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Climate Change Impacts and Adaptation Actions in Central Rift Valley of Ethiopia

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Abstract
This paper evaluates the climate change impacts and adaptation actions in Central Rift Valley of Ethiopia. The impact of climate change is the common phenomenon of the worldwide even though its vulnerability varies in place and time. Thus, Ethiopia has been considered as one of the countries highly susceptible to climate change. Because of the country's economy heavily depends on traditional rain-fed agriculture within a fragile highland ecosystem, which has been threatened by population pressure and land degradation. Among other regions in the country, the Central Rift Valley has been adversely affected by climate variability and change, which manifested in the frequency and intensity of flood and drought. In addition to these weather extreme events, human activities like land use change and over exploitation of natural resources are also an alarming problem in the area. For example, forest land was decreased by 66.3% whilst agricultural land expanded by 84%, and organic carbon losses were amounted to 60-75% during 1973 to 2006. On one side land degradation, deforestation, overgrazing, soil erosion, flooding, waste disposal and sediment loads are the main threats of the lakes. On the other hand, increasing in temperature and varying in rainfall pattern leads to evaporation, salinity and water shortage; these create higher competition in water use for irrigation projects, floriculture industry, soda abstraction, fish farming, domestic and livestock consumption, which could have an adverse impact on lake quality, level, and river discharges. The prevalence of invasive species, diseases and parasites are also among the significant issues in the area.Meantime, mitigation and adaptation are used as the fundamental global responsive strategies to address climate change. Hence, Ethiopia has identified different adaptation options in Climate Resilient Green Economy Strategy. Watershed based land and water resources management; forest development, energy options, capacity building etc. are among the actions have been used. Beside to this, various potential adaptive activities, including traditional and their effects were examined in the central rift valley. Such as: by adjusting sowing time, applying improved agricultural technologies/inputs, crop rotation, mixed farming system, Agroforestry, afforestation/reforestation, rehabilitation of degraded land, physical soil and water conservation measures, capacity building, enhancing income generation and employment opportunities were among the most actions used to combat climate change impacts in the area. However, the impacts of climate change on the biophysical and social-economic of the area were beyond to adaptation capacity. So that, the author recommended that climate change adaptation should be addressed through ensuring the local community needs and participation in integrated approaches like Integrated Watershed Management. It should be also addressed by focusing on highly vulnerable sectors (agriculture and water resources) through effective cropping system, conservational agriculture, effective water application and use, diversification of crop and livestock species, mixed farming system, access to extensional services, access to improved farm technologies and crop varieties, access to information about weather conditions. Generally, any adaptation actions should be enhanced food security and water availability, combating land degradation, reducing loss of biodiversity and ecosystem services.
Keywords: Vulnerability, Climate Change Mitigation and Adaptation, Integrated Watershed Management, Community Participation, Food Security

Introduction

Climate change is one of the current issues that severely impact all climate sensitive sectors, especially rain-fed agriculture. Climate change is mainly manifested in rising temperatures, erratic rainfall, and ultimate recurrent droughts and floods. Despite the fact that the impacts of climate change is the common phenomenon of the worldwide, but its vulnerability is vary from continent to continent, country to country, sector to sector, and even it can vary within age and sex categories (UNFCCC, 2007).

Ethiopia is among the most vulnerable countries in Africa as its economy heavily depends on subsistence rain-fed agriculture within a fragile highland ecosystem, which has been threatened by population pressure and land degradation (World Bank, 2010). Historically it has been portrayed as a food deficit country with its people and animals suffering from recurrent droughts and floods. The famine followed the 1984 droughts caused the death of up to a million persons, and the 2006 catastrophic flood in Dire Dawa can be the crucial examples (NMA, 2006).

Central Rift Valley (CRV) is one of the vulnerable regions in the country which adversely affected by climate variability and change (Kassie *et al*., 2013 and Jansen *et al*., 2007). Because it consists of a chain of lakes, streams and wetlands with unique hydrological and ecological characteristics; the wide diversity of landscapes and ecosystem comprise extensive biodiversity. Also it covers a variety of agro-ecologies characterised by extensive areas of low rainfall and limited areas receiving adequate rainfall (Getachew and Tesfaye, 2015).

Various studies indicated that climate variability, the frequency and intensity of extreme events have negative impacts on biophysical and socio-economic assets of Ethiopia specifically in the CRV (Gizachew and Shimelis, 2014; Kassie *et al*., 2013; Oxfam International, 2010; Raventós, 2010 and NCAP, 2007).

