Farmer’s response to climate change and variability in Ethiopia: A review

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Abstract: Ethiopia is one of the most vulnerable countries experiencing drought and floods as a result of climate variability and change. Climate change in the form of higher temperature, reduced rainfall, and increased rainfall variability reduces crop yield and threatens food security in low income and agriculture-based economies. This study reviews impact of climate change and variability, and climate change adaptation strategies employed at farm level in response to perceived changes in temperature and precipitation. Climate change negatively affects agriculture, nutrition, ground water availability, soil organic matter and soil quality, health conditions, growth and poverty. The survey reveals that Ethiopian farmers adopt many strategies in response to climate change. These strategies include “use of improved crop varieties,” “agroforestry practices,” “crop diversification,” “soil conservation practices,” “tree planting,” “off-farm activities,” “irrigation practices,” “adjusting planting dates,” “selling of assets,” “food aid,” and “permanent and temporary migration in search of employment” are the most important adaptation strategies by smallholder farmers. However, “level of education,” “gender,” “age,” “wealth of the head of household,” “access to extension and credit,” “information and climate social capital,” “agroecological settings,” and “temperature” all influence farmer’s choices; “lack of information on adaptation methods,” “financial constraints,” and “lack of access to land” as main barriers to adapt climate change and variability. Another investigator also revealed that farmers living in the dry lowland area perceived more change in climate than farmers in the wet lowland area.

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**PUBLIC INTEREST STATEMENT**

Currently, climate change and variability is a hot issue and needs a higher concern about its impacts in Ethiopia. People especially rural society is highly vulnerable by the impact of climate change due to the occurrence of irregular temperature and rainfall. Therefore, identifying farmer’s adaptation strategies in different agroecological zone is important to recommend appropriate options to overcome climate change risk.
1. Introduction

1.1. Background and justification of the review

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). Vulnerability analyses for Ethiopia under climate change indicates that changes in rainfall patterns and increasing temperatures are expected to have significant negative impacts on environment and water resources, crops and livestock, human health, and other farming livelihoods (Temesgen Deresa, 2006). According to the IGAD-ICPAC (2007) report, the mean annual temperature across the country is projected to increase between 0.9°C and 1.1°C by the year 2030. As a result of such climatic changes, frequency and intensity of drought is likely to increasingly present a serious threat to the rural farming communities. Drought and floods will also lead to an increased distribution of the malaria-bearing mosquito and other vector-borne diseases, incurring health disaster to the poor and vulnerable.

Agriculture is the main sector of the Ethiopian economy. It comprises about 52% of GDP, generates more than 85% of foreign exchange earnings and employs about 80% of the population (CSA, 2005). The sector is dominated by small-scale mixed crop livestock production with very low productivity. The major factors responsible for low productivity include reliance on traditional farming techniques, soil degradation caused by overgrazing and deforestation, poor complementary services such as extension, credit, marketing, infrastructure, and climatic factors such as drought and flood (Deressa, Hassan, & Ringler, 2011). Climate change causes wide-ranging effects on the environment, and on socioeconomic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems, and biodiversity (Belay Zerga & Getaneh Gebeyehu, 2016).

Climate change in the form of higher temperature, reduced rainfall and increased rainfall variability reduces crop yield and threatens food security in low-income and agriculture-based economies. Adverse climate change impacts are considered to be particularly strong in countries located in tropical Africa that depend on agriculture as their main source of livelihood (IAC, 2004; Dixon, Gulliver, & Gibbon, 2001; IPCC, 2001). 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). Rural people, who depend on agriculture for sustenance and livelihood, are often vulnerable to the direct impacts of adverse weather, climate variations and change (Molnar, 2010). 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 (Negussie Zeray and Ashebir Demie., 2016). Hence, this paper initiated with the objective of reviewing farmer’s response and adaptive capacity to the impact of climate change and variability in Ethiopia. Specifically, this review paper also tries to observe impact of climate change and adaptation strategies employed at farm level in response to perceived changes in temperature and precipitation.
2. Literature review

2.1. Climate change and variability in Ethiopia

Climate change is a change of climate which is attributed directly or indirectly to human activity. It alters the composition of the global and/or regional atmosphere and natural climate variability observed over comparable time periods. Climatic variability’s are the types of changes (temperature, rainfall, occurrence of extremes); magnitude and rate of the climate change that causes the impacts on the area of public health, agriculture, food security, forest hydrology and water resources, coastal area, biodiversity, human settlement, energy, industry, and financial services (UNFCCC, 2007). In Ethiopia, climate variability and change is mainly manifested through the variability and decreasing trend in rainfall and increasing trend in temperature. Besides, rainfall and temperature patterns show large regional differences (Zerga & Gebeeyehu, 2016). Climate change is a key concern to Ethiopia in our time and need 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)

