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# Climate Change Impact Pathways on Agricultural Productivity in Africa: A Review

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**Abstract**
This paper reviews literature on the impact of climate change on agriculture, highlighting on gender and adaptation issues. The study looked at climate change impact pathways on the three main sectors of agriculture including crops, livestock and fisheries. The major findings were that crop production has been severely hampered through rising temperatures, irregular rainfall and increasing concentration of carbon dioxide in the atmosphere, leading to crop failure in some cases, low production and productivity levels. In livestock, the effect of unfavourable thermal conditions leads to compromised meat quality and reduced production potential. Women were also seen to suffer the most in the event of adverse changes in climate by their disposition as the primary caregivers in the home. These impacts among others could render economies efforts towards achieving their development agenda a mirage. The study recommends among others holistic policies that will support the fight against climate change.
**Key words**: Climate change, pathways, adaptation, gender, agricultural productivity

## 1. Introduction

In Africa, agriculture is currently facing serious challenges. While agricultural activities are mainly rain-dependent, the amount of rainfall and its distribution have in recent years become inadequate and unreliable (AGRA, 2013). Agricultural production system is highly susceptible to drought and flood and may also cause high volatility and severe fluctuations in market price of output produced by farmers. In spite of this, only a small percentage (6%) of the continent's arable land is presently under irrigation (You *et al*., 2010). While the top soils are fast depleting of soil nutrients, the cost of fertilizer is not affordable to many smallholder farmers who produce the bulk of the agricultural produce in the region. These in concert with other challenges facing the sector have resulted in low investments, lower yields, and high post-harvest losses. These have occurred in the midst of the rising food demand of the teeming population in the region. Like other agro-based economies in the developing countries, Ghana is already facing serious climate challenges. In Ghana the sectors of the economy being hit hard by impacts of climate change include the agriculture, water supply, energy, health and environment. The current situation is likely to be worsened as the country and the continent at large continues to experience unfavourable and unpredictable weather conditions.

The future of global food production, its impact on food security, the price and availability of food for the world's over seven billion people will depend on how well societies can adapt to such climatic changes, as well as the influence of other pressures, such as the competition for land from biofuel production. On current projections, by 2050 there will be between one and three billion additional mouths to feed (IPCC, 2009). However, food production in itself is a significant emitter of greenhouse gases, as well as a cause of environmental degradation in many parts of the world. Agriculture contributes about 15% of all emissions, on a par with transport (Ranger, 2011). When land conversion and the wider food system are taken into account the total contribution of food may be as high as 30%. Therefore to limit the long-run impacts of climate change, food production must become not only more resilient to climate but also more sustainable and low carbon itself (Ranger, 2011).

The general objective of this review is to determine the major pathways through which climate change impact on agricultural productivity. Specifically the review sought to determine the climate change impact pathways on crop production, livestock production and fisheries; discuss the role of gender in climate change issues and finally discuss the various adaptation strategies to dealing with climate change.

## 2.0 Materials and Methods

The methodology adopted for this paper was basically reviewing of literature on the subject area from journal articles and institutional reports. Various reports on climate change impact pathways on crops, livestock and fisheries were reviewed spanning from past to current literature. The methodology employed was necessary to get an in-depth understanding of the issue so that recommendations will be made for future survey studies.

## 3.0 Results and Discussion

### 3.1 Impact Pathways on Crop Production

Crop production is affected biophysically by meteorological variables, including rising temperatures, changing precipitation regimes, and increased atmospheric carbon dioxide levels. Biophysical effects of climate change on

 

agricultural production are predicted to be positive in some agricultural systems and regions, and negative in others, and these effects will vary through time. Socio-economic factors on the other hand influence responses to changes in crop productivity, with price changes and shifts in comparative advantage. Across Africa, yields from rain-fed agriculture could decline by as much as 50% by 2020 due to biophysical effects. Beyond this, if global temperatures rise by more than about 1°C –3°C, declining conditions could be experienced over a much larger area (Sagoe, 2006). Figure 1 shows a flow diagram of the possible pathways through which climate change can impact on crop production.