Hence, Ethiopia is committed to building a Climate-Resilient Green Economy. It comprises policies and options to reduce greenhouse gas emissions as well as it enhances adaptation initiatives to minimize vulnerability of climate change impacts (EPA, 2011). However, the country also required additional adaptation options especially by giving priority to effective integrated action at the community level (World Bank, 2010). This is also the same with Lakew et al (2005) that watershed development in Ethiopia started in the 1980's was remained mostly unsatisfactory due to lack of effective community participation, limited sense of responsibility over assets created, and unmanageable planning units.

Despite the fact that, currently land and water management in a watershed context is used as a central adaptive strategy in the country. Because, natural resources management in watershed is not only to protect and conserve the environment but also it contributes to the livelihood security (Kumar and Palanisami, 2009; Samra *et al*., 2005 and Turton, 2000) Consequently, various studies agreed with as Community-Based Adaptation (CBA) is an important tool for developing adaptation options to apply 'bottom-up' participatory process (Reid and Huq, 2014 and UNFCCC, 2007).

In this context the seminar paper aimed to review the impacts of climate change and adaptation actions in Central Rift Valley of Ethiopia. The paper has four main sections: first, it describes the study area; second, it justify why the area is highly vulnerable to climate change; thirdly, it analysis the climate variability and its impacts on crop, livestock, water resources and biodiversity; finally, it evaluates and suggests the climate change adaptation options in the CRV.

Description of the Study Area

The study was conducted in Ethiopian Central Rift Valley (CRV) which is located approximately between $38^{0}05$ E and $39^{0}25$ E and between $7^{0}06$ N and $8^{0}27$ N (*Fig. 1*). It is one of the primary four sub-basins of Rift Valley Lakes Basin (RVLB) known as Ziway-Shala Sub-basin, which covers an area of approximately 14,477 sq. km and located at 150 km south of Addis Ababa. Ethiopian Central Rift Valley is characterized by alternating topographical altitudes ranges from 1500 to above 4000 m a.s.l, and bounded by North-western and South-eastern highlands. The area is predominantly characterised by semi-arid and sub-humid eco-climatic zones. It is characterized by a bi-modal rainfall pattern and high erratic distribution. Its valley floor receives 175–358mm rainfall during a short rainy season (March–April), locally known as *Belg* and 420–680mm during the main rainy season (June–September), locally known as *Kiremt.* In the highlands and rift valley the mean annual temperature is around 15°C and 20°C, respectively (Jansen *et al*., 2007 and NMA 2007).

