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The Impact of Climate Change on Agricultural Production and Productivity, Ethiopia

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Abstract
Climate and agriculture are highly interlinked, and one affects the other in many ways. In Ethiopia, climate change and associated extreme events are causing significant damage to life, property, natural resources and the economy by affecting climate sensitive sectors such as agriculture. In this respect, agricultural research plays an important role in identifying the risks of climate change and developing appropriate adaptation options. It is recognized that climate related risks need better understanding and strong national and international collaboration in identifying, developing and evaluating adaptation interventions. Adaptation to climate change requires forward-looking agricultural research based on new agro-ecological zones which take into account the changing climate and the advances in data availability. Climate change has been a significant issue since the end of the 20th century, and impacts a variety of economic sectors, primarily agriculture. The negative impacts of climate change on agricultural production are important because agriculture is closely linked to food security. Although they contribute the least to global pollution, it is estimated that African countries will be the most affected by climate variability. The results indicate that variable precipitation positively affects agricultural production, while the overall increase in annual mean temperature decreases agricultural production in ESA countries. Quantifying the impacts of climate change on agricultural production can help policymakers determine the best adaptation and mitigation measures. Tackling Climate Change is closely linked to poverty alleviation and economic development.
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Introduction

Globally, climate change is the most serious environmental threat that adversely affects agricultural productivity (Enete & Amusa, 2010). The impact and consequences of climate change for agriculture tend to be more severe for countries with higher initial temperatures, areas with marginal or already degraded lands and lower levels of development with little adaptation capacity (Keane *et al.,* 2009).

Agriculture is the source of livelihood to an overwhelming majority of the Ethiopian population and is the basis of the national economy, where small-scale subsistence farming is predominant. This sector employs more than 80% of the labour force and accounts for 45% of the GDP and 85% of the export revenue. Ethiopian agriculture is heavily dependent on natural rainfall, with irrigation agriculture accounting for less than 1% of the country's total cultivated land. The dependency of most of the farmers on rain fed agriculture has made the country's agricultural economy extremely vulnerable to the adversities of weather and climate. Agriculture in the country is exposed to the effect of failure of rains or occurrence of successive dry spells during the growing season, which could lead to food shortage (MoFED, 2010).

The major factors responsible for the low productivity include: reliance on traditional farming technologies, soil erosion caused by deforestation and overgrazing, poor complementary services such as extension, credit, marketing and infrastructure; and climatic factors such as drought and flooding. These factors reduced adaptive capacity or increased the vulnerability of farmers to future change in climate and negatively affect the performance of the already weak agricultural production (Temesgen, 2010).

It is therefore, important to have a good understanding of the potential impacts of predicted future climate trends to improve agricultural planning and productivity. Therefore, adaptation to climate change is critical to many proposed strategies, for reducing the negative impacts of climate change. Adaptive capacity building is increasingly embraced by governments and other institutions as a means to improve economic and ecological resilience, sustainable development and will require action across multiple sectors at all levels (Bishaw *et al.*, 2013).

Climate and agriculture are highly interlinked, and one affects the other in many ways. Agriculture contributes to climate change on a global scale through emission of greenhouse gases (GHGs) while climate change affects agriculture through changes in average temperatures, rainfall, and climate extremes; changes in pests and diseases conditions; changes in the nutritional quality of foods; and changes in sea level among other (Niang *et al.*, 2014). Climate change is already affecting agriculture and its effects are unevenly distributed across the world (Porter *et al.,* 2014).

Climate has a prominent role in Ethiopia. Climate variability and extreme events (drought and heavy rains)

are causing significant damage to life, property, natural resources and the country's economy; making the most important economic systems highly vulnerable. Large areas of the country, particularly the arid and semi-arid areas, are prone to high climate variability and frequent drought evens. Recent studies have shown that flood hazard is increasing in the highland areas due to changes in land use/land cover, rainfall pattern, and drainage (Kassa, 2014).

