Climate Change Impact, Vulnerability and Adaptation Strategy in Ethiopia: A Review

Negussie Zeray*[1], Ashebir Demie [2]
1. *Department of Agricultural Economics, Dilla University, P.O.BOX 419, Dilla, Ethiopia
E-mail: negussiezeray@yahoo.com
2. Department of Agricultural Economics, ATA, Ethiopia

INTRODUCTION

Review of long-term climate data for Ethiopia shows increasing rainfall for some regions and decreasing rainfall for others with temperature rising for all regions (Energy Group of ECSNCC Network, 2011). Global circulation models predict a 1.7-2.1ºC rise in Ethiopia's mean temperature by 2050 (EPA, 2012). Average annual temperatures nationwide are expected to rise 3.1°C by 2060, and 5.1°C by 2090 (Kidanu *et al*., 2009). In addition, precipitation is projected to decrease from an annual average of 2.04 mm/day (1961-1990) to 1.97 mm/day (2070-2099), for a cumulative decline in rainfall by 25.5 mm/year (Kidanu *et al*., 2009). This could cause food insecurity, outbreak of diseases such as malaria, dengue fever, cholera and dysentery, malnutrition, land degradation and damage to infrastructure (Kidanu *et al*., 2009; Adem and Bewket, 2011; Adem and Guta, 20011; Oates *et al*., 2011; EPA, 2012).

The current development plan, GTP, envisages the country's GDP per capita to grow from 378 USD in 2010 to 1271 USD in 2025. It also projects that the contribution of agriculture will diminish from 42% to 29% indicating migration of jobs from the agriculture sector to industry and services, which are expected to contribute 32% and 39% of the GDP (FDRE, CRGE, 2011). The GTP explicitly recognizes that environment is a vital and important pillar of sustainable development, and states that "building a 'Green Economy' and ongoing implementation of environmental laws are among the key strategic directions to be pursued during the plan period" (MoFED, 2010; EPA, 2012). To protect its citizens from such devastating catastrophe and to attain its vision of becoming a middle income country by 2025, the government of Ethiopia has adopted a climate resilient green economy strategy to keep its development objectives on track in the context of a changing climate.

Adem and Bewket (2011) contend that addressing current and future climate vulnerabilities in development planning and programming through mainstreaming of climate change adaptation should be an immediate priority for Ethiopia. Being prepared to adapt to climate change is important, even as the world strives to reduce the factors that cause it (Adem and Bewket, 2011). Kidanu *et al*. (2009) claim that including voluntary reproductive health and family planning as a core component of integrated community approaches and strengthening the country's national family planning program will increase the effectiveness of climate change adaptation efforts in Ethiopia. According to Adem and Bewket (2011), development as usual, without consideration of climate risks and opportunities, will lead to maladaptive practices weakening national resilience to climate change in Ethiopia.

In a nut-shell, Ethiopia's endeavours to respond to the impacts of climate change through adaptation and mitigation policy frameworks are highly appreciable (Adem and Bewket, 2011). Nevertheless, the practical implementation of these policy frameworks is impaired by different challenges. Therefore the main focus of this paper is to show climate change impacts, vulnerability and adaptation strategy in Ethiopia.

Climate Change Observations in Ethiopia

Given the range of negative impacts of current climate (and non-climate) hazards on pastoralist and agro-pastoralist livelihoods, the implications of climate change must be taken into account to ensure longer-term survival and sustainability of these communities. This requires an appreciation of how the climate has already changed in recent decades and what is projected to change in the decades to come. According to the UNDP Climate Change Profile for Ethiopia, the mean annual temperature in Ethiopia has increased by 1.3°C between 1960 and 2006, at an average rate of 0.28°C per decade. The temperature increase has been most rapid from July to September (0.32°C per decade). It is reported that the average number of hot days per year has increased by 73 (an additional 20% of days) and the number of hot nights has increased by 137 (an additional 37.5% of nights) between 1960 and 2006. The rate of increase is seen most strongly in June, July and August. Over the same period, the average number of cold days and nights decreased by 21 (5.8% of days) and 41 (11.2% of nights), respectively. These reductions have mainly occurred in the months of September to November (McSweeney *et al*., 2008).

It is very difficult to detect long-term rainfall trends in Ethiopia, due to the high inter-annual and inter-decadal rainfall variability. Between 1960 and 2006, no statistically significant trend in mean rainfall was observed in any season. The decrease in rainfall observed in July to September in the 1980's recovered in the 1990s and 2000s. In addition, there are insufficient daily rainfall records to identify trends in daily rainfall variability and changes in rainfall intensity (McSweeney *et al*., 2008).

According to the National Meteorological Agency, Ethiopia experienced 10 wet years and 11 dry years over the last 55 years, demonstrating the strong inter-annual variability. The wet years included 1958, 1961, 1964, 1967, 1968, 1977, 1993, 1996, 1998 and 2006. Dry years were 1952, 1959, 1965, 1972, 1973, 1978, 1984, 1991, 1994, 1999, and 2000 (Ethiopian NAPA, 2007).

Ethiopia has contributed very low to the current climate change. Per capita GHG emissions of Ethiopia has been estimated 900kg CO2 equivalent which can be compared to U.S. emissions of 23.7 tonnes CO2 equivalent per capita and year in 1994. Much of the emission in Ethiopia is accounted to the agriculture sector which is about 80% of the total GHG emissions.

Sector wise, Ethiopia's GHG emissions are dominated by agriculture, which contributes 80% of the total GHG emissions. This reflects the fact that livestock farming goes together with high methane emissions. The dominant position of livestock farming in Ethiopia's economy also influences the relative contribution of GHG to the total emissions. These are dominated by methane emissions, which account for 80% of the warming potential.

