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REVIEW ARTICLE

ETHIOPIA'S RESPONSE TO CLIMATE CHANGE AND VARIABILITY: A REVIEW

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ABSTRACT

This review paper was initiated to review the Ethiopia's response to the existing climate variability and change. Climate variability and change have been occurring in Ethiopia. Evidences showed that there is an increase in temperature and spatial and temporal rainfall variability has been increasing. The changing climate has led to recurrent droughts and famines, flooding, expansion of desertification, loss of wetlands, loss of biodiversity, decline in agricultural production and productivity. Ethiopia had shown many efforts to combat climate change in the different parts of the country. Promoting conservation agriculture, home gardens and traditional agro forestry systems, harvesting non-timber forest products, protected area systems, a forestation and reforestation programs, renewable energy sources, livestock selling and production are among the mechanisms for mitigating and adapting climate change in Ethiopia as a response.

INTRODUCTION

There is a rapid change and variability in the earth's climate as a result of increases in the concentrations of greenhouse gases in the atmosphere mainly caused by human activities, particularly burning of fossil fuels, agriculture and deforestation (Wigley, 1999; Stern, 2006; IPCC, 2007; Zegeye, 2013; Hailab, 2018). According to the Intergovernmental Panel on Climate Change (IPCC) prediction, the global surface temperature will increase by 1.4 - 5.8°C by 2100 years due to increasing concentration of GHGs specifically carbon dioxide. The Least Developed Countries (LDCs) like Ethiopia are highly vulnerable to climate change and variability since they are dependent on agriculture and climate sensitive economic sectors (Bruckner, 2012). Climate, as a natural resource, is probably the most important single factor in agriculture and food production. Agriculture remains highly sensitive to climate variations, which are the dominant source of the overall inter-annual variability in production in many regions and a continuing source of disruption to ecosystem services (Howden *et al.*, 2007). Adverse climate change impacts are particularly high in countries located in tropical Africa that depend on agriculture as their main source of livelihood (IAC, 2004; Dixon, Gulliver and Gibbon, 2001; IPCC, 2001).

Rural communities, who depend on agriculture for sustenance and livelihood, are often vulnerable to the direct impacts of adverse impacts of climate variability and change (Molnar, 2010; Melese, 2019). Negussie and Ashebir, 2016 reported that the smallholder, low-input and rain-fed agriculture, and the pastoral livelihood system in the arid and semiarid lowlands are more vulnerable to the adverse effects of climate variability and change because of dependence on climate sensitive natural resource based economic activities. Ethiopia is mainly at risk to climate change and variability because of its greater reliance on climate sensitive economic sectors like subsistence crop cultivation and livestock production. In addition, a large part of the country is arid and semiarid and is highly prone to desertification and drought (NMA, 2001 and Melese, 2019). Thus, this review paper was initiated to review the country's response to the existing climate variability and change.

Climate variability and change in Ethiopia: Even if the climate of Ethiopia is changing in recent years, it is naturally diverse and variable (Umer, 2010; Eshetu, 2011; Mokria *et al.*, 2017). The temperature (maximum, minimum, mean) is increasing, but the rainfall does not show any definite trend, it shows high variability (NMSA, 2007; Bewket and Conway, 2007; McSweeney *et al.*, 2008; Addisu *et al.*, 2015). Since 1950, the annual average maximum and minimum temperatures of the country have been increasing every decade by about 1 and 0.25°C, respectively (NMSA, 2001). In Ethiopia, climate variability and change is mainly manifested

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through the variability and decreasing trend in rainfall and increasing trend in temperature. Besides, rainfall and temperature patterns show large regional differences (Zerga and Gebeyehu, 2016). According to Addisu *et al.* (2015), the annual total rainfall data from 109 representative ground based meteorological stations in Ethiopia indicated a coefficient of variation ranging from 20 to 89%, and 17 stations had above 42% coefficient of variation highlighting the extreme variability of rainfall over the country. They also noted that the maximum, minimum and mean temperatures had increasing trend; whereas rainfall amount showed a general decreasing trend in Lake Tana Sub-Basin. The amount of rainfall has been decreasing in many parts of the country. But some areas in the western part of the country have experienced irregularities, unpredictability and a pattern of shortened rains, temperature increase, heavy rains, frost and hail (Troeger, 2010).