According to National Meteorological Services of Ethiopia (NMS, 2007) indicate that the average minimum and maximum temperatures have been increasing by about 0.25°C and 0.1°C, respectively over the past decade whereas the rainfall has been characterized by a very high level of variability over the past 50 years. Climate change is a change of climate which is attributed directly or indirectly to human activity. It alters the composition of the global and/or regional atmosphere and natural climate variability observed over comparable time periods. Climatic variability are the types of changes (temperature, rainfall, occurrence of extremes); magnitude and rate of the climate change that causes the impacts on the area of public health, agriculture, food security, forest hydrology and water resources, coastal area, biodiversity, human settlement, energy, industry, and financial services. Changes in physical and socioeconomic system have been identified in many regions (UNFCCC, 2007).

Vulnerability to climate change in Ethiopia is highly related to poverty (loss of copying or adaptive capacity) in most of the regions. Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, in order to reduce adverse impacts and take advantage of new opportunities (IPCC, 2007a). Those societies that can respond to change quickly and successfully have a high adaptive capacity (Smit & Wandel, 2006). Ethiopia is vulnerable to climatic variability due to its low adaptive capacity accountable to low level of socioeconomic development, high population growth, inadequate infrastructure, lack of institutional capacity and high dependence on climate sensitive natural resource-based activities (NMA, 2007). According to the study of Negussie Zeray and Ashebir Demie (2016), South Nations Nationalities and people (SNNP), and Benishangul-Gumuz region were relatively not vulnerable, whereas Afar, Amhara, Oromia, and Somali regions were vulnerable. The lesser vulnerability of SNNP was associated with its relatively higher access to technology and food market, its highest irrigation potential and its literacy rate. Afar, Somali, Oromia, and Tigray regions were among the highly vulnerable regions. The vulnerability of Afar and Somali was mainly associated with lower levels of regional development. Despite the fact that these regions were less populated than the other regions, the percentage of people with access to institutions and infrastructure remains very low due to the lowest level of regional development.

2.2. Impact of climate change and variability

2.2.1. Impact of climate change on agriculture

Agriculture is the most important sector in sub-Saharan Africa, but it is predicted to be negatively impacted by climate change. It is clear that climate change will bring about substantial welfare losses especially for smallholders whose main source of livelihood derives from agriculture (Paulos Asrat & Belay Simane, 2018). 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).

Using the single-index approach, the study results indicate that the combined riskiness of crop portfolios at a household level responds negatively to annual rainfall variability, while seasonal rainfall variability has less consistent impact. Farmers are more likely to select less risky crops with less return, even when intercrop interactions are taken into account (Bezabih, Di Falco, & Yesuf, 2011).

The intensity of tropical cyclones (Knutson, McBride, Chan, & Emanuel, 2010) and frequency of heavy precipitation events are very likely to increase over many areas during the twenty-first century, with consequences for the risk of floods. At the same time, the proportions of arid lands are projected to increase, in addition to a tendency for drying during summer, especially in the subtropics, low and mid latitudes (Bates, Kundzewicz, Wu, & Palutikof, 2008). The vulnerability of these sensitive regions to impacts of hydrometeorological disasters, in terms of loss of assets and economic value, has increased dramatically over the past few decades despite ongoing efforts in several sectors including agriculture (Mills, 2005).

Climate change causes wide-ranging effects on the environment, and on socioeconomic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity. Changes in rainfall pattern are also likely to lead to severe water shortages and/or flooding. Rising temperatures also will cause shifts in crop growing seasons which affects food security and changes in the distribution of disease vectors putting more people at risk from diseases such as malaria. Temperature increases will potentially severely increase rates of extinction for many habitats and species (UNFCCC, 2007).

Climate change causes the frequency and severity of weather events. Some indirect effect of climate change includes, 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-Jones, Plassmann, & Harris, 2009).

According to study of Deressa (2006) for Ethiopia, by using Heckman sample selection model both increasing temperature and decreasing precipitation are damaging Ethiopian agriculture. According to FAO (2011), 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.