The Impacts of Climate Change in Ethiopia

Impacts on Agriculture

Ethiopia confronted many adverse impacts which are manifestations of variable climate. Yet there are indications by which these impacts will continue to influence the socio-economic activities of the community at larger scale. The northern, southern and south-eastern dry land regions of Ethiopia have repeatedly faced increased frequency of meteorological drought episodes, famines and outbreaks of diseases which are believed to be linked with climatic change. The droughts have highly impacted the agriculture of the country and brought about the loss of crops, animals and above all the loss of millions of people. Flood hazards have increased in recent decades. The flood hazards which have occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996 and 2006 are such indications. These flood hazards have demanded in crop and animal destructions as well as human lives.

Many studies have concluded that the agriculture sector of the country is the most affected sector by climate change. Deressa *et al.,* (2008) made an integrated quantitative vulnerability assessment for seven Regional States of the total eleven regions by using biophysical and social vulnerability indices of Ricardian approach. The study revealed that decline in precipitation and increase in temperature are both damaging to Ethiopian agriculture.

Impacts on Crop Production

In the Economics of Climate Change Adaptation (EACC) study, CliCrop was used to assess the changes in CO2 concentration, precipitation, and temperature from the four GCMs and was used to estimate the changes in production (yield) each year for four major crops (Figure 5). The yield effects reflect the reductions in yield due to either the lack of available water, or due to the overabundance of water that causes water logging.

CO2 fertilization is included in the analysis but does not make a significant difference. The research is suggesting much smaller CO2 fertilization than initially thought. Additionally, new research shows that under higher CO2 levels, ozone will also be present and that has a negative impact on crop yields. Climate impacts are significant, but variable over regions and crop type. The impact of these trends tends to grow stronger in time. The Dry2 scenario is the most damaging scenario due to the frequent occurrence of droughts.

The impacts of climate on yields are first-order effects that trigger direct and indirect economic impacts - such as reductions in income, employment, savings and investments.

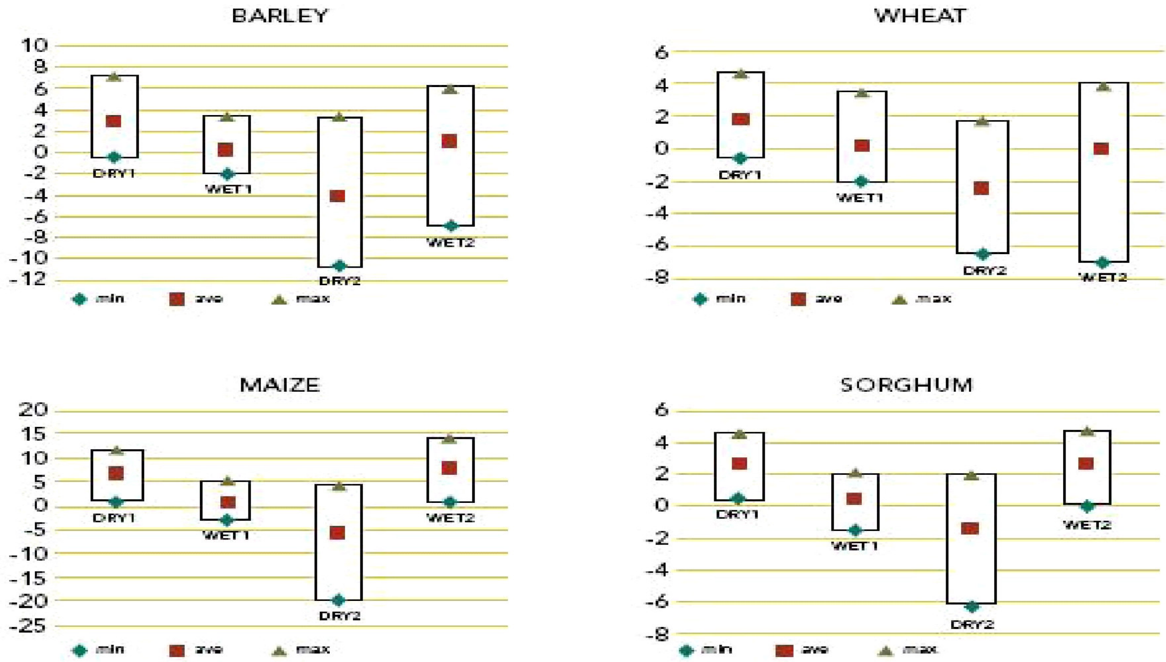


Figure 5: World Bank: Range of Percent Yield Deviation from no -CC Base (2006-2050) for selected crops under different “wet” and “Dray scenarios”

Note: The effects of climate change on the different crops are weighted averages across regions, using the regions’ shares in crop total production as weights. Baseline yields include a technology growth component reflecting historical trends (World Bank, 2011).

According to Deressa and Hassan (2009) studies that have investigated impacts of climate change in the context of Ethiopia using a Ricardian approach, find that the climate variables have a significant impact on net crop revenue per hectare of farmers under Ethiopian conditions. They also find that, whereas marginally increasing seasonal precipitation during spring would significantly increase net crop revenue per hectare, marginally increasing seasonal temperature during summer and winter would significantly reduce net crop revenue per hectare. Moreover, their analysis of impact of predicted climate scenarios from three models (i.e., CGM2, HaDCM3 and PCM) for the years 2050 and 2100 show that there would be a reduction in net crop revenue per hectare by the years 2050 and 2100 and that the reduction in net revenue per hectare by the year 2100 would be higher than the reduction by the year 2050, suggesting that the damage posed by climate change will increase with time unless this negative impact is countered through adaptation efforts. Their results also indicate that the net revenue impact of climate change is not uniformly distributed across the different agro-ecological zones of Ethiopia. However, these studies looked at the impacts of climate change on crop agriculture only.

Whilst water availability for crop production is the major challenge, there are also challenges posed by declining farm sizes, natural resource degradation and increases in crop pests.