The likely consequences of water and heat stress on crop production include yield reductions and stunted growth (Tao *et al*., 2006, Parry *et al*., 2004, and Wang *et al*., 2007). Delay in the onset of rains could also render agrochemicals applied ineffective, contributing to crop failure, thereby reducing food accessibility and consumption. Increases in Carbon Dioxide ($CO_2$) will on the other hand lower crop water requirements by reducing transpiration per unit leaf area. These changes could affect the nutritional value, taste and storage quality of some fruits and vegetables (Chijioke *et al*., 2011; Vermeulen *et al*., 2010). However, some studies (Ainsworth and Long, 2005; Babinszky *et al*., 2012) reports that increasing $CO_2$ concentration together with rising temperatures could have some positive impact on crops. The mechanism is such that it reduces stomatal conductance and consequently increases water use efficiency in plants even in low soil moisture condition. This implies that rising atmospheric $CO_2$ concentrations offer some counteracting tendencies to the negative impacts of rising temperatures and reduced soil moisture. Another school of thought argues that rising $CO_2$ concentration may have some negative effect in the nutritional quality of harvested crops as mentioned previously and depicted in Figure 1. The net effect of $CO_2$ is therefore a topic of debate among scientists. This explains why in figure 1, it can be observed that there is no direct link between the impact of $CO_2$ concentration and crop productivity.

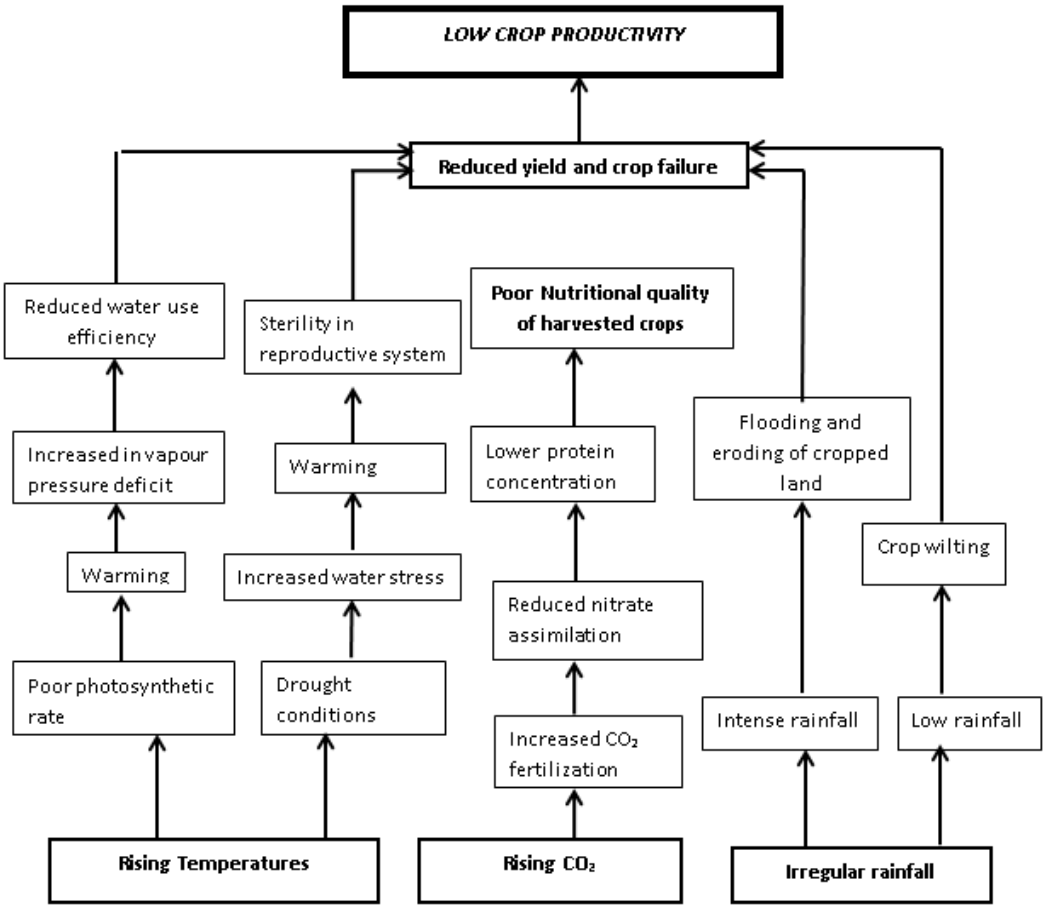


Figure 1: Schematic representation of potential climate change effect pathways on crop productionSource:

Authors' elaboration based on Hatfield *et al*. (2011) and Babinszky *et al*. (2011)

Studies by Schlenker and Lobell (2010) on five tropical crops: millet, cassava, maize, sorghum and groundnuts show that with the exception of cassava, all the other crops responded significantly to the changes in weather. This has a negative implication to food availability in the tropics given that most of these crops studied are the

 

major staples in Africa. They also reported that temperature effect on productivity was much stronger compared to precipitation effect. Wang *et al*. (2011) reported similar results in a temperate region in China. In this regard, there is the need for researchers, policy-makers and government to develop more temperature resistant varieties of crops that can withstand the negative impact of climate change on productivity and also to improve on irrigation systems for crop production.