Nowadays climate change is a key concern to Ethiopia and needs to be tackled in a state of emergency. It has brought an escalating burden to already existing environmental concerns of the country including deforestation (Ayana *et al.*, 2011) and agriculture sector (UNDP Ethiopia, 2011). Climate change and its impacts have also been perceived by local people, who express climate variability and change in that generally the temperature is increasing and the rainfall is decreasing (Kassa, 2013; Addisu *et al.*, 2016; Belay *et al.*, 2017; Mekonnen *et al.*, 2017; Tilahun *et al.*, 2017). The frequency of droughts in Ethiopia, particularly in the recent decades, is an indication of the prevalence of the variation in climate. There were 19 drought events which occurred in Ethiopia in the period 1900-2002, which is almost once in 6 years in the period 1900-1987 (14 drought events) and roughly in 3 years in the period 1988-2002 (5 drought events) (NMSA, 1987; World Bank, 2005). Since 1876, about 22 droughts with an average cycle of every 6 years are occurring in Ethiopia (Eshetu *et al.*, 2010). According to study of Deressa (2006) for Ethiopia, by using Heckman sample selection model both increasing temperature and decreasing precipitation are damaging Ethiopian agriculture. Climate change has strong impact on the agricultural sectors and forestry by modifying or degrading productive capacities and by directly and indirectly increasing the risks associated with production (FAO, 2011).

Major impacts of climate change in Ethiopia: Agriculture is a sector which is negatively impacted by climate change. It is clear that climate change will bring about substantial welfare losses especially for smallholder farmers whose main source of livelihood comes from agriculture (Zerga and Gebeyehu, 2016). Changes in climate extremes are already having impacts on social, economic and natural systems, and future changes associated with continued warming will present additional challenges (Karl *et al.*, 2008). Indirectly climate change has an effect on agricultural sector as: -changes in soil moisture, land and water condition change in frequency of fire and pest infect, and the distribution of diseases. The potential for a system to sustain adverse impact on agriculture is determined by its capacity to adapt to the changes. Higher temperatures, reduced rainfall, and increased rainfall variability reduce crop productivity that would be affected food security in low income and agriculture-based economies. Thus, the impact of climate change is detrimental to countries that depend on agriculture as the main livelihood (Edwards *et al.*, 2009). In Ethiopia, many species are vulnerable to the impacts of climate change. Many forest tree species in Desa'a forest in Northern Ethiopia have showed poor regeneration due

to human disturbances and changing environmental conditions including climate change (Aynekulu *et al.*, 2011). Species with limited geographical opportunities, restricted habitat requirements and/or small populations (for example, species restricted to Afroalpine ecosystems, such as Giant Lobelia, Walia Ibex, Ethiopian Wolf) are typically the most vulnerable (Zerga and Gebeyehu, 2016). Similarly climate change has increased the spread and abundance of invasive alien species which are becoming threats to biodiversity of the country (Zegeye, 2017; Sharma and Nigatu, 2013). Climate change will alter the hydrology of both surface and ground water resources thereby affecting the spatial and temporal availability as well as their productivity (Ludi 2009; Negash, 2010). It will affect the distribution, quantity and quality of water. As such, climate change will cause shortage of water for domestic, industrial and agricultural/irrigation purposes; fishery and aquaculture, hydroelectric power generation, transportation, water-based recreation and ecosystem health. It is obvious that water scarcity is a critical problem in many parts of the country, particularly arid and semi-arid regions. Climate change has also direct and indirect impacts on the prevalence and spread of diseases and pests. Warmer temperatures and variations in rainfall patterns associated with climate change are already altering the transmission mechanisms of water and vector borne diseases in Ethiopia. Incidence of malaria, dengue fever, and water borne diseases like cholera, dysentery is likely to become more prevalent, while food insecurity related to extreme events also threatens the lives and livelihoods of millions of Ethiopians (NAPA, 2007).

World Health Organization (2002) states that in year 2000, climate changes was estimated to be responsible for approximately 2.4% of worldwide diarrhoea, and 6% of malaria in some middle income countries. Ethiopia is highly vulnerable to drought and floods. Drought occurs anywhere in the world but its damage is not as severe as in Africa in general and in Ethiopia in particular due to low adaptive capacity. Recurrent drought events in the past have resulted in huge loss of life and property as well as migration of people. The other climate-related hazards that affect Ethiopia from time to time are flash and seasonal river floods. Areas in the Afar region along the Awash River, in the Somali region along the Wabi Shebele river and in the Gambela region along the Baro-Akobo river, in the Southern region along the Omo-Gibe river, Bahirdar Zuria and Fogera areas along the Abbay river in the Amhara region are prone to seasonal river floods (Tadege, 2007).

Climate Change Adaptation and Mitigation Mechanisms in Ethiopia: Adaptation to climate change refers to adjustments in environmental, social and economic systems in response to the actual and expected impacts of climate change. Adaptation to climate change has to be localized, given that adaptation to climate change is inevitably and unavoidably local (Blaikie *et al.*, 1994; Ribot, 1995). Adaptation to climate change requires combining scientific knowledge with indigenous knowledge and practices. Moreover, adaptation to climate change needs to be a continuous endeavor. Ethiopia is taking the necessary steps to implement the two categories of responses to climate change mitigation and adaptation. Accordingly, Ethiopia prepared its National Adaptation Programme of Action (NAPA) and Nationally Appropriate Mitigation Action (NAMA) and submitted to the UNFCCC in 2007 and 2010, respectively.