Hence, climate variability/droughts have impacted seriously on the country over the past ten years, resulting in increasing agricultural losses and human suffering as shown in Table-2, placing the country in a situation of critical food insecurity and water shortages.

Table-2. Impact of drought on people and crop production over the last ten years (1994-2004)

Years	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Crop yield (t/ha)	10	12	12	11	11	11	10	13	9	14	14
People affected (millions)	6.7	4	2.8	3.4	4.1	7.2	10.6	6.6	7.7	13.2	7.2

Source: Mathewos Hunde, 2004

Impacts on Livestock production

Although the direct effects of heat stress on livestock have not been studied extensively, 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 particularly 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.

The Economics of Climate Change Adaptation study uses survey data from Seo and Mendelsohn (2006) which predicts that relative to the baseline, the probability of choosing beef cattle and chickens will decline with rising temperatures, but that the probability of selecting dairy cattle, goats, and sheep will increase. Seo and Mendelsohn predict a reduction in expected income of 32 percent and 69 percent resulting from a 2.5°C and 5°C increase in mean temperatures. Overall, although both the probability of selection and the number of animals per farm increases for certain types of livestock, the negative responses to climate overwhelm these positive effects.

Angassa (2007) study reconstructed 21 years of household cattle population data in key resource and non-key resource (pond-water) rangelands in southern Ethiopia, to analyze the relationship between long-term rainfall and cattle population dynamics. The evidence of density-dependence was relatively important at the local land use level as compared with the regional level. Cattle population below carrying capacity under ranch management did not reduce herd die-offs, suggesting that rainfall variability, not density, had greater influence on cattle population dynamics. The evidence that droughts were more harmful to breeding females and immature animals than to mature males suggested that drought management needs to focus on herd recruitment potential.

The amount and duration of rainfall is declining and the dry season is becoming longer, which has led to shortage of water and pasture, spread of human and livestock diseases, and intensification of conflicts. Prolonged drought has led to the loss of livestock assets, and it has become difficult to restock. Usually during drought, as the animals have less access to pasture and become weak, they are more susceptible to different diseases when they are concentrated around a few water points (Yohanes and Mebratu, 2009).

Impacts on Agricultural GDP and GDP Growths

Studies show that decrease in rainfall and increase in temperature both affect agriculture of the country (Deressa *et al*., 2008). The trends in the contribution of agriculture to the country's total GDP clearly explain the relationship between the performance of agriculture, climate and the total economy. Years of drought and famine (1984/1985, 1994/1995, 2000/2001) are associated with very low contributions, whereas years of good climate (1982/83, 1990/91) are associated with better contributions (CEEPA, 2006).

Impacts on Food Availability

Because of irregular rainfall and droughts the country is experiencing deficits in food production in several areas, and likely increase in acute weather events, amplified aridity and a decrease in precipitation, range resources and soil moisture will escalate the situation. The shortage of water which is supposed to happen due to climate change will highly impact the already water stressed lowland regions and agricultural activities may no longer be successful. The availability of food has become a major bottleneck for millions of households in many parts of Ethiopia due to the repeated drought cycles and disparity in rainfall. This has been evidenced that when the rainy seasons are normal the amount of food aid decreases and vice versa. Agro-pastoral and pastoral households, which are reliant on livestock for their livelihoods, also suffer severe asset losses during droughts (World Bank, 2007).

Impacts on Water Resources

Home to twelve major river basins, Ethiopia is rich in water resources and is considered to be the "water tower" of Northeast Africa. Yet extremely limited water storage capacity prevents the country from capitalizing on these abundant water resources. Climate change is expected to reduce run-off to Nile tributaries (Abay and Awash Rivers) by up to one-third. Decrease in river run-off has important consequences for flow into hydropower generation. In addition, climate change is expected to lead to drying of wetlands with severe implications for key breeding sites of some bird species (World Bank, 2011).

According to NAPA (2011) 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 (the case of Haramaya Lake is notable example).

In general discrepancy of the rainy season, which emanates from climate variability, results in water shortage. Consequently, the ecosystem, which is the source of rain and water resource, will be affected. Rainwater scarcity would affect the aquatic life by deteriorating the quality and quantity of a water body. For instance, water insufficiency endangers the fish resource, which is the cheap source of protein and leads to food shortage. In general, development activities based on water will be deteriorated as a result of water deficiency.

Impacts on Health

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). The NAPA cites the migration of malaria carriers to highland areas as the predominant risk to the human health sector.

Malaria already accounts for up to 20% of deaths of children under five years of age. During years when epidemics prevail, mortality rates of nearly 100,000 children are not exceptional. The last serious malaria epidemic occurred in 2003; up to 16 million cases of malaria were detected, 6 million more than those in an average year (UNICEF, 2011). Minor shifts in geographical presence of malaria could expose millions to infection (e.g. in densely populated areas of east African highlands) (IPCC, 2001.). Rainfall also plays a role in determining the availability of mosquito habitats and the size of mosquito populations.

In a 2004 study (McMichael *et al.,* 2004) it was calculated that 36,000 lives were already being lost each year across Eastern Africa (including Ethiopia) because of climate change. The same study calculates that the greatest future health risks associated with climate change in 2030 will be flooding, followed by malaria, diarrohoeal disease, malnutrition and cardiovascular diseases.

According to the World Health Organisation (2004), 68% of Ethiopians are already living in areas at risk from malaria, where transmission is unstable and characterized by large scale epidemics. For example, in 2003 large scale epidemics resulted in 2 million confirmed cases and 3000 deaths.

The 4th report of the IPCC states that by the 2050s malaria will have entered into the highland areas of Ethiopia and that by 2080 conditions will be highly suitable for malaria transmission.

To avoid future health risks associated with climate change, it will be necessary to organize and implement community-based health education programs in order to raise awareness and educate local population about the importance of personal hygiene and environmental health management. Such a community-based mechanism would benefit from training programs to build local capacity to take up adaptive measures such as use of bed nets and to encourage the use of climate and meteorological data in the planning of malaria control measures (NAPA, 2007).