### 3.2 Impact Pathways on Livestock Production

A variety of environmental factors such as heat stress and water availability affect livestock growth and development. Heat stress for example has a variety of detrimental effects on livestock, with significant effects on milk production and reproduction in dairy cows, and swine fertility. There is also the possibility of pasture and rangeland vulnerability to changes in climate. Pasture lands for livestock feeding may dry up as a result of high temperatures and long periods of drought. In sub-Saharan Africa, there have been many instances particularly in Sudan, Somalia and Ethiopia where severe and prolong periods of drought resulted in the death of herds of cattle and other livestock. The negative impact of climate change on feed crops also influences the feed base of farm animals, which in turn affect animal-product quality and their reproductive system (Babinszky *et al*., 2011), as depicted in Figure 2.

Unfavourable temperature conditions leads livestock to lose energy due to increased heat production. Less energy hence remains for food producing animals impairing development and product quality. The thermoregulatory ability of farm animals is equally compromised in events of unfavourable weather. In order to maintain the thermoregulatory ability of farm animals, feed intake should be increased which will also lead to extra cost of production to the producer. In laying birds for instance, there is excessive loss of carbon-dioxide during heat stress, leading to poor egg shell formulation, decreasing egg shell thickness, increase incidence of broken eggs and hence limiting egg production thereby aggravating loss to the producer. There is also decreased protein synthesis and increased protein breakdown thereby lowering body and muscle protein with higher fat levels in broilers, hence reducing meat quality (Aksit *et al*., 2006).

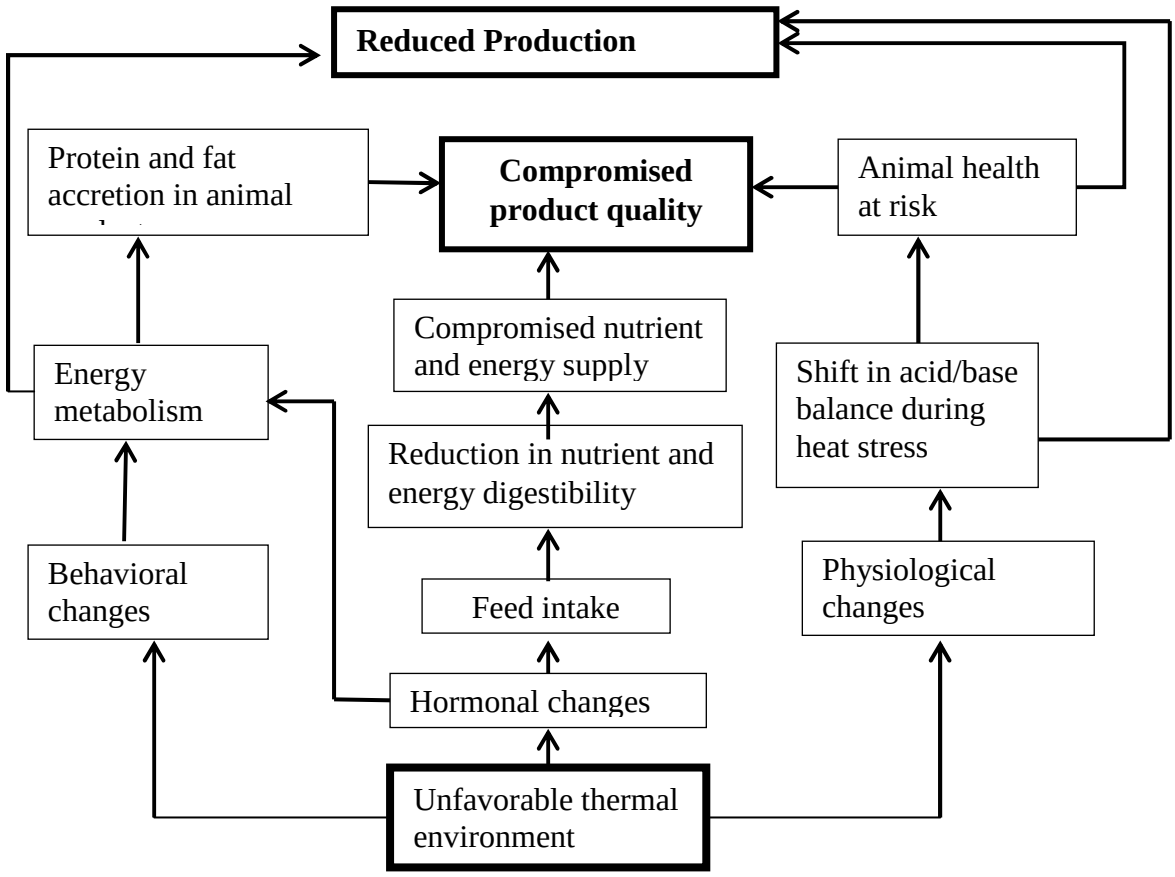


Figure 2: schematic representation of unfavorable thermal environment effect pathways on livestock
Source: Authors' elaboration adapted from Babinszky *et al*. (2011)