2.2.2. Impacts on pests and pathogens
Increases in temperature and changing rainfall patterns likely will increase the populations and ranges for some agricultural pests and water-borne pathogens, requiring changes to crop and livestock management practices, more aggressive adoption of integrated pest-management practices and introduction of new inputs to counter more virulent challenges (Bukantis & Rimkus, 2005).

2.2.3. Impacts on nutrition
Increased atmospheric CO₂ has been shown to reduce the nutrient content of crops, creating nutritional challenges. At the same time, warming surface and groundwater increase the prevalence of waterborne pathogens that cause diarrheal disease (Bukantis & Rimkus, 2005).
2.2.4. Impacts on groundwater availability
In most cases, groundwater supplies are directly linked to surface water and rainfall, with groundwater recharging through soil infiltration. When surface water sources become insufficient due to decreased replenishment and/or increased evaporation rates, groundwater exploitation increases. However, groundwater recharge rates generally are insufficient to meet sustainable demand, leading to decreased water quality and increased pumping depths (and associated increased costs) (Bukantis & Rimkus, 2005). The water resources sector will be affected by climate change through a decrease in river run-off, a decrease in energy production, as well as increased floods and droughts.

2.2.5. Impact on soil organic matter and soil quality
Projected climate change may affect soil moisture and temperature regimes. At the ecosystem level, the soil affects vegetation through its influence on water availability, elemental cycling, and soil temperature regime. Changes in soil moisture and temperature regimes can affect species composition in the ecosystem. These changes may affect the soil organic carbon pool and soil physical properties because of the changes in biomass (detritus material, above ground and below ground biomass) returned to the soil. The effect of climate change may be different in tropical, temperate, and boreal regions. Projected increase in temperature and decrease in effective rainfall may decrease the net primary productivity (NPP) in many tropical regions, but increase it in the boreal forest regions (Lal, Follett, Stewart, & Kimble, 2007).

According to Tripkovic (2014), the following threats were identified that influenced by climate change. Firstly, “Soil erosion by wind and rain affects both the productivity of soils but also water quality and aquatic ecosystems. Second, Compaction of soil reduces agricultural productivity and water infiltration, and increases flood risk through higher levels of runoff. Finally, the loss of soil organic matter reduces soil quality, affecting the supply of nutrients and making it more difficult for plants to grow, and increases emissions to the atmosphere.”

2.2.6. Climate change effects on nutrients
Climate change affects the soil by variations in temperature and rainfall including the soil loss and degradation as well as changes in nutrient and carbon cycling and budgets (Tripkovic, 2014) addressed whether changes in soil organic carbon would consequently act as positive or negative feedbacks on climate change. He suggested it could lower the build-up of CO₂ in the atmosphere and reduce further warming. In contrast, a loss of organic carbon with warming would constitute a positive feedback by further adding to the build-up of CO₂ in the atmosphere.

2.2.7. Impacts on livestock production
While the direct effects of heat stress on livestock have not been studied broadly, warming is expected to alter the feed intake, mortality, growth, reproduction, maintenance, and production of animals. Collectively, these effects are expected to have a negative impact on livestock productivity (Thornton et al., 2009 cited in EACC). Chickens are predominantly vulnerable to climate change because they can only tolerate narrow ranges of temperatures beyond which reproduction and growth are negatively affected. Further, increases in temperature caused by climate change can be exacerbated within enclosed poultry housing systems (Zeray & Demie, 2016).

2.2.8. Impacts on settlement and infrastructure
The study of Freeman and Warner (2001) stated that climate variability such as storms, floods, and sustained droughts, already has marked impacts on settlements and infrastructure. Indeed, for urban planners, the biggest threats to localized population concentrations posed by climate variability and change are often expected to be from little-characterized and unpredictable rapid-onset disasters such as storm surges, flash floods, and tropical cyclones (Freeman, 2003). Negative impacts of climate change could create a new set of refugees, who
may migrate into new settlements, seek new livelihoods, and place additional demands on infrastructure (IPCC, 2007a).

2.2.9. Impacts on health conditions, growth, and poverty

Impact of the changes in temperature can be worsening of health conditions. Climate change has 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 (e.g. 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 Oomo-Gibe river, Bahirdar Zuria and Fogera areas along the Abbay river in the Amhara region are prone to seasonal river floods (Tadege, 2007).