Impacts on settlement and infrastructure

Climate variability, including extreme events such as storms, floods and sustained droughts, already has marked impacts on settlements and infrastructure (Freeman and Warner, 2001). 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, 2007).

Impacts on settlements and infrastructure are well recorded for recent extreme climate. For instance, the devastating flood in August 6, 2006 caused death of 256 people, displaced 9956 and 244 people missing. The flood has made 2685 households homeless. Out of the displaced people, 5524 are in temporary shelter while 4432 living with their relatives and friends**.** The flood has inflicted huge damages on urban infrastructures (Table

3). Roads, bridges and houses were destroyed. Electric poles, water pipes and sanitation facilities were also damaged.

Table 3. Impact of climate change on infrastructure

S.N.	Damage on urban infrastructures	Estimated cost of damage (Birr)
1	The rehabilitation of Dechatu main bridge, which was done few years back by 2.4 million birr (from the previous damage),	3,000,000.00
2	Taiwan Irish crossing that joins Taiwan with Number-1 area.	900,000.00
3	Halfkat Irish crossing which connects Halfkat and Vera pasta areas	500,000.00
4	Dechatu retaining wall in two parts (60m)	400,000.00
5	Kefira guide wall about 120m has been destroyed	950,000.00
6	About 100m retaining wall along Goro River in GTZ settlement area	930,000.00
7	All the roads with in the radius of 40m from Dechatu River bed covered by silt brought by the flood	517,100.00
8	Electric poles and lines	500,000.00
9	Telephone poles and lines	6,098.36
	Total	7,703,198.36

Source: DDAEPA (2011)

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. About 6 houses were washed out and a total of 10,809 people were affected in one way or another (Table 4).

Table 4. Damage on rural infrastructure and farmlands

No.	Description	Unit	Total Damage
1	**Infrastructure damaged**		
	Soil bund	Km	224.2
	Stone bund	Km	62.3
	Stone check dam	M3	8600
	Water harvesting ponds	No	2
	Cut off drain	Km	43.85
2	**Damage on farms**	**Ha**	**230.64**
	Sorghum	Ha	203.36
	Maize	Ha	25.9
	Haricot beam	Ha	0.75
	Sesame	Ha	0.63
3	**Fruits and Vegetables**	**Ha**	**17.21**
	Fruit	Ha	15
	Vegetables	Ha	2.21
4	**Cash crops**	**Ha**	**9.72**
5	**Different farm tools**	**Ha**	**399**
6	**Livestock killed**	**No**	**21**
7	**Water Schemes**	**No**	**10**
8	**Small scale irrigation schemes**	**No**	**5**
9	**Houses**	**No**	**6**

Source: DDAEPA (2011)

Current Climate Variability and Observed Trends

According to NMA (2007), Mean annual minimum temperature and annual rainfall variability and trend observed over the country in the period 1951-2006. Annual minimum temperature is expressed in terms of temperature differences from the mean and averaged for 40 stations. There has been a warming trend in the annual minimum temperature over the past 55 years. It has been increasing by about 0.37 0C every ten years. The country has also experienced both dry and wet years over the same period. The trend analysis of annual rainfall remained more or less constant when averaged over the whole country (NMA 2007).

Impacts of current climate variability

Although models predicting precipitation give controversial results of both increasing and decreasing precipitation, all models agree that the temperature in Ethiopia will increase in the coming years. For instance, Strzepek and McCluskey (2006) showed that, based on different models, precipitation will either increase or decrease. They point out, however, that the temperature will increase under all models (Table 5).

Strzepek and McCluskey (2006) used three climate prediction models based on two scenarios from the IPCC Special Report on Emission Scenarios (SRES). These models are: the Coupled Global Climate Model (CGCM2) (Flato and Boer 2001): the Hadley Centre Coupled Model (HadCM3) (Senior and Mitchell, 2000): and the Parallel Climate Model (PCM) (Washington *et al.* 2000). The two SRES scenarios used in the study are the A2 and B2 scenarios. The A2 scenario describes a world in which population growth, per capita economic growth and technological changes are heterogeneous across regions. The B2 scenario describes a world in which the population increases continuously across the globe at a rate less than A2. This scenario is an intermediate level of economic development that is oriented towards environmental protection and social equity with a focus on local and regional levels (IPCC 2001). Additionally, forecasts by NMS (2007) indicate that the temperature in Ethiopia will increase in the range of 1.7 – 2.1^{o}**C** by the year 2050 and 2.7 – 3.4^{o}**C** by the year 2080.

Table 5. Climate predictions for 2050 and 2100 (Changes from a 1961- 1990 base for SRES A2 and B2)

Model	**Temperature in ^{o}C**		**Precipitation change in %**	
CGCM2	**2050**	**2100**	**2050**	**2100**
A2	3.3	8	13	28
B2	2.9	5.1	13	28
HadCM3				
A2	3.8	9.4	9	22
B2	3.8	6.7	9	22
PCM				
A2	2.3	5.5	5	12
B2	2.3	4	5	12

Source: Strzepek and McClusky (2006).

VULNERABILITY TO CLIMATE CHANGE

A nationwide comparative vulnerability trend analysis study, undertaken by the CVI Core Group of EWWG/DPPC (WFP-VAM, 2004) (1994-1998 to 1999-2002) on 418 crop-dependent woredas, showed that the vulnerability status of 161 woredas had worsened over the study period. The reduced, limited and erratic natures of rainfall as well as the recurrent droughts are acknowledged as major factors contributing to increased vulnerability and destitution. Kalu Woreda/district is one of those with worsened vulnerability. According to a wealth ranking study, 65% of its population fall into a poor to destitute category (BoRD, 2003).