In some ruminants however, higher temperatures impair growth and their nutritive value. Heat stress is also one major cause of ketosis-a metabolic disorder which leads to decline in milk production. A decline in milk production also results in increased mortality rate in sucklings, thereby reducing livestock population. Some school of thought suggests that supplemental feeding could be provided to these animals under the negative climatic conditions. However, Babinszky *et al*. (2011) on the other hand argue that providing feeding like concentrate will reduce the nutritive and health value of animals whilst increasing the producer's cost of production. They also add that several studies have proven that livestock fed on grazing land have greater nutritive value compared to those fed on concentrates and hence any decline in grassland will affect the nutritive value of farm animals.

In fisheries**,** the impact of climate change can occur at two main levels; the micro (within sector) and macro (national) levels (Macfayden and Allison, 2009). At the micro-level, impact is evident in incomes, assets and livelihoods of individual fishers, fish farmers, processors and those engaged in marketing and input supply. At the macro-level on the other hand, revenue loss, decreased exports, per capita fish supply and decrease in contribution to employment and GDP may be some of the physical evidence being experienced. They also add that in many developing commonwealth states, the general impact will be experienced more at the micro level irrespective of the relative importance of the sector in the economy at large. They argue that macro-economic concerns will only arise when the fisheries sub sector contributes sufficiently to the economy. Nonetheless economies, especially African countries need to build their fisheries sub sector as the effects of climate change is not a respecter of the size of an industry.

### 3.3 Climate Change Adaptation

IPCC (2001) defines Adaptation to climate change and variability as the adjustment of a system to moderate the impacts of climate change, to take advantage of new opportunities, and to cope with the consequences. Parry *et al. (*2005) also states that adaptation involves the action that people take in response to, or in anticipation of, projected or actual changes in climate to reduce adverse impacts or take advantage of the opportunities posed by climate change.

#### 3.3.1 Local/Farm Level Adaptation Actions

Below *et al.* (2010) and Nhemachena and Hassan (2007) report that coping strategies commonly in place to reduce vulnerability to seasonal variation include the following:

Planting mixtures of crops and cultivars adapted to different moisture conditions thereby reducing the risk of complete crop failure

Using landraces resistant to climate stresses and increased mulching for water conservation

Planting of drought-tolerant and fast maturing crops development of small scale irrigation farming systems

Access to improved seeds, agrochemicals and finance

Diversification of livestock types and varieties, crop types and varieties, including crop substitution, to address the environmental variations and economic risks associated with climate change

Clarification of land tenure, tree tenure, and carbon rights which are necessary for smallholders to access capital and make long-term investments in conservation practices, agro-forestry, and improved crop varieties and inputs

#### 3.3.2 National Level Adaptation Actions

GCAP (2012) and Smit and Skinner (2002) suggest the following adaptation strategies at the national level.

Modify subsidy, support and incentive programmes to influence farm-level production practices and financial management.

Develop and implement policies and programmes to influence farm-level land and water resource use and management practices in light of changing climate conditions.

 

Provide rural credit facility to enable subsistence farmers to buy new varieties of seeds and fertilizer and disseminate information to farmers on various adaptation options through extension services;

Formulate appropriate policies for marketing agricultural input and output products which are advantageous to subsistence farmers in particular, as this group makes up almost 80% of the entire farming community in the country and is most vulnerable to the negative impacts of climate;

Invest in research into agricultural issues such as climate resistant crop varieties, water harvesting, irrigation schemes and water rights and invest in technological innovations, seed banks, etc.