Ethiopia is one of the countries that are most vulnerable to the impacts of climate variability and change on agriculture (Kassie *et al.,* 2013). The IPCC's fifth report indicates that future climate change will lead to an increase in climate variability and in the frequency and intensity of extreme events in Africa including Ethiopia (Niang *et al.,* 2014). The changing rainfall pattern in combination with warming trends could make rain fed agriculture more risky and aggravate food insecurity in Ethiopia. Such new challenges require new approach in agricultural research and development. This paper highlights the nexus between agriculture and climate in Ethiopia, past and project climate challenges and their impacts, the historical development of climate research in agriculture, and the research areas need for making agriculture climate smart and resilient. Climatic changes have already strongly affected agriculture in African countries by adversely impacting different farming systems (Gornall *et al.,* 2010).

Objective: to make a review on the Impact of Climate Change on Agricultural production and productivity.

Result and Discussion

Agriculture and Climate Change

The sensitivity of Ethiopia's agriculture to climate arises from the fact that it is primarily rain fed and practiced by smallholder farmers who have limited capacity to respond to climate variability and extremes. Climate variability, particularly rainfall variability and associated droughts, have been major causes of food insecurity and famine in Ethiopia (Conway and Schipper, 2011). Frequent drought events caused sharp reductions in agricultural output and rural employment with multiplier effects on the economy (Benson and Clay, 1998) and profound social impacts (Conway and Schipper, 2011). Currently over 10 million people are affected by the recent drought caused by the 2015 El Niño (OCHA, 2016). The World Bank's analysis predicts that climate change will lower Ethiopia's gross domestic product (GDP) growth by 0.5–2.5% per annum, largely by increasing the variability in rainfall. Over the coming 25 years, this could halve Ethiopia's potential GDP unless reasonable resilience measures are embraced now.

An age-old phenomenon, climate change can happen due to increasing population levels, innovation, high living standards, technological progress, industrialization, increasing infrastructure, reduction of trees and agricultural land, etc. According to the results of IPCC, (2013), the level of Greenhouse Gases has surpassed the highest levels of concentrations on earth over the last 800,000 years. This greenhouse effect, in turn, is causing increased rainfall, frequent hot extremes, floods, droughts, cyclones and gradual recession of glaciers. Rise in precipitation levels has been observed in Northern Europe, eastern parts of North America, South America, Northern Asia as well as Central Asia. According to the IPCC Fourth Assessment Report, intensification of activities performed by humans since 1750 has resulted in atmospheric concentrations of Carbon-dioxide, Methane and Nitrous Oxide around the world. The level of greenhouse gases has now exceeded the preindustrial values that existed thousands of years ago.

Climate change may not always have a negative effect on agriculture, especially in case of high latitude and high-income countries where agriculture cultivation is complimented by advanced technological implements and resources, leading to higher productivity of land. However, this climate change is a major barrier to developing economies, like India where agriculture accounts for 55 per cent of its total working population (Registrar General 2013) and constitutes about 14.1 per cent of its GDP (GoI, 2013).

Furthermore, due to this alteration in climate, crop productivity is being affected adversely resulting in food and livelihood security issues (Tripathi, 2014). This climate change coupled with the increasing poverty and unavailability of food leading has led to the immensity of food security challenges which further poses a threat to the nation, in its entirety.

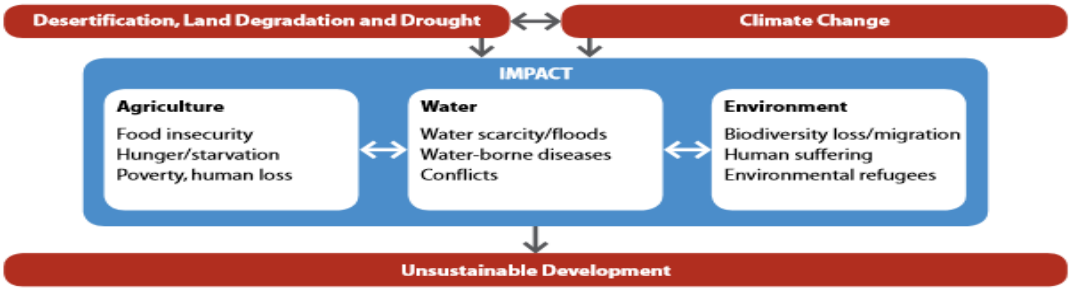

Figure 1: The impact of CC, desertification, land degradation and drought on LDCs Source: (UNFCCC, 2008)

Food Security and Agriculture

"No society can surely be flourishing and happy, of which the far greater part of the members are poor and miserable" -Adam Smith.