Causes of Vulnerability to Climate Conditions in Ethiopia

Generally, Ethiopia is vulnerable to the impacts of climate change because of interlinked several factors: poverty, recurrent droughts, high population growth, inequitable land distribution, over exploitation of natural resources, subsistence rain-fed agriculture, etc.

Ethiopia is above all vulnerable to climate change as a consequence of its landscape variability, low income, and bigger dependence on climate susceptible socio-economic sectors such as agriculture, pastoralism and natural resources. Hence, it is very critical to consider the vulnerability of Ethiopia to climate change impact is a function of several biophysical and socioeconomic factors.

With the very nature of agricultural productivity and natural resources management has much to do with the climate of Ethiopia. Particularly the observed changes in the two parameters of climate, viz. temperature and rainfall have affected the agriculture and livelihoods of the people. The vulnerability is amplified by inadequate and unaffordable agricultural inputs, landlessness and unemployment, and water shortage. Climate change also indirectly affects agriculture by influencing emergence and distribution of crop pests and livestock diseases, exacerbating the frequency and distribution of adverse weather conditions, reducing water supplies and irrigation, and enhancing severity of soil erosion (Watson *et al*., 1998; IPCC 2001).

The key climate induced vulnerabilities of households in the lowlands are shortage and variability of rainfall, decline in crop production, chronic water shortages, floods, livestock and human diseases, conflicts over pasture and water, and livestock and crop price fluctuations (SC-UK/DPPFSB/DPPA 2008; SC-UK/DPPA 2008). In the highland areas the main climate-related vulnerabilities relate to erratic rainfall, drought, hailstorms, frost, strong winds, land degradation, and pests and livestock diseases affecting crop and livestock production (LIU/DMFSS 2008). Overall, climate variability and climate change will adversely affect crop yields, resulting in income fluctuations and declining food security (World Bank, 2007).

According to Temesgen (2010) study on assessment of the vulnerability of Ethiopian agriculture to climate change and farmers' adaptation strategies based on the integrated vulnerability assessment approach using vulnerability indicators. The vulnerability indicators consist of the different socioeconomic and biophysical attributes of Ethiopian Seven agriculture based regional states. The results indicate in Table 6 that the mean vulnerability levels of the surveyed households at basin level and across agro-ecological settings using different scenarios of poverty lines. When the poverty line is fixed at 2 US dollars per day, the majority (93 percent) of the surveyed households were vulnerable, whereas only 7 percent of them were identified as vulnerable when the poverty line is fixed at 0.3 US dollars per day. This indicates that the number of vulnerable households increases with increasing the minimum income level required to sustain daily life.

The analysis undertaken to compare the vulnerability of households across different agro-ecologies for the different scenarios of poverty line indicate that farmers living in Kola were the most vulnerable to climatic extremes. This is depicted under columns 3-5 of table 6.

Table 6. Vulnerability at basin level and across agro-ecological settings using different scenarios of poverty lines

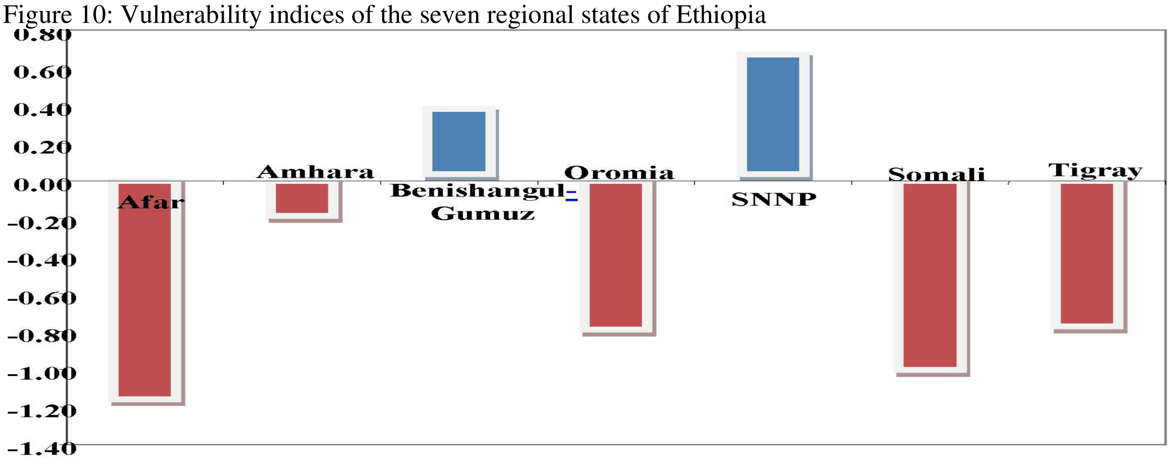
Scenario ($US per day)	Nile Basin	Kola	Weyandega	Dega
2.00	0.93	0.97	0.91	0.93
1.50	0.86	0.94	0.85	0.82
1.25	0.84	0.93	0.82	0.76
0.30	0.07	0.11	0.08	0.02

According to Temesgen (2010) study, vulnerability varies across different households' socio-economic characteristics and the types of climate extreme events experienced For instance, a drought increases the probability of a household falling below a given level of income (poverty line) more than floods and hailstorms in the Nile Basin of Ethiopia under all scenarios. Results also show that household characteristics associated with poverty increase vulnerability. For example, households with a level of education less than the sample average are more vulnerable than households with a level of education more than the sample average, whereas female-headed households are more vulnerable than male-headed households. Moreover, older heads of households are more vulnerable than younger heads of households. Households who do not own livestock are more vulnerable than households who own livestock. Alternatively, there is no significant difference in the levels of vulnerability across different sizes of households, indicating a need to further look at the quality of household members than numbers of households as the determinant of vulnerability. Moreover, the different sizes of farms do not significantly affect vulnerability to climate extreme events. This indicates the need to focus on the quality of land rather than on the quantity in affecting vulnerability to climate extreme events.