According to Negussie Zeray and Ashebir Demie (2016), in rural areas of Dire Dawa, farm lands with crops (cereals, vegetables, fruits, and cash crops), estimated to be 257.6 hectares and soil and water conservation infrastructures across 17 kebeles, water schemes in 7 kebeles, and irrigation schemes in five kebeles were damaged with irregular flooding (Figure 1). Besides, about six houses were washed out and a total of 10,809 people were affected by flood due to the occurrence of higher rainfall.

The study of Aragie (2013) on the impact of climate change on growth and poverty in Ethiopia should focus on the agricultural sector for it is undoubtedly the most important, and sensitive, sector to climate change. Current climate variability is imposing a significant
challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction, and sustainable development efforts (Kristiansen, 2011)

Ethiopian agriculture currently accounts for close to 42% of Ethiopia’s output, employs 85% of the population, contributes to more than 90% of national exports, and serves as the main source of input to the existing industrial sector. Whatever is happening to the agricultural sector can significantly affect the entire economy. The current work considers the strategic importance of the sector, while understanding its sensitivity to climate change. Poverty continues to be a major development challenge in Ethiopia. Despite a significant decline in the incidence of poverty during the past four decades, poverty is still prevalent in the country. More than 28 million people, or 34% of the population, earn less than USD 1 per day.

In Ethiopia, approximately 84% of the poor are located in rural areas; implying poverty is mainly a rural phenomenon, with the large majority of people depending on agriculture for employment and income (Figure 2). Agricultural growth, thus, offers a potentially enormous opportunity for poverty reduction in the country, particularly when the growth is broad-based. Likewise, agricultural failure exacerbates poverty and food insecurity in such agrarian economies. Climate change and the associated environmental degradation are emerging as big challenges to Ethiopian agriculture and poverty alleviation efforts (Aragie, 2013).

Additionally, rainfall variability has been reported to have significant effect on Ethiopia's economy and food production for the last three decades (Araya & Stroosnijder, 2011). Climate changes might raise the global economic inequality since many developing countries have a current climate close to or slightly warmer than what is considered optimal for agriculture (Mideksa, 2010).

2.3. Climate change adaptation strategies in Ethiopia
Climate change adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities but mitigation refers to reducing climate change by reducing the GHG emissions (UNFCCC, 2007). The study conducted by Chinasho (2017), the adaptation and mitigation potential of developing countries to climate change are weakened as a result of poor building designs, agriculture, food in security, low income, deforestation, and conventional solid-waste management system. Adaptation to climate change impacts in general and to the agriculture sector in particular is an existing phenomenon. The agriculture sector has the capacity to adapt provided that technologies, resources, and management changes have been undertaken relatively quickly (Mendelsohn, 2000).

According to Mendelsohn (2000), adapting to climate change will entail adjustments and changes at every level from community to national and international. Communities must build
their resilience, including adopting appropriate technologies while making the most of traditional knowledge, and diversifying their livelihoods to cope with current and future climate stress. Local coping strategies and traditional knowledge need to be used in integrated with government and local interventions. To enable effective adaptation measures, governments as well as nongovernment organizations, must consider integrating climate change in their planning and budgeting in all levels of decision making.

Farmers adapt to climate changes to maximize profit by changing crop mix, planting, and harvesting dates, and a host of agronomic practices (Deressa, 2006). Mano and Nhemachena (2006) described crop choice as an important example of farmer adaptation strategies, where depending on the effects of warmer climate, a particular crop will be an optimal choice. Mendelsohn and Tiwari (2000) also asserted the importance of optimal crop switching that must be considered when measuring the impact of climate change on agriculture.

According to the IPCC third Assessment Report, adaptation has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts, but will incur costs and will not prevent all damages. Furthermore, it is argued that human and natural systems will, to some extent, adapt autonomously and that planned adaptation can supplement autonomous adaptation. However, options and incentives are greater for adaptation of human systems than for adaptation to protect natural systems (IPCC, 2001).

By using household survey methods the study of Bryan, Deressa, Gbetibouo, and Ringler (2009) revealed that, use of different crops or crop varieties, planting trees, soil conservation, changing planting dates, and irrigation are the most common adaptation strategies in the study area. However, despite having perceived changes in temperature and rainfall, a large percentage of farmers did not make any adjustments to their farming practices.

According to Asrat and Simane (2018), studies revealed that the use of improved crop varieties, agroforestry practices, soil conservation practices, irrigation practices, and adjusting planting dates are the most important adaptation strategies by smallholder farmers. However, adaptation decision is location-specific and influenced by key drivers such as socioeconomic, environmental, and institutional factors.