The World Food Summit stated,1996, "Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" Food security has four dimensions: food availability, food accessibility and food utilization and stability over time.

Figure 2. Climate change in four dimensions of food security. Source: FAO (2011)

Agriculture plays an indispensable role in the economic growth of a country. It not only provides the nation with food, but is also responsible for generating employment, savings, supporting all the other sectors of the economy and earning foreign exchange for the country. Agriculture is a source of employment to 55% of the Indian population. The food grain production in India has increased tremendously however, malnutrition and poverty levels continue to shoot up as a result of biotic, abiotic and socio-political situations (Gahukar, 2011).

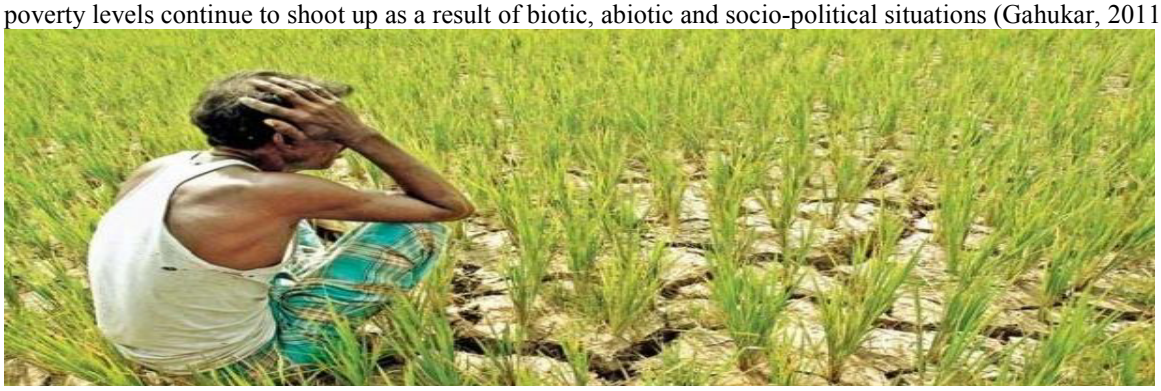

Figure 3. Climate change impacts on agriculture. Source: IIPM (2018)

Causes and Manifestations of Climate Change

The Earth's climate has changed many times during the planet's history, with events ranging from ice ages to long periods of warmth. During the last centuries natural factors such as volcanic eruptions or the amount of energy released from the sun have affected the Earth's climate on a smaller scale. The contribution of human activities to climate change, however, is increasing. The probability that human activities are the main cause for the increase in temperature since the mid-twentieth century has risen from 66 % in 2001 to more than 90 % in 2007 (Keshav and Niraji, 2013).

The Impacts of Climate Change in Ethiopia

Ethiopian climate is characterized by a history of climate extremes, such as: droughts and floods; and increase and decreasing in temperature and precipitation, respectively. The history of climate extremes, especially drought, is not a new phenomenon in Ethiopia. The most drought prone and affected areas of the country are in the northern, eastern and southern parts. Total failure or shortage of rainfall is often cited as the major cause for the recurring droughts and harvest failures. Such a problem or situation is further exacerbated by the social, economic and ecological situations (Dawit & Habtamu, 2011).

Continued climate change is expected to bring greater variability, and extreme weather events (e.g. droughts) which will further drive degradation of the country's ecosystems. The impact of climate change in Ethiopia is already apparent in the increasing temperature and declining rainfall, particularly in northern parts which are exceptionally vulnerable to drought (Cesar and Ekbom, 2013).