Limited access to basic services is the other source of vulnerability at the household level. For instance, farmers who have access to credit services are less vulnerable than farmers with no access to credit services. Additionally, farmers who have access to extension on livestock and crop productions are less vulnerable than farmers who do not. In general, using different scenarios of poverty lines affect vulnerability at the household level almost similarly across the different scenarios.

ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.5, No.21, 2015

Figure 10: Vulnerability indices of the seven regional states of Ethiopia



The above Figure shows that the net effect of adaptation, exposure and sensitivity is positive for SNNP and Benishangul-Gumuz, but negative for Afar, Amhara, Oromia Somali, and Tigray. This indicates that SNNP and Benishangul-Gumuz are relatively not vulnerable, whereas Afar, Amhara, Oromia and Somali are vulnerable. The lesser vulnerability of SNNP is associated with its relatively higher access to technology and food market, its highest irrigation potential and its literacy rate. Afar, Somali, Oromia and Tigray are among the highly vulnerable regions. The vulnerability of Afar and Somali is mainly associated with lower levels of regional development. Despite the fact that these regions are 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.

The vulnerability of Oromia is associated with a high frequency of droughts and floods and lower access to technology, institutions and infrastructure. Similarly, the vulnerability of Tigray is attributed to lower access to technology, health services, food markets and telephone services and the high frequency of droughts and floods. Unlike Afar and Somali, the lower access to technology, institutions, and infrastructure in Tigray and Oromia is due to their high population in proportion to what is available.

In general the agriculture sector is obviously very vulnerable to climate variability. Some reasons can be mentioned:

- high dependence of the livelihoods of most people on rain fed agriculture (it is tremendously reliant on the timely start, amount, duration, and distribution of precipitation),
- traditional system of agriculture with low use of input and obsolete farm implements,
- low an inefficient use of irrigation as compared to the potential of the country,
- In addition highlands, land area that accounts for only 45% of the country account for over 80% of the total population and for 95 percent of the cropped land, and has been suffering from widespread erosion, over-grazing, deforestation and loss of nutrients and consequently reduced per capita share of arable land (Adgolign, 2006).
- high reliance of the population on natural resources and climate sensitive livelihoods, and high dependence on natural resources which are highly affected by environmental degradation,
- the existence of extensive poverty,
- Over 90% of the food supply comes from rain fed subsistent agriculture and rainfall failure means loss of major livelihood source that always accentuate food deficit (Adgolign, 2006).
- the limited economic, institutional and logistical capacity to adapt to climate change, etc.

Predictions indicate that the country will be challenged by impacts of climate change such as droughts, floods, strong winds and heat waves (high temperatures), frosts, pests and diseases affecting livelihoods and health of the people and the natural ecological systems. The country's major economic sectors including water and range resources, food security, biodiversity and human and animal health are vulnerable to current climate variability, and will be affected even more by future climate change (NMA, 2007).

Climate Change Adaptation in Ethiopia

Climate adaptation

Awareness and adaptation to climate related hazards are influenced by the experience in prolonged climate hazards such as higher mean temperature and lower precipitation (Deressa, *et al.,* 2008). In many instances, households are aware of some of the climate related hazards they are facing and their consequences and as a result they have developed strategies to deal with such hazards. Identifying the key adaptation strategies and factors explaining household's choice of a particular climate adaptation strategy is important for designing and/or scaling-up interventions for better climate adaptation.

The main adaptation strategies in the lowlands include livestock sales and slaughter; inter household support, casual labour employment and migration, change in herd composition, reducing expenditure on non-essentials/non-food items, reducing food consumption, livestock
migration, increase in firewood/charcoal sales, increasing wild food consumption, loping trees for fodder, seeking food aid rations in towns, digging wells at river banks (SC-UK/DPPFSB/DPPA, 2008; SC-UK/DPPA, 2008). Adaptation strategies specific to Afar and Borana pastoralists include income diversification through migration to nearby towns or through labor hiring for herding livestock of the well-off absentee pastoralists, changing herd composition by increasing the size of camel and sheep, livestock sales, opportunistic crop production as well as planning use of water through traditional water administration committees (Kibebew *et al,* 2001). It is also indicated that loping evergreen trees to feed animals, consumption of wild plants and building assets through constructing houses in the nearby towns in good years is also among the adaptation strategies for cash earning during periods of climate hazards.

In highland areas, important adaptation mechanisms include planting disease and drought resistant short cycle crops, labor migration (no. of migrant household members and duration varies with severity of the stress), firewood/charcoal sales, livestock sales and agricultural wage labor. Related responses include reduction in expenditure on non-essentials, reduction in educational expenses, increase in school drop outs, remittances from relatives, and reduction in frequency and size of meals (LIU/DMFSS, 2009). Deressa *et al.* (2008) identified the use of various crop varieties, tree planting, soil conservation, early and late planting and irrigation as the main climate adaptation strategies in the Nile Basin of Ethiopia.

Household choice of a particular climate adaptation strategy can be influenced by the resource demands (e.g. labor, other inputs) the strategies pose. According to Deressa *et al* (2008), important determinants of farm level climate adaptation in the Nile basin of Ethiopia include the level of education, access to extension, information on weather data, diversified agriculture and social capital. It also shows that an increase in household wealth (indicated by farm and farm income and livestock holding), level of education, age and family size increases the likelihood of climate change awareness and adaptation.

According to Deressa *et al* (2008), study indicates that wealth is important for climate awareness and adaptation, the question, however, becomes whether there is a potential reverse causation running from adaptation to wealth such that adaptation also leads to increased wealth. Specifically, where non-farm income is considered among wealth indicators, there is a question of whether labor income, e.g. through labor migration, is an adaptation strategy itself or an outcome of other adaptation strategies. The same question applies to livestock holding as wealth indicator. Identifying the determinants of adaptation with proper caution (e.g. through proper econometric procedures or use of exogenous wealth indicators), would help to identify between different vulnerability groups/households for further analysis.