Based on the household level evidence Mahmud, Salvatro, Temesgen, Claudia, and Gunnar (2008) studied impact of climate change on food production in a typical low-income developing country. Their analysis relies on primary data from 1,000 farms producing cereal crops in the Nile Basin of Ethiopia. They found that climate change adaptations, namely, changing crop varieties, adopting soil and water conservation measures, water harvesting, tree planting, and changing planting and harvesting periods have significant impact on farm productivity. This study revealed that farm households with larger access to social capital are more likely to adopt yield-related adaptation strategies. On the other hand, lack of information and shortages of labor, land, and money were identified as major reasons for not adapting. Besides, Temesgen et al. (2008) identified the use of different crops or crop varieties, tree planting, soil conservation, changing planting dates, and irrigation as common adaptation strategies; and level of education, gender, age, and wealth of the head of household; access to extension and credit; information on climate, social capital, agroecological settings, and temperature all influence farmers’ choices; lack of information on adaptation methods, financial constraints, and lack of access to land as main barriers to adapt. By applying similar methods with the above studies Temesgen et al. (2008) also revealed that age of the household head, wealth, information on climate change, social capital, and agroecological settings have significant effects on farmers’ perceptions of climate change. Literature findings have been identified the following common climate change adaptation strategies in Ethiopia.
2.4. Crop diversification
This strategy seeks to avoid risks of total crop failure rather than maximizing yields of one particular crop. In Ethiopia, crop diversification is widespread. Crop diversification is the most commonly used method to overcome climate changes in Ethiopia. Greater use of different crop varieties in the same season could be associated with lower expenses and ease of access by farmers (Kristiansen, 2011). Legesse B. et al. (2013) noted that crop diversification together with soil and water conservation and water harvesting practices were commonly used climate change adaptation strategies in eastern Ethiopia.

2.5. Mixing crop production with pastoralism
Mixed species herds, widespread and seasonally available pastures, splitting animals into discrete herds, and mobility in response to seasonal variation in pasture productivity are key strategies in Ethiopia. Selling of livestock was a common coping strategy during drought periods amongst farmers in the Upper Awash Basin in Ethiopia (NAPA, 2007).

2.6. Tree planting
According to Kristiansen (2011), tree planting to be one of the major methods used by farmers to adapt to climate changes in the Nile Basin of Ethiopia. Vegetation like trees, plants, and grass are valuable because the roots protect the soil from erosion. Trees are valuable during floods and droughts, and many trees together might give lower temperatures in the near area, a more fresh air, and also shadow.

2.7. Off-farm activities
According to the study of Cooper et al. (2008), farmer's vulnerability to climate changes can be mitigated if the farmers have off-farm work on the side. Sale of labor was a successful coping strategy among farmers in the Upper Awash Basin of Ethiopia during drought periods. Traditional and contemporary coping mechanisms in Ethiopia also include increased petty commodity production. Off-farm activities can for instance be selling of honey, clothes, or home made products like mattresses, hot food, beverages, whips, and ropes.

2.8. Soil and water conservation (SWC)
In Ethiopia, they have often used different kinds of soil and water conservation strategies since around 1990, and soil and water conservation strategies have probably developed much since that time. Soil and water conservation strategies are mainly used because of soil degradation and soil erosion, and because farmers due to this, want to rehabilitate their fields. These activities are increasingly important today because climate changes to some extents are accelerating these processes (Kristiansen, 2011).

2.9. Selling of assets
Temesgen Desalegn 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. According to Amsalu and Adem (2009a) using a household survey, about 78% of the households in Borena, 40% in Guji, and 33% in South Omo Ethiopia reported an increasing trend of livestock selling.

2.10. Enset
Closely related to the former section, enset, or false banana, is a relatively drought resistant plant and it is a highly valuable plant in many Ethiopian communities, especially in the south. Enset is a suitable plant in some parts of Ethiopia and therefore more or less an example of the former section. It is however so important that it is decided to be taken as an individual section. Enset provides more amount of foodstuff per unit area than most cereals in Ethiopia.
The study of (Nater, 2010), estimated that 40–60 plants occupying 250–375 square meters can provide enough food for a family of five to six people.

2.11. Food aid
Food appeal and food aid have been identified as a coping mechanism to climate variability and extremes in Ethiopia. During critical times of drought, government, NGOs, relatives, and others can help farmers financially (NAPA, 2007). Costs associated with droughts in Ethiopia in 1999 are estimated to have coasted 5.3 million US $ (United Nations 1999).