Ethiopia is also vulnerable to the health impacts of climate change, and to climate induced damage to transportation infrastructure. The implications of future climate change will be felt throughout these particularly

vulnerable sectors, although secondary impacts will be felt more widely, for example in education and gender equity. A recent study by the World Bank projects that, unless steps to build resilience are effective, climate change will reduce Ethiopia's GDP growth by between 0.5 and 2.5% each year(CRGE, n. d)Ethiopia is also vulnerable to the health impacts of climate change, and to climate induced damage to transportation infrastructure. There are strong links between environment and health concerns in Ethiopia, particularly related to malnutrition, indoor air pollution and water-related diseases (Cesar and Ekbom, 2013).

Ethiopia is especially vulnerable to climate variability and change because large segments of the population are poor and depend on agricultural income, which is highly sensitive to rainfall variability. Most have low access to education, information, technology, and basic social and support services, and, as a result, have low adaptive capacity to deal with the consequences of climate variability and change (Oxfam 2010, The World Bank Group 2010, Regassa *et al*., 2010, cited in Bishaw *et al.,* 2013).

Climate change is considered as the biggest environmental threat in human history and the defining human challenge for the twenty-first century. Consequences of climate change are already felt throughout the earth system. Climate change is already affecting rainfall amounts, distribution, and intensity in many places. This has direct effects on the timing and duration of crop growing seasons, with concomitant impacts on plant growth. Rainfall variability is expected to increase in the future, and floods and droughts will become more common. Changes in temperature and rainfall regime may have considerable impacts on agricultural productivity and on the ecosystem provisioning services provided by forests and agro forestry systems on which many people depend (Thornton & Lipper, 2014).

Climate change affects all countries, but those likely to be worst affected are the world's poorest countries, especially poor and marginalized communities within these countries. Ironically it is these poor countries and people who have contributed least to the problem of climate change, because of their very low greenhouse gas emissions, but who will suffer most from its consequences (Hannah, *et al.*, 2010). The foregoing argument shows that climate change can no longer be side lined as a development issue. The effect that climate change has on the poor communities in sub-Saharan Africa is increasingly prominent (Dube, 2013).

Impacts on Agriculture & agricultural productivity

During drought and delay in the onset of rain land becomes dry and difficult to plough, forage deficit leads to weakness and oxen mortality (engine of subsistent cultivation), and lack of precipitation hinders seed cultivation and germination of cultivated seeds. Even weeks delay in the onset of rain was found to have significant difference on the harvest and has deprivation of households' livelihood (Abate, 2009).

The impacts of climate change on water resources have a direct effect on agricultural productivity and production. Although previous studies differ in methodological approach, models, scenarios and periods to arrive at a general conclusion about the future impacts of climate change on productivity and production of major crops, the results give a general clue about the future of crop production and productivity in Ethiopia. For example, some studies indicate a general decrease in the yield of wheat and teff (Kelbore, 2012) and sorghum (Withaka *et al.,* 2013) across the current major growing areas of the crops while others studies indicate general increase for maize in the highlands (Withaka *et al.,* 2013; Tesfaye *et al.,* 2015b) but a decrease in the lowlands such as the central rift valley and similar agro-ecologies (Fig. 8; Kassie *et al.,* 2014; Tesfaye *et al.,* 2015b)).

In general, the impact of climate change on the productivity of major crops in Ethiopia varies with crop type, location, and future time span considered (Tesfaye *et al.,* 2015a). Climate variability and extreme events (drought and heavy rains) are causing significant damage to life, property, natural resources and economy making the country highly vulnerable to climatic vagaries (Tesfaye *et al.,* 2015a). Drought and floods are catastrophic for the lowland pastoralists and mixed cropping systems areas of the country (Tesfaye *et al.,* 2015a). Recent studies have shown that flood hazard is increasing in the highland areas due to changes in land use land cover, rainfall pattern, and drainage (Kassa, 2014). It is well known that the agricultural sector is directly related to and affected by climatic factors (particularly precipitation and temperature). Thus, agriculture has been largely used to project the effects of climatic change and variability because precipitation and temperature directly enter agricultural production functions (Fisher *et al.,* 2012).