Moreover, male headed households are reported to have a higher likelihood of adoption of adaptation strategies which raises the question of whether climate adaptation strategies are gender specific. The positive adaptation effect of being male headed and an increase in family size are indicators that climate adaptation strategies may be more labor demanding.
The study furthermore shows that a lack of information on climate change impacts and adaptation options, a lack of financial resources, and labor and land constraints explain why no adaptation is adopted among the farmers. An important component of factors explaining farmers' choice of adaptation strategies and the degree of

adoption of a particular strategy is the cost associated with the particular strategy. Hence, designing a framework for costing and estimating the cost associated with the adaptation strategies is relevant in the effort towards addressing climate adaptation issues among the most vulnerable groups.

Ethiopia's response to climate change

Determined enough to combat climate change, Ethiopia has duly reacted by ratifying relevant international conventions and is taking the necessary steps to implement the two categories of responses to climate change, mitigation and adaptation. With this respect, Ethiopia has so far:

- ratified the UNFCCC and its related appliance, the Kyoto Protocol
- presented its initial national communications to the UNFCCC in 2001
- presented its first Climate Change National Adaptation Programme of Action (NAPA) in 2007 to the UNFCCC
- Ethiopia has set target to build carbon neutral economy by 2025
- presented its Nationally Appropriate Mitigation Actions in 2010
- sectoral adaptation plan of action is being prepared
- and many other associated activities

Existing national policies and sectoral programs targeted towards environmental rehabilitation, socio-economic development, and ending poverty have possibly addressed the issues of climate change either directly or indirectly. Among others, the following are notable:

- Conservation Strategy of Ethiopia
- Environmental policy of Ethiopia
- Agriculture and Rural Development Policy and Strategy
- Integrated Watershed Management
- Water Resources Management Policy
- National Policy on Disaster Prevention and Preparedness
- National Policy on Biodiversity Conservation and Research
- Plan for Accelerated and Sustainable Development to End Poverty (PASDEP)
- Growth and Transformation Plan (GTP)

In spite of this fact, considering the ever increasing threats of climate change Ethiopia still requires a standalone climate change policy and even a specific institution watchful to address the complicated unforeseen impacts (Ayana *at al.,* 2011).

Considering the nature of the climate change as a crosscutting issue, it will be useful to incorporate some of the climate change/adaptation interventions into the on-going national programmes like poverty reduction as a sub-component. In addition to poverty reduction programmes, climate change and adaptation issues could be addressed along with two other national programmes; namely, food security and disaster prevention and management. In general, crosscutting issues like poverty, food security and others are aspects that should be considered when planning interventions that address climate change and adaptation.

CONCLUSIONS

Now-a-days climate change is acknowledged as one of the most pressing threats to the development. Extreme weather events, combined with low capacity to adapt to the adverse impacts of climate change, aggravated food security risks. The shortage of rainwater or changes in rainfall patterns, exposed to flooding /erosion, declining soil fertility, decline in productivity, reduced yield, and the resulting food insecurity, have been observed as the results of climate change and drought. Trends showed that addressing climate change induced impacts requires that countries transform their economies and grow in a different way. This requires climate and development planning be integrated. This integration means integration and proper coordination of policies and actions across multiple sectors and scales. By doing so countries could lower greenhouse gas emissions, reduce vulnerability to climate shocks and deliver poverty reduction gains.

Among the hardest hit countries, Ethiopia suffers much from drought and climate change induced impacts, in which the vulnerability to climate change impact is a function of several biophysical and socioeconomic factors. The mainstay of the country agriculture, which is affected by climate related hazards mainly recurrent drought and flood. The various livelihood zones in the country differ in their vulnerability and adaptation strategies to the adverse effects of climate variability and change. The smallholder, low-input and rain-fed agriculture and the pastoral livelihood system in the arid and semi-arid lowlands are more vulnerable to the adverse effects of climate variability and change because of dependence on climate sensitive natural resource based economic activities. Hence, research and intervention efforts need to be responsive to the specific needs of each community.

REFERENCE

Adem A, Bewket W. 2011. *A Climate Change Country Assessment Report for Ethiopia.* Addis Ababa: *Epsilon* International R and D.

Adem A, Guta A. 20011. *Engendering Climate Change Policy and Practice in Ethiopia*. Addis Ababa: Forum for Environment.

Angassa A. and Oba G. 2007. *Relating long-term rainfall variability to cattle population dynamics in communal rangelands and a government ranch in southern Ethiopia* Agricultural Systems Vol 94 Issue 3 June 2007, pp 715 – 725

Ayana Salehu, Beyene Sebeko, Nebil Shekur, Sertse Sebuh, Tefera Tadesse. 2011. Agriculture Sector Programme of Plan on Adaptation to Climate Change, Addis Ababa

BoRD (Bureau of rural development). 2003. Rural household socio-economic baseline survey of 56 woredas in the Amhara region, Vol. IX: Food security, Bahirdar.

CEEPA (Centre for Environmental Economics and Policy in Africa). 2006. Climate Change and African Agriculture. Policy Note No. 25, August 2006, CEEPA.

Deressa, T. T., R. M. Hassan, C. Ringler, T. Alemu, and M. Yesuf. 2008. Analysis of the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia, IFPRI Discussion Paper No. 798 ,Washington, DC: International Food Policy Research Institute.

Energy Group of ECSNCC Netzork. 2011. Renewable Energy and Climate Change Nexus in Ethiopia. Addis Ababa: Gaia Association.

EPA (Environmental Protection Agency). 2012. National Report of Ethiopia, the United Nations Conference on Sustainable Development (Rio+20). Addis Ababa: Federal Democratic Republic of Ethiopia.

