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Present and Future Prospects of Climate Change and Agricultural Productivity in Ethiopia: Review

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Abstract
Global climate change is the hottest environmental issue today. It is not new phenomena, but the warming that is occurring today is unprecedented with respect to the rate of change. Future annual warming of the world is projected to increase in the coming decades. Agriculture is one of the most climate-sensitive industries, with outdoor production processes that depend on particular levels of temperature and precipitation. The Ethiopian economy is largely depends on rain-fed agriculture, which is highly sensitive to climate change and variability. Experiencing high temperature and rain fall variability is a common feature in the country. Therefore, this paper will give an over view on climate change and agricultural productivity in Ethiopia.
Keywords: Climate change, agricultural productivity, Ethiopia

1. Introduction

Agriculture is one of the most climate-sensitive industries, with outdoor production processes that depend on particular levels of temperature and precipitation. In monetary terms, agriculture in the world represents 2.9% of Gross Domestic Product (GDP). In spite of its less contribution in world GDP, it amounts to almost one-fourth of GDP in the least developed countries. And its product is an absolute necessity of life, with virtually no substitutes (Ackerman and Stanton, 2013). The mosaic of agricultural systems has been shaped over time by a number of factors, including abundance and quality of land and water resources in area, social, cultural, economic, and political conditions of human settlers, and climate (Jones, 2003).

In most African countries, farming depends entirely on the quality of the rainy season (IPCC, 1997). Overall Africa has warmed 0.7°C over the 20th century and general circulation models project warming across Africa ranging from 0.2°C per decade (low scenario) to more than 0.5°C per decade (high scenario) (IPCC, 2001). Again, African rainfall has changed substantially over the last 60 year. Over tropical North Africa, this change has been notable as rainfall during 1961–1990 declined by up to 30% compared with 1931–1960 (Sivakumar *et al*., 2005). The continent is particularly vulnerable to the impacts of climate change because of factors such as widespread poverty, recurrent droughts, inequitable land distribution and overdependence on rain-fed agriculture. Under the assumption that access to adequate financing is not provided, Africa is the continent most vulnerable to the impacts of projected changes because widespread poverty limits adaptation capabilities (IPCC, 1997; Boko *et al*., 2007).

The effects of global warming and increased atmospheric carbon concentrations will result in improved growing conditions in some areas, and thus crop production may increase. Elevated atmospheric CO2 levels are expected to augment crop productivity because of increased photosynthetic activity and improved water use efficiency. At the same time, however, higher temperatures may intensify pest and disease problems, which in turn would lead to crop losses (IPCC, 1997; Fischer *et al*., 2002). Similarly, Ackerman and Stanton (2013) reported that global warming is now causing unprecedentedly rapid changes in the climate conditions that affect agriculture – much faster than crops can evolve on their own, and probably too fast for the traditional processes of trial-and-error adaptation by farmers. On the other hand, Leakey (2009) argued that C3 plants could be beneficial from increased CO2 concentrations. In contrast, C4 plants, including maize, sugarcane, sorghum and millet do not benefit from increased CO2 concentrations except in drought conditions. Thus, it is important to understand the clear impact of climate change on agricultural productivity in Ethiopia by review scientific materials.

2. Climate change and agricultural productivity in Ethiopia

2.1 Country overview

Agriculture is the most important sector of the Ethiopian economy, which accounts for half of GDP, 83.9% of exports, and 85% of total employment (UNDP, 2011). Ethiopia's climate is typically tropical in the south‐eastern and north‐eastern lowland regions, but much cooler in the large central highland regions of the country. Mean annual temperatures are around 15‐20°C in high altitude regions, whilst 25‐30°C in the lowlands (McSweeney *et al*., 2007). Mean annual rainfall distribution has maxima (>2000 mm) over the Southwestern highlands and minima (<300 mm) over the Southeastern & Northeastern lowlands (FDRE, 2001).

2.2 Recent climate Trends

Mean annual temperature of the country has increased by 1.3°C between 1960 and 2006, an average rate of

0.28°C per decade. The mean annual temperature is projected to increase by 1.1 to 3.1°C by the 2060s, and 1.5 to 5.1°C by the 2090s. Under a single emissions scenario, the projected changes from different models span a range of up to 2.1°C (McSweeney *et al*., 2007).