Impacts on Livestock Production

Similar to crop production, the impact of climate change and variability in the livestock production is generally negative. Heat stress and its impact on seasonal water availability have a variety of detrimental effects on livestock, with significant effects on milk production and reproduction in dairy cows, and swine fertility (Nigus, 2011). Drought and delay in the onset of rain led to poor grass regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures (Abate, 2009).

Climate change affects livestock both directly and indirectly. The direct effects from air temperature, humidity, wind speed and other climate factors influence animal performance: growth, milk production, wool

production and reproduction. Climate change will have far-reaching consequences for dairy and meat production, especially in vulnerable parts of the world where it is vital for nutrition and livelihoods. The impact of climate change can heighten the vulnerability of livestock systems and exacerbate existing stresses upon them, such as drought (Abebe, 2013). The most vulnerable communities to the impacts of climate change inhabit the dry lands areas. Pastoralists inhabiting dry lands have been able to survive the harsh environments practicing various sustainable livelihood approaches including seasonal movements, keeping livestock, among others.

According to (UNDP, 2010), climate change can affect animal production directly and indirectly in four ways:

- ✓ Affecting livestock feed availability and price;
- ✓ Changes in livestock pastures and forage crop production and quality;
- ✓ Changes in the distribution of livestock diseases and pests; and
- ✓ The direct effects of weather and extreme events on animal health, growth and reproduction.

Impacts on agricultural water resources

Impact of climate change on agricultural systems has several dimensions. One of the prominent impacts is the reduction of water available for crop production. Studies on the impact of climate change on agricultural water resources under various emission scenarios has shown that there will be an increase in evapotranspiration (Getnet *et al.,* 2014), and a decrease in soil water, ground water and stream flows (Haregeweyn *et al.,* 2016; Nigatu *et al.,* 2016) both by 2050 and end of century.

Impacts on crop suitable area

Another evidence of the impact of climate change in Ethiopian agriculture is relocation of suitable area of production for different crops. Evangelista et al. (2013) showed that by 2020 the major cereal crops of Ethiopia such as maize, teff, sorghum and barley will loss over 14, 11, 7 and 31% of their current suitable area of production, respectively. For maize, teff and barely this will be expected to increase to over 18, 11 and 37% by 2050, respectively. This indicates that C4 species (maize, sorghum, millet and teff), which are originated in warm tropical environments, will reach near to their upper limit of maximum temperature tolerance and a small increase in temperature over the present maxima will displace them from their current adaptation area. Apart from C4 crops, C3 species, which area adapted to cool temperature, will be most affected by projected climate change because of loss of suitable area as a result of conversion of current cooler environments to warmer conditions (Tesfaye *et al.,* 2015a).

Impacts on length of crop growing period (LGP)

Climate change affects duration of crop growth by slowing or hastening growth and development processes. Although there are no detailed studies in Ethiopia on how climate change affects LGP in the different parts of the country, a recent study on maize in the central Rift Valley of Ethiopia using two crop simulation models under various climate change scenarios predicted a reduction of maize growth duration by 14-33 days in 2050 compared to the present due to higher temperature and variable rainfall conditions (Kassie *et al.,* 2014).Another study in northern Ethiopia indicated a decrease in the LGP by 14–26 days in 2030s and 2050s in some areas (Alamata and Mekelle) but an increase in others (Maichew, Adigrat, Edagahamus and Shire) (Hadgu *et al.,* 2014). These examples indicate that climate change will definitely change the LGP but the change may vary across locations suggesting the need for further local studies.

Impacts on crop disease and pests

There are no studies that indicate the impact of climate change on the dynamics of crop pests and diseases in Ethiopia. However, there is evidence that climate change will affect the geographic range of specific species of insects and diseases for a given crop growing region and increase crop losses (IPCC, 2014). Climate change may also influence the migration of agronomic and invasive weeds species which possess characteristics that are associated with long-distance seed dispersal, and it has been suggested that these species may migrate rapidly with increasing surface temperatures (IPCC, 2014).