FDRE (Federal Democratic Republic of Ethiopia). 2011. Ethiopia' Climate Resilient Green Economy Strategy. Addis Ababa

Flato, G.M., & Boer, G.J. 2001. Warming asymmetry in climate change simulations. *Geophysical Research Letters*, 28(1):195–198.

Freeman, P. and K.Warner. 2001. Vulnerability of infrastructure to climate variability: how does this affect infrastructure lending policies? Report commissioned by the Disaster Management Facility of the World Bank and the ProVentionConsortium,Washington, District of Columbia.

Freeman, P.K. 2003.Natural hazard risk and privatization.Building Safer Cities: The Future of Disaster Risk,A. Kreimer, M.ArnoldandA. Carlin, Eds.,World Bank Disaster Management Facility,Washington, District of Columbia.

IPCC (Intergovernmental Panel on Climate Change). 2001. Impacts, adaptation and vulnerability. Published for the Intergovernmental Panel on Climate Change by UNEP/GRID Arendal, 1032pp. Retrieved from http://www.ipcc.ch/

IPCC (Intergovernmental Panel on Climate Change). 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva.

Kibebew, F., D. Tsegaye, and G.Synnevag. 2001. Traditional coping strategies of the Afar and Borana Pastoralists in response to drought. Dryland Coordination Group, Report No. 11, November 2001.

Kidanu A, Rovin K, Hardee K. 2009. Linking Population, Fertility and Family Planning with Adaptation to Climate Change: Views from Ethiopia. Addis Ababa and Washington, DC: Miz-Hasab Research Center (MHRC) and Population Action International (PAI).

LIU/DMFSS (Livelihood Integration Unit / Disaster Risk Management and Food Security Sector). 2008. Livelihood Baseline Data, Ethiopia.

Mathewos Hunde. 2004. Generation and application of climate information, Products and services in Early warning and monitoring activities in agriculture and food security, MoARD, Addis Ababa

McMichael A J, Campbell-Lendrum D, Kovats R S, Edwards S, Wilkinson P, Edmonds N, Nicholls N, Hales S, Tanser F C, Le Sueur D, Schlesinger M, Andronova N. 2004. Climate Change in *Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors* (eds Ezzati M, Lopez A D, Rodgers A and Murray C J L) Ch. 20: pp. 1543 –1649. World Health Organization. Geneva.

McSweeney*, C.*, New, M., and Lizcano, G. 2009. *UNDP Climate Change Country Profile: Ethiopia. Retrieved from http://ncsp.undp.org/sites/default/files/Ethiopia.oxford.report.pdf*

MoFED (Ministry of Finance and Economic Development). 2010. Growth and Transformation Plan (GTP) 2010/11-2014/15: Draft. Addis Ababa: MoFED).

NAPA (National Adaptation Programme of Action). 2007. Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. Report of the Federal Democratic Republic of Ethiopia, Ministry of Water Resources, National Meteoro-logical Services Agency.

NMA (National Meteorological Agency). 2007. Climate Change National Adaptation Program of Action (NAPA) of Ethiopia. Addis Ababa: NMA

Oates N, Conway D, Calow R .2011. *The 'mainstreaming' approach to climate change adaptation: insights from Ethiopia's water sector***.** Overseas Development Institute Background Note. London: ODI.

SC-UK and DPPA (Save the Children – UK and Disaster Prevention and Preparedness Agency). 2008. Livelihoods and Vulnerabilities – An Understanding of Livelihoods in Somali Regional State, Ethiopia.SCUK and Disaster Prevention and Preparedness Agency. Addis Ababa, Ethiopia.

SC-UK/DPPFSB/DPPA (Save the Children – UKDisaster Prevention and Preparedness Agency). 2008. Livelihoods and vulnerabilities: an Understanding of Livelihoods in Afar Regional State, Ethiopia.

Seo, N., and Mendelsohn, R. 2006. "Climate change impacts on Latin American farm land values: The role of farm type"

Strzepek, K. & McCluskey, A. 2006. District level hydro-climatic time series and scenario analysis to assess the impacts of climate change on regional water resources and agriculture in Africa. CEEPA Discussion Paper 13. Center for Environmental Economics and Policy in Africa, University of Pretoria.

Thornton, P.K., J. van de Steeg, A. Notenbaert, and M. Herrero. 2009. "The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know." *Agricultural Systems* 101 (3): 113–127.

UNICEF (United Nation International Children Fund). 2011. Malaria in Ethiopia. Accessible at http://www.unicef.org/ethiopia/malaria.html

Washington, W.M., Weatherly, J.W., Meehl, G.A., Semtner Jr., A.J., Bettge, T.W., Craig, A.P., Strand Jr., W.G., Arblaster, J., Wayland, V.B., James, R. & Zhang, Y. 2000. Parallel Climate Model (PCM): Control and transient scenarios. *Climate Dynamics,* 16: 755-774.

Watson, R.T., Zinyowera, M.C. and Moss, R.H. 1998. Climate Change 1995. Impacts, Adaptations and Mitigation of Climate change: Scientific-Technical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, Cambridge University Press.

WFP-VAM (World Food Programme's - Vulnerability Analysis and Mapping). 2004. UK http://docustore.wfp.org/stellent/groups/public/documents/eb/wfp032712.pdf

World Bank. 2005. Climate Change Knowledge Portal. Retrieved 12 February 2005 from http://sdwebx.worldbank.org/climateportal.

World Bank. 2007. The Little Green Data Book. Washington.

World Bank. 2010. The economics of adaptation to climate change. Washington: World Bank.

World Bank. 2011. Costing Adaptation through Local Institutions Village Survey Results: Ethiopia. Washington.

Yohanes GebreMichael & Mebratu Kifle. 2009. Local innovation in climate change adaptation by Ethiopian pastoralists. PROLINNOVA–Ethiopia and Pastoralist Forum Ethiopia (PFE) Final report, Addis Ababa.