In relation to rain fall, many studies revealed the reduction of rain fall amount in different parts of the country (Seleshi and Zanke, 2004; Funk *et al*., 2012). For example, there is a reduction of spring and summer rainfall by 15–20% across parts of southern, southwestern, and southeastern Ethiopia between the mid-1970s and late 2000s. The combined spring and summer rainfall reductions were a loss of more than 150 mm of rainfall per year in the most densely populated long cycle crop growing area of the country (Funk *et al*., 2012). Similarly, Seleshi and Zanke (2004) also reported the decline of rainfall in eastern, south and southwestern Ethiopia from 1986 to 2002 which is caused by the corresponding persistent warming of the South Atlantic Ocean over the period. In the same way, there is a negative rainfall anomaly in north central highland of Ethiopia with frequently reduction of the main rainy season (June–September) than the long-term average in the second half of 20th century (Osman and Sauerborn, 2002). Regarding future rain fall, McSweeney *et al*. (2007) argued there will be an increase of annual rainfall in Ethiopia. These increases are largely a result of increasing rainfall in the 'short' rainfall season (October, November, and December) in southern Ethiopia. While, Christensen *et al*. (2007) reported the difficulty of projecting East Africa's rain fall. This is because of it can be strongly influenced by ENSO, and this contributes to uncertainty in climate projections, particularly in the future inter‐annual variability.

2.3 Climate change and agricultural productivity

In the arid and semi-arid tropics of Africa, climate change resulting in increased frequencies of drought poses the greatest risk to agriculture (Sivakumar *et al*., 2005). Ethiopia has experienced droughts for hundreds of years, with major events (that is, ones involving famine or documented suffering) including 1888-92, 1899-1900, 1920-22, 1933-34, 1973-74, 1983-84, 1987-88, 1990-91, and 1993-94. Mostly the occurrence of drought in Ethiopia is related to El Nino Southern Oscillation (ENSO) events (UNDP, 2008). Again, the onset and duration of the rainfall seasons vary considerably inter annually were a cause for frequent drought and famine (McSweeney *et al*., 2007). During drought years, the country suffered significant production deficit of about 20% in the agricultural sector, resulting in a significant decrease of total annual production, mainly involving cereals and pulses. The central highlands of Ethiopia, which play a great role in the country's agro economy, have suffered most, compared to other parts of the Ethiopian highlands (UNDP, 2008). The recent drought years in the country (1965, 1972–73, 1983–84, 1987–88 and 1997) resulted low agricultural production and affected millions of rural poor farmers, pastoralists, domestic and wild animals, with serious degradation of the environment (Hurni, 1993; Camberline, 1997).

The Intergovernmental Panel on Climate Change's (IPCC, 2007) findings suggests that developing countries like Ethiopia will be more vulnerable to climate change due to their economic, climatic and geographic settings. In the same way, Zenebe *et al*. (2012) also reported that its low adaptive capacity, geographical location and topography make the country highly vulnerable to the adverse impacts of climate change. It is believed that climate change in Tropics may jeopardize many societies. In these areas even small changes in climate, such as an increase in drought frequency from 1 in ten years to 2 in ten years could result in major food shortages and permanent damage to societies that barely are able to produce (Jones, 2003). In parallel with the above studies, Tennigkeit *et al*. (2013) also argued that as a result of climate change developing countries are expected to become increasingly reliant on food imports.

Preliminary projections suggested that climate change can have 7-8% GDP loss per year, with stronger impacts in later decades and on the poor (UNDP, 2011). Similarly, according to the World Bank (2007) climate change is projected to reduce yields of the wheat staple crop by 33% in Ethiopia. This amounts to a serious threat to food security and to the achievement of major developmental goals. Additional study result indicated that, over a 50-year period, the projected reduction in agricultural productivity may lead to 30% less average income, compared with the possible outcome in the absence of climate change (Zenebe *et al*., 2012). In the same manner, it is estimated that, by 2100, parts of the Sahara are likely to emerge as the most vulnerable, showing likely agricultural losses of between 2 and 7% of GDP (Boko *et al*., 2007).

In the moisture-sufficient highlands where cereals dominate, overall productivity is projected to increase until approximately 2030 as a result of climate change, but to decline sharply thereafter. This is apparently due to nonlinear effect of temperature on yields. While, in the drought-prone highlands, the situation is somewhat different. Land productivity and crop yield is expected to decline as a result of climate change more or less continuously (Zenebe *et al*., 2012). If recent warming trends continue, most of Ethiopia will experience more than a 1.0°C increase in air temperature, with the warming tendency projected to be greatest in the south-central part of the country. This warming will intensify the impacts of droughts, and could particularly reduce the amount of productive crop land for coffee (Funk *et al*., 2012) which will be a threat for the country's export capacity.

3. Conclusion

Agriculture, the main stay of Ethiopian economy, is being threatening by the existing climate change. The country's low adaptive capacity, geographical location and topography make the country highly vulnerable to the adverse impacts of climate change. The variability of rain fall and the increasing temperature were a cause for frequent drought and famine, and putting disastrous impact on the livelihood of the peoples. In addition, climate change will be a treat for the export capacity of the country.

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