Impact on national economy and food security

Ethiopia's GDP is heavily dependent on agriculture and it is highly correlated with rainfall variability. Climate change could reduce GDP by 3-10% by 2025 (Evan, 2012). A marginal impact analysis indicated that a 1°C increase in annual temperature will lead to statistically significant change in net revenue of -694.15 Birr from total agriculture inclusive of crop and livestock (Gebreegziabher *et al.,* 2014).Through its strong negative effect on the economy in general and by reducing crop yields, increasing land degradation, and lowering water availability in particular, climate change poses more pressure on the food security of millions of people in Ethiopia. A bio-economic analysis using a maize as a case study indicate that the number of food insecure people

in Ethiopia would increase by up to 2.4 million people by 2050 as a result of the impact of climate change not only on production but also on global agricultural import and export trade and prices (Tesfaye *et al.,* 2015b).

The Effect of Climate Change on food security

The importance of agriculture in the context of food security and poverty is well understood. It also underlined the sensitivity of agricultural sector to the volatility and uncertainty in the climate. More than 60 per cent of the population in India is dependent on the primary sector for living. This explains that the livelihood of a large number of rural and urban households stand in danger in case of frequent changes in the climate affecting the agricultural productivity. The consequences of meteorological changes can be seen both in urban and rural areas leading to food insecurity and poverty. Variations in the climate have affected food productivity and water availability in India. TienShiao *et al.,* (2015), mentions that 54 percent of India faces a water shortage leading to 600 million people under the risk of acute shortage of water supply. Additionally, agriculturally rich states, such as, Punjab and Haryana where rice and wheat productivity is the main source of livelihood have been facing a huge risk of water shortage. Lobell *et al.,* (2012), states that wheat production can be adversely affected in case there is a rise in the temperature over 34 degree Celsius.

Not only does this meteorological variation affect productivity of crops and water resources, but it also has serious repercussions on the economic and financial resources of the poor and the small and landless farmers. Prolonged duration of a particular cropping season resulting in the destruction of the crop may have serious implications on the income of the farmer. Another prominent reason for the vulnerability of the farmers is the high reliance of Indian agriculture on monsoon. Currently, the rain fed land in India hardly supports the farmers dependent on it. Reduced profits, decrease in the productivity of the land, small land holdings and heavy dependence on monsoon for productivity pressurizes the small farmers to move to the urban slums where they resort to menial and low paid jobs, lacking job security. Growing inflation in the country and higher prices of food grains in the urban areas also adds up to the problem of poverty. Statistics show that 30 percent of the children in India belonging to the age group of 5 years and below are undernourished in well-developed states of Bihar, Uttar Pradesh and Karnataka (Chakrabarty, 2016).

Responses to Climate Change in Ethiopia

Cognizant of the challenges posed by climate change and variability, the Ethiopian government is taking initiatives that are believed to minimize the negative impacts of climate change while seizing the opportunities that come with it. The 1995 Constitution of the state provides the legal basis for policies, strategies, and programs for managing disasters such as drought and floods. The Ethiopian Government announced its Climate Resilient Green Economy Strategy (CRG-I) at the COP21 in Durban in 2011 (FDRE, 2011) and adopted the Drought Resilience and Sustainability Initiative in 2012. Ethiopia has also developed its Adaptation and Resilience strategy (CRG-II) in 2014. The country's Growth and Transformation Plan (GTP-II) emphasizes the need to address climate change in all sectors of the economy. All these and other regional initiatives provide the legal and policy framework that the government put in place to respond to the challenges posed by climate change at different levels.

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Individual and Community Responses

As already mentioned, for many centuries, Ethiopia has been characterized by climate variability and change and the local people have developed different adaptation strategies. These include early , indigenous soil and water conservation techniques, diversification of crop and livestock species, mobility, reciprocity, customary conflict resolution etc. Thus, the historical accounts indicate that adaptation had been practiced in Ethiopia before the concept of "climate change" was developed (OECD, 2009).

According to (Sorhaug, 2013). Locally the most widely practiced coping and adaptation strategies to climate change in Ethiopia includes: crop diversification, mixed farming, tree planting, off farm activities, soil and water conservation, selling of assets, use of improved seeds Inset production , food aids and irrigation as the most widely practiced adaption strategies by individuals in response to climate change and variability effects in

Ethiopia.

