# 4. Conclusion and Policy Strategies

This term paper summarizes the multiple effects that climate change has on crop production and food accessibility in SSA. We found that climatic change has significant negative effects on the crop yields and this will pose a huge challenge to the livelihoods and food accessibility of most people living in SSA. This will not only result in an increase in the regions reliance on food imports but also, the number of households who will not be able to have access to adequate food to meet their nutritional requirements would increase. The paper also describes how high food price volatility is partly driven by climate change and, how other factors as access to markets affect food accessibility and how the lack of food accessibility affects malnutrition, human capital and productivity.

Climate change may be seen as a challenge in the way of SSA reaching its potential, but the respective governments and relevant stakeholders should vigorously pursue, adopt and push for adaptation strategies that will not only mitigate further food insecurity, but could also diminish that which had already set in. This is especially necessary since poor farmers often lack the ability to adapt and are therefore more sensitive to climate change (Thompson 2010). One possible adaption strategy for farmers is to diversify livelihoods since not all sources of income are affected as much by climate change (e.g. off-farm employment). There is no doubt that action and investment of governments is needed for effective adaption strategies. To directly improve the physical access to food, investments in infrastructure are essential. This could mean to modernize roads as well as to build storage facilities for surplus crop harvest. With respect to production, governments may support the breeding of crops for biotic and abiotic stresses with a high tolerance to drought, heat stress, salinity or flooding. Enhancing the agricultural management skills as well as making relevant information available to relevant stakeholders could go a long way in helping farmers improving and developing their own mitigation or adaption strategies. The respective SSA governments should also strive to implement a good social safety net, e.g. through weather based crop insurance systems. Property rights need to be in place so that market-based water management and environmental services can be implemented. Moreover, water control measures can be improved, IT systems upgraded and extended and their services extended to the poor resource famers in rural areas. An open trade regime, which is a way to share climate risk across countries and mitigate adverse effects of climate change, should be adopted. Finally, there should be a greater commitment of the various stakeholders and significant investments and expenditures in the agricultural sector to reduce the adverse impacts of climate change in SSA.

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