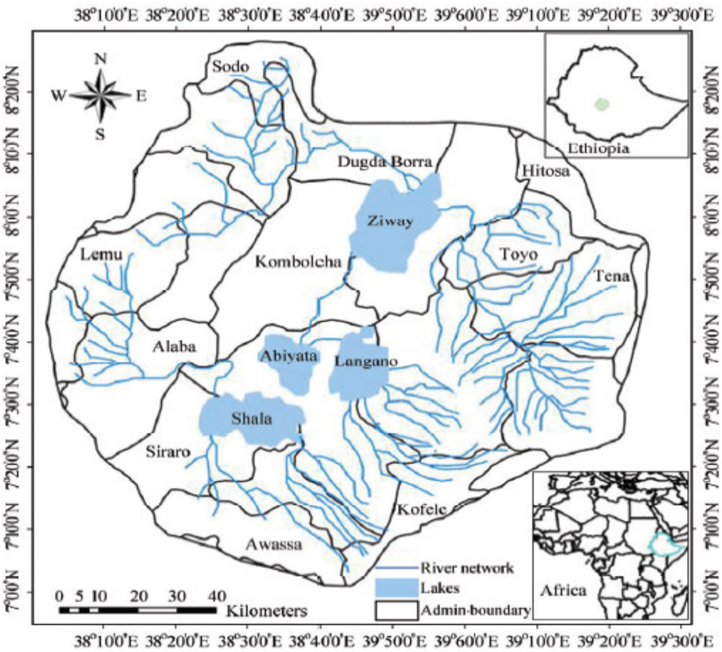

Figure 8: Map of CRV Basin
Source: Meshesha *et al*., 2012

Ethiopian Central Rift Valley covers Ziway-Shala Sub-basin which comprises the catchments of lakes, from north to south: Ziway, Langano, Abiyata and Shala Lakes. Lake Ziway receives most of its water from two tributaries (Meki and Ketar Rivers) of the western and eastern escarpments. Lake Ziway is connected with Lake Abiyata through Bulbula River. Lake Langano is mainly maintained by five major rivers (Huluka, Lepis, Gedemso, Kersa and Jirma rivers) and it is connected with Lake Abiyata through Horakelo River.The surface inflows to Lake Shala come from two main sources (Dadaba and Gidu Rivers) enters from the southeastern and western escarpments. Both Lake Abiyata and Shala are terminal lakes/hydrological closed, meaning there is no surface water outflow from the lakes except for evaporation. Therefore, the lakes are highly vulnerable to changes in water use and they are highly environmental sensitive area (Raventós, 2010 and Jansen *et al*., 2007).

Soils in CRV are largely derived from recent volcanic rocks. The main parent materials of the soils are: basalt, ignimbrites, lava, gneiss, volcanic ash, alluvium and pumice. The major soil units are Vertisols, Cambisols, Fluvisols, Regosols, Lithosols, Andosols and Acrisols (King and Birchall, 1975; FAO/UNESCO, 1977 cited in Itanna *et al*., 2011). Sandy loam soil texture is the predominant of soils in area which are prone to surface crusting and erosion (Biazin *et al*., 2014).

Vegetation in sub-humid to semi-arid of CRV ranges from open woodland to bushed grasslands. The important tree species in the region include: predominate of Acacia spp. *(A. brevispica, A. mellifera, A.nilotica, A. seyal, A. reficiens, and A. tortilis. A. hockii, A. abyssinica), Albizia gummifera, Croton macrostachyus, Cordia abyssinica, Vicus spp Combretum aculeatum, Terminalia brownie, Balanites aegyptium, Commiphora africana etc*. The dominant grasses include *Eragrostis superba, Heteropogon contortus, Hyparrhenia hirta, Andropogon spp., Themeda triandra,* etc. But, currently due to land conversion, the Acacia woodland and other vegetation types were reduced into 4% of the total area (Itanna *et al*., 2011 and Gebreslassie, 2014).

Mixed farming, crop production, mainly rain-fed systems and modest livestock rearing are the mainstays of livelihoods for households in CRV. The major field crops include '*teff*'', maize, wheat, sorghum, lentils, haricot beans and peas. Cattle, goats, sheep, equines and chickens are the major livestock rearing in the area.

The human population of the area is about 4.8 million and that of livestock 1.8 million tropical livestock units. The annual population growth rate is 3% and family size range from 4–8 persons (CSA, 2006).

I. Impacts of Climate Change in Central Rift Valley

Vulnerability of Central Rift Valley to Climate Change

The Ethiopian Central Rift Valley is the most vulnerable area to climate variability and change. Even though vulnerability is not the same for different populations living under different environmental conditions, and confronting different social, economic, political, and institutional challenges, IPCC (2007) have noted vulnerability into three components: exposure, sensitivity, and adaptive capacity of the area.

In terms of livelihood approach, CRV smallholders are highly dependent on rain-fed agriculture which is very sensitive to climate variability and change. Crop production in this region is largely determined by climatic and soil factors. Among the climatic factors, changing in the distribution and amount of rainfall affect the agricultural system in the area as its extensive region combated with low rainfall and limited region receiving adequate rainfall (Getachew and Tesfaye, 2015; Shimelis and Gizachew, 2014; Kassie *et al*., 2013 and World Bank, 2010). One consequence of the volcanic origin of the bedrock of the Rift Valley is the extensive and serious erosion in certain areas. So that, the area is very susceptible to land degradation due to the anthropological or natural factors like coarse soil texture and fragile topography, high population growth rate, land use change, deforestation, land security etc.

The Central Rift Valley of Ethiopia is characterized by a chain of lakes and wetlands with unique hydrological and ecological characteristics which provide habitats for a wide range of birds, animals, trees and other vegetation. Despite of this, agriculture, water and range resources, biodiversity and human health are vulnerable to climate variability and change, with huge social and economic impacts (NMA, 2007).