Communities and societies in general have long been responding or adaption measures to climate changes, but these adaptations have typically been discrete and reactive. The idea that adaptation to climate change should be planned, proactive, and anticipatory is relatively new and is an important element of CBA (UNDP, 2010). Although climate change is universal phenomenon, its indicators and manifestations are entirely local. However, until recently, most efforts to help countries adapt focused on national planning and top-down approaches based on climate change modelling. Remarkably little attention has been paid to the ways in which poor people have been coping with climate variability and extremes for decades. There has, thus, been increasing emphasis on the bottom – up approach that climate change studies should be conducted at the local level where adaptation ultimately takes place (Maharaja & Joshi, 2013).

Community-based adaptation (CBA) as a response to climate change has evolved as a systematic, participatory, bottom-up approach. And it strengthens the resilience of communities and the ecosystems, upon which they rely in light of climate impacts, (Mannke, 2011). The use of genuine participatory processes is important if CBA is to fit with community priorities and build on existing practices or those used in the past. Participatory tools are sometimes used as a way of collecting local information about vulnerability and climate change to be used and analysed by outsiders and it is not uncommon for the priorities and interests of outsiders to override those of communities in any subsequent planning(Reid *et al.,* 2010).

The aim of CBA is to enable the community to understand and integrate the concept of climate risk into their livelihood activities in order to increase their resilience to immediate climate variability and long-term climate change. Community-based adaptation is essentially an action research approach to the problem of climate change impacts on livelihood s(Ensor and Berger, 2009). Incorporating or integrating adaptation to climate change into planning processes is a necessary strategy for sustainable development over the long term. Climate change impacts do not happen in isolation; impacts in one sector can adversely or positively affect another; sectors can be affected directly and/or indirectly by climate change. Accordingly, this study describes CBA as any group–based approach to adaptation with the following characteristics:

- ✓ It requires collective action and social capital.
- ✓ It incorporates information about long–term climate change and the anticipated impacts into planning processes.
- ✓ It integrates local knowledge and perceptions of climate change and risk management strategies.
- ✓ It emphasizes local decision-making processes.
- ✓ It is in accordance with community priorities and needs.
- ✓ It provides poverty reduction or livelihood benefits.

Institutional and Policy Responses

Ethiopia has ratified the UNFCCC and Kyoto Protocol in April 1994 and 1997 respectively. It has also designated institutions to follow up the implementation of the environmental and climate issues in the country (Dawit & Habtamu, 2011). Over the last two decades, the Ethiopian government has put in place a number of policies, strategies and laws that are designed to support sustainable development. The country has developed and implemented a wide range of legal, policy and institutional frameworks on environment, water, forests, climate change, and biodiversity (César & Ekbom, 2013). Among others, the Environment Policy of Ethiopia (EPE) and the Conservation Strategy of Ethiopia (CSE) approved in 1997 enabled the country to develop specific mechanisms to fulfil its obligations regarding the UN Framework Convention on Climate Change.

The Ethiopian Environmental Protection Authority (EPA) issued the Climate Change National Adaptation Programmes of Action (NAPA), thus identifying the integration of climate change adaptation activities with national development policies. The NAPA process in Ethiopia identified arid and dry sub-humid areas of the country as being most vulnerable to drought; in addition, agriculture was identified as the most vulnerable sector where small-scale rain-fed subsistence farmers and pastoralists are identified as the most at risk(Ibid,.P.13).

Established under the leadership of the late prime minister Meles Zenawi, the country embarked on a Climate Resilient Green Economy (CRGE) initiative, a key plank in the wider and even more ambitious Growth and Transformation Plan, GTP (MoFED, 2010). This plan seeks to enable an economic transformation to middle income status by 2025. The CRGE is receiving substantial support from UK Aid, South Korea, Japan and the UNDP (Leulseged, et al, 2013).

Government and development agencies are now emphasizing that future agriculture development should be 'climate smart', enabling systems that are more resilient and adaptive to climate change. The basic concept is of a system that maintains or increases production of foods or other crops, supports livelihoods and sustains environmental resources and ecosystems, adapts to existing and future climate, sequesters carbon and/or reduces GHG emissions (Beddington et al, 2012).