To boost socio-economic development and combat climate change, Ethiopia developed a CRGE strategy in 2011 (Anonymous, 2011). Conservation agriculture and climate smart agriculture, has a high potential for both climate change mitigation and adaptation in Africa including Ethiopia (Ching *et al.*, 2011). Conservation agricultural practices include terracing, crop rotation, intercropping, retention of crop residues and use of animal dung, composting, mulching, crop diversification (including farmers' varieties), water harvesting and storage, home gardening and traditional agroforestry, management of grazing areas, etc. The agricultural system of the Konso people in southern Ethiopia is famous for its perfect adaptation to a harsh environment of steep, stony hills and little rainfalls. Traditional technologies are used for soil and water conservation, water harvesting and many more (Kebede *et al.*, 2010). According to Ching *et al.* (2011) report, conservation agriculture in Tigray has showed positive results, both in terms of rehabilitation of degraded lands and improvement of livelihoods of local communities, and is being scaled up to many areas within the region and other regions of the country. According to Temesgen *et al.* (2006), sale of agricultural tools and other assets are identified as a coping mechanism to climate variability and extremes in Ethiopia. Farmers may sell some of their resources in market, and this can be an important extra income, and can also function as a safety net and a coping mechanism. Material assets within the household can be seen as a buffer against difficult periods, in the same way as for example livestock.

Table 1. Climate change adaptation and mitigation mechanisms in Ethiopia

<i>Climate change mitigation and adaptation mechanisms</i>
Tree planting such as home gardening and traditional agroforestry
Crop diversification (growing different crops and varieties)
Growing fruit plants (e.g. apple in the highlands)
Soil and water conservation practices
Promoting small-scale irrigation
Government and international agencies assistance
Involvement of traditional institutions (Edir, Equb, religious institutions) and social networks
Seasonal migration to other neighboring areas
Sale of grains and livestock and their by-products
Changing crop sowing dates
Traditional water harvesting and storage
Sale of grains and livestock and their by-products
Collection of wild foods
Indigenous forecasting and early warning systems

Sources: Asfaw (2010), Zegeye (2013), Kassa (2013), Tadesse *et al.* (2013), Addisu *et al.* (2015), Simane *et al.* (2016), Zerga and Gebeyehu (2016), Belay *et al.* (2017), Mekonnen *et al.* (2017) and Tilahun *et al.* (2017)..

Pastoralists and agro-pastoralists in the drylands such as Afar in northeastern, Somali in eastern and Borana in Southern Ethiopia use different strategies like decreasing the number of cattle and sheep and increasing the number of camels and goats (because of their remarkable capacity to adapt severe drought) in their herds as a strategy to improve their livelihoods and adapt to climate change to cope with the impacts of climate variability and change (Aklilu and Catley, 2010; Tadesse *et al.*, 2013). Those pastoral communities in Afar, Somali and Borana are living with climate change and are able to adapt to the changing climate with their own short and longterm strategies (Riché *et al.*, 2010; Tilahun *et al.*, 2017). Homegardens and agroforestry systems are other sort of mechanisms in climate change adaptation in Ethiopia (Asfaw, 2010). Homegardens and agroforestry systems have a range of environmental, social, economic and cultural benefits. They help to sustain the environment and improve livelihoods of people, and as such

hold considerable potential for human and livestock adaptation to climate change (FAO, 2000; Asfaw, 2010; Zegeye, 2013). They control soil erosion, improve soil fertility, sequester carbon, moderate microclimate, provide various products; fuel wood, charcoal, construction material, timber, poles, posts, farm implements, food, medicines, fodder, spices, bee forage, etc.), increase income, and provide shade and amenity. They supplement food supplies and also serve as a buffer during periods of droughts and crop failures. Moreover, they are well placed for adding new plants to the existing flora.

Conclusion

Ethiopia has been experiencing the impacts of both climate variability and change. Climate change has led to recurrent droughts and famines, flooding, expansion of desertification, loss of wetlands, loss of biodiversity, decline in agricultural production and productivity, shortage of water, and increased incidence of pests and diseases.

It is apparent that climate change will have dramatic environmental, social, economic, cultural and political impacts. Ethiopia is vulnerable to the impacts of climate change mainly due to geographical location, rapid human population growth, heavy dependence on agriculture and natural resources for subsistence, widespread poverty and limited resources (human, financial, technical, technological, institutional, and infrastructural). It also has in general low adaptive capacity to the impacts of climate change. To combat climate change, Ethiopia has shown both conservation and policy responses. Protected area systems, afforestation and reforestation programmes, development of renewable energy sources and energy efficiency, ecological agriculture, flexible livestock production, home gardens and traditional agroforestry systems, harvesting and use/marketing of non-timber forest products and climate change education, are all feasible strategies for mitigating and adapting climate change. Indeed, there is a need to employ the right mix of climate change mitigation and adaptation strategies prioritized in space and time so as to reduce vulnerability of biodiversity and humanity to the escalating impacts of climate change.

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