2.12. Irrigation and diverting of water
In Ethiopia, only 2,900 km$^2$ (2003 estimation), or 1% of cultivated land, is irrigated (CIA, 2011). Use of irrigation is one of the least practiced adaptation strategies among the major adaptation methods identified in Ethiopia (Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009).

2.13. Migration climate
Traditional and contemporary coping mechanisms to climate variability and extremes in Ethiopia include permanent and temporary migration in search of employment (NAPA, 2007). Some people in Ethiopia live a semiomadic lifestyle. They migrate a couple of times during a year in search for pastures for their livestock. For instance, they have a permanent farm one place, but parts of the year they move the family and their livestock to other areas and come back several months later (Dadi, 2007).

2.14. Farmers’ response to perceived change to temperature and precipitation
In developing countries like Ethiopia, the common approach to studying the perception of farmers to climate change is based on comparing farm survey or farm group discussion results with data records from meteorological stations. Although informative in terms of understanding the level of awareness of farmers and the possibility of validating farmers’ claims of perceptions of change against meteorological data, these approaches do not explicitly identify factors influencing awareness of climate change (Deressa et al., 2011).

The study of Paulos Asrat and Belay Simane (2017) and Deressa et al. (2011) revealed that farmers living in the dry lowland area perceived more change in climate than farmers in the wet lowland. This could either be associated with the repeated drought events occurring in the area in recent years or could be linked to various environmental changes that cause reduced water availability and agricultural yield in the dry lowland areas. With regard to adaptation, better awareness and use of adaptation measures is revealed in the wet lowland condition as compared to the dry lowland. This difference between the two locations may call for further heightening of intervention to facilitate the scene for enhanced climate change perception and adaptation.

According to Deressa et al. (2011), the age of the head of the household represents experience in farming and studies have indicated that experienced farmers are more likely to perceive climate change. The degree of education of the head of household is also hypothesized to be positively related to awareness of climate change. Access to information on climate change through extension agents or other sources creates awareness and favorable condition for adoption of farming practices that are suitable under climate change. Higher income positively affects public perception of climate change. Similarly, it is hypothesized that higher farm and nonfarm incomes positively influence farmers’ perception of climate change.

3. Conclusion and recommendations
Ethiopia’s pastoral and agropastoral communities, as well as smallholder farmers, are particularly vulnerable to climate change, and will require a concerted focus on adaptation to reduce poverty and build resilience. With regard to adaptation, better awareness and use of adaptation measures is revealed in the wet lowland condition as compared to the dry lowland. This difference between the two locations may call for further heightening of intervention to facilitate the prospect for
enhanced climate change perception and adaptation. Farmers' living in different agroecological setting used different adaptation measures in response to climate variability. It has been reported that households’ living in areas, where the amount of rainfall is less and high temperature than the average is more likely to employ different measures than households’ receiving much rainfall and less temperature. This implies that rural households’ living in the mid highland (Woina Dega) are more likely to adapt to the changing situations than those in highland due to the existence of high variability in climate compared with highland (Dega) households'.

The major adverse impacts of climate variability in Ethiopia include: food insecurity arising from occurrences of droughts and floods; outbreak of diseases such as malaria, dengue fever, water borne diseases (such as cholera, dysentery) associated with floods and respiratory diseases associated with droughts; land degradation due to heavy rainfall; damage to communication, road and other infrastructure by floods. Besides, the severity of climate change in Ethiopia is due to poor building designs (living standard), agriculture (seasonal production), food insecurity and low income, deforestation, conventional solid waste management system, less adaptive capacity, limited financial resource, skills and technologies, and others (Chinasho, 2017). In most cases, Ethiopia has been identified as one of the most vulnerable countries to climate variability and change, and is frequently faced with climate-related hazards, commonly drought and floods (Burnett, 2013).

It is therefore, more programs that deal with awareness of climate change impact must be encouraged among rural farmers who depend on rain-fed agriculture. Government policy on climate change should focus more on illiterate farmers who are still alert and aggressive in farm activity and the government must also set policies for adapting climate change in terms of agricultural growth. Besides, information on effective agricultural adaptation strategies should be promoted, the farmer’s access to agricultural inputs should be increased, and institutions that limit the adaptive capacity of farmers should be removed in order to increase the adaptive capacity of farmers. Farmers also should know how to implement climate change adaptive strategies and they could make long term adjustments such as changing crop varieties that are grown as well as where they are grown (i.e. location).

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