Climate resilience is therefore, the ability to cope with, and manage the change brought by weather stresses and shocks. A climate resilient economy is one which is protected against the negative impacts of extreme climate events, normally referred to as the weather, and climate change so that the well-being of the people and the economic growth and prospects of the country are not damaged by the impacts. Climate change will impact on all aspects of Ethiopia's economy, and particularly on health, infrastructure/ transport, agriculture, natural resources, energy and industry sectors. Climate resiliency has tremendous dimensions and the impact goes accordingly on environment (environmental resilience, Biodiversity resilience), social (community resilience, knowledge resilience) and economy (Kindu, *et al*, 2012).

Major environmental conventions on climate change and agriculture

Since the first world climate conference takes place in 1979 in Geneva, there are different documents that mention about agriculture in various environmental conventions and agreements, even if the attention for this sector is not enough despite its important. Agriculture and food security under a changing climate have come up the international agenda in recent years (Ayana *et al.,* 2011) & (FAO, 2014b). Therefore, this review includes some of environmental conventions are presented as follow:

Article 4 (c) of UNFCCC, describe that all parties should Promote and cooperate in the development, application and diffusion, including transfer of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of GHG in all relevant sectors, including agriculture. Also article 4 (e) of UNFCCC states about the need of cooperation in preparing for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods.

The linkage between climate change and agriculture is clearly addressed directly in Article 2 of Kyoto protocol which states: promotion of sustainable forms of agriculture in light of climate change considerations. In Article 3.4 of Kyoto protocol also mentioned about the carbon sink partly be accomplished efficiently by organic agriculture. Article 10 of Kyoto protocol also stated how to mitigate climate change and measures to facilitate adequate adaptation to climate change by concerning different sectors including agriculture.

It clearly describes the potential future effects of climate change on agriculture and identified current knowledge gaps to be addressed (FAO, 2014b). In Copenhagen accord (2009), there was discussion about how agriculture is seriously affected by climate change. In addition it mentioned that the role of agriculture to mitigate and adapt climate change. It was a good progress but no specific decisions were taken in Copenhagen for agriculture sector with regards to climate change.

The Cancun agreements in (2010) allow for consideration of agriculture as a driver of deforestation and thus can be considered under adaptation actions. Agriculture already figured prominently in national adaptation programmes of action (NAPAs) formulated by least-developed countries. NAPAs are now to inform the new national adaptation plans, which, in accordance with the Cancun Agreements, are to be prepared by developing countries. Also, following the fifteenth session of the COP, a number of developing countries indicated their intention to undertake nationally appropriate mitigation actions (NAMAs) related to agriculture.

In 2014, the IPCC 5th assessment report Working Group II published an update of the potential future effects of climate change on agriculture, identifying knowledge gaps and increased urgency for adaptation in the sector (Ayana *et al.,* 2011). This is a part of Lima international climate change conference agreement. These all conventions and agreements indicate that, there is an increase to concern about agriculture under climate change situation.

Conclusion

Climate change has relationship with agriculture in one or another way. This relationship becomes strong in developing countries because their livelihood depends on agricultural activities and these activities mostly depend on climatic condition. For instance in Ethiopia, almost all farm activity is rain fed. In relation, the impact of climate change is very serious in developing countries due to their limited adaptive capacity and lack of technology and also they are the main emitter of noncarbon GHGs from their cattle and farm management mainly from use of synthetic fertilizers. On the other hand, by the help of the right farming practice agriculture could be the main solution for climate change by mitigation and adaptation response. Within the current and projected situation of climate change globally, only climate change mitigation is not enough so long term solution is important by combining climate change adaptation in agriculture sector. Such practices could be organic agriculture, manure management, agroforestry practice etc. Know a days, the significant relation of climate change and agriculture sector become well known.

Clearly, climate change provides both challenges and opportunities for the agricultural development of Ethiopia and therefore, addressing climate variability and change is a matter of survival, food security and poverty alleviation.

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