Allocate adequate funding to the National Meteorological Department to procure measuring equipment and build capacity in climate data collection, storage, analysis and forecasting;

Disseminate climate forecasts in everyday language, not in scientific terms;

Formulate policies to encourage the NGOs, private sector and civil societies to complement the government's efforts to implement adaptation policies

Adaptation strategies would not only imply adjustments in infrastructure and development but includes the adjustments by humans of their surrounding environment and behavioral changes. Multi-year droughts for instance will overpower short-term coping strategies and may cause long-term impacts (Challinor and Wheeler, 2007). Schipper (2007) raises questions about whether a process of adaptation involves the development of technology or infrastructural changes that maintain existing livelihoods, or instead implies the actual behavioural adjustments needed to adapt livelihoods to new climatic conditions. She argues that some solutions to climate change will only be short-lived whereas an effective adaptation requires long-term goals. This is because when technology or infrastructure becomes obsolete, individuals that have been masked by these technical adjustments will find it difficult to cope with the changes in climate. Paavola and Adger (2005) suggest that since communities exhibit different levels of vulnerabilities and adaptive capacities, it is important that adaptation activities are localized (district, regional or national) rather than internationalised. Care (2011) also suggests that adaptation approaches must incorporate actions targeted at climate-resilient livelihoods and disaster risk reduction, as well as addressing the underlying causes of vulnerability. Adaptation strategies could be facilitated by the local/national government to increase stakeholders' resilience, especially agricultural producers to increase productivity.

### 3.4 Gender and Climate Change

The increasing attention on climate change issues necessitates a holistic and multi-faceted approach in dealing with the issues. One of such approaches is to mainstream gender into climate change policies, adaptation and mitigation strategies. By biological disposition, males and females react differently to circumstances such as disasters. According to Aguilar (2004), It has been recorded that women and children are 14 times more likely to die than men during a disaster The paper cites evident instances such as the 1991 cyclone disaster which killed 140,000 in Bangladesh, which was reported that 90% of the victims were women and also the 2003 European heat, in Europe, where more women than men died. During Hurricane Katrina in the USA, African-American women who were the poorest population in that part of the country also faced the greatest obstacles to survival (Aguilar, 2004). A study by Neumayer and Pluemper (2007) of disasters in 141 countries provided decisive evidence that gender differences in deaths from natural disasters are directly linked to women's economic and social rights.

Many men particularly the poor ones, also find themselves in similar situations. For example, men may experience deep anxiety and stress when their rural livelihoods are undermined as a result of climate change and they are no longer able to fulfill their socially expected roles as providers (Skinner, 2011). A study by the UNDP also indicates that a lot of pressure fall on men leading them into taking "heroic" actions in providing for their families, and in turn places them at a higher risk than women and children. An example is the incidence of Hurricane Mitch hitting Central America in October 2000, a higher proportion of men than women were killed due to risk-taking behavior (UNDP, 2009).

In Africa, most women have the primary responsibility of ensuring food security, provision of water and energy for their household use. In this sense, adverse effect of erratic rainfall, drought and deforestations places

additional burden on them in performing their core responsibilities in the home. Girls of school going age may have to spend more time helping their mothers in gathering fuel-wood and water, or in the extreme case drop out of school, thereby having a long-term repercussion on their education and future as a whole. Skinner (2011) has stated that in many developing countries, the implication of economic constraints and cultural norms restricting women's access to paid employment is that their livelihoods are particularly dependent on climate-sensitive sectors, such as subsistence agriculture or water collection. Yet gender inequalities in the distribution of assets and opportunities mean their choices are severely constrained in the face of climate change. For example, restrictions around land ownership for rural women mean they may not have access to productive land to farm, and inadequate access to financial capital means they cannot easily diversify their livelihoods.

Gender has not been properly represented in various climate change adaptation and mitigation policies. Even though there have been efforts to include it, Hannan (2009) reports that most policies still remain gender blind. In instances where gender issues are considered they are too often an "add-on" to existing policies. It was observed that international instruments such as the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC) unfairly represented gender issues. In reaction to this, the United Nations Commission on the Status of Women in 2002 agreed strongly for the need to include a gender perspective on climate change which will provide a critical mandate for work at global, regional, national and local levels. The Commission called for action to mainstream a gender perspective into ongoing research, inter alia, the academic sector on impact of climate change, natural disasters and related environmental vulnerabilities, and encourages the application of results in policies and programmes (Hannan, 2009).

## Conclusion

The manifestations of climate change as well as its negative repercussions on economic activities such as agriculture have long been recognized. Climate change impact pathways on agricultural productivity are also well documented. Most agricultural activities especially crop production in Africa and other tropic areas are rain-dependent, hence the effects of climate change are quite evident. Though the changes in climate are natural phenomenon, a significant portion of them are caused by human activities. The world may not be able to mitigate climate change entirely since it is caused by not only human activities but also natural factors. Therefore in addition to mitigation measures, developing adaptation strategies is the most practical option to dealing with climate change impact. A call for survey research into climate change impact pathways on agriculture at the farmer level is also recommended.

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