Rainfall and Temperature Variability

Climate change is expected to manifest itself in the frequency and intensity of floods and droughts as well as in variable temperature and rainfall. The annual and seasonal rainfall variability almost accounts 50 to 80% in Ethiopia (Tsidu and Bayable, 2011). According to NMA (2007) report showed that the temperature in the country has been increasing by 0.37 ^{0}C every ten years, and the maximum daily temperature has increased with 1.5^{0}C. Consequently, the droughts and floods are the most common existing natural hazards that have been caused huge loss of life and properties. The arid, semiarid and dry sub-humid regions in generally, and particularly CRV is the most affected by drought.

According to Gizachew and Shimelis (2014) research result indicated that drought frequency ranging from 2 to 5 times in CRV within next 33 years. At the same time they predicted as rainfall and mean temperature changes significantly vary within the area. In highlands of CRV, rainfall will be increased by 8.6%, and the temperature will be decreased by 1.1^{o}C, whereas, in lowlands, Rainfall will be reduced by 11.3% and temperature increased by 3.5^{o}C in 2050's. Here, it informs us how the CRV is vulnerable to climate variable extremes.

Land Use Change and Soil Erosion

The ability of ecosystems naturally to adapt climate change is severely reduced. It is not only due to unprecedented combinations in climatic events (droughts and floods) but also due to human activities like land use change and over-exploitation of natural resources.

Soil erosion and land degradation become an alarming problem in the country (Wolka *et al*, 2015; Gebreslassie, 2014; Kassie *et al*., 2012; Jansen *et al*., 2007 and Lemenih, 2004). The main causes of soil erosion are the rapidly increasing population (human and livestock) resulting in land use change, deforestation, overgrazing and continuous cultivation of extensive steep slopes and consequently they have adversely affected land productivity.

Annually 1.5 billion metric tons of topsoil erodes from Ethiopian highlands, in turn causes an estimated potential loss of 1 to 1.5 million tons of grain (*Oxfam International, 2010 and Taddese, 2001*). More over it is severe in arid and semiarid regions generally and particularity CRV. For instance, the organic carbon losses amounted to 60-75 percent which has contributed to regular decline in crop yields (Itanna et al., 2011 and Gebreslassie, 2014). According to Meshesha *et al*, (2012), during 1973-2006 while the areas of water and forest land decreased by 15.4 and 66.3% whereas, mixed cultivation and degraded land increased by 79.7 and 200.7% respectively. As a result soil erosion is increased markedly with annual rates of 31, 38, and 56 t/ha in 1973, 1985 and 2006 respectively. *See figures (2 &3) bellow that interpreted from Landsat images, and adopted from Meshesha et al., 2012.*

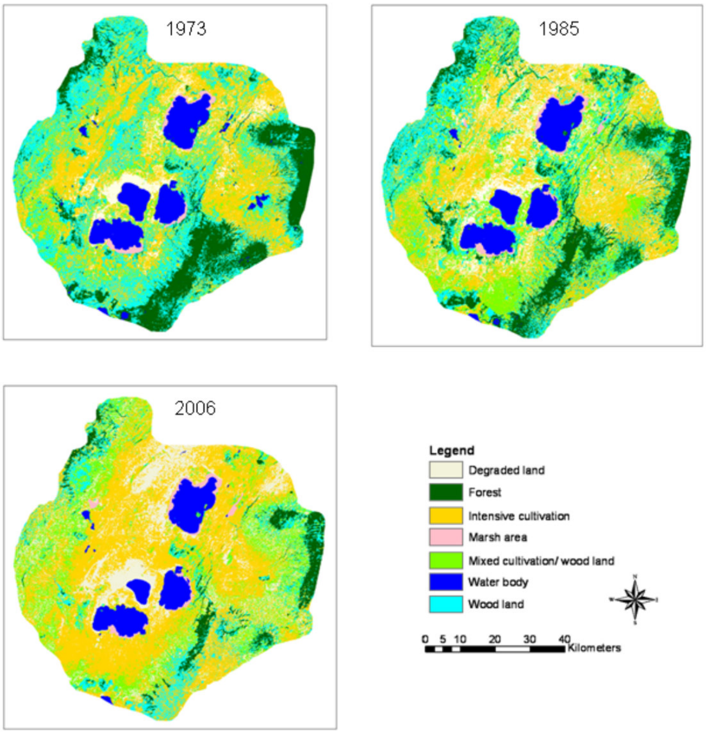

Figure 9: Land use and cover maps of the CRV (1973, 1985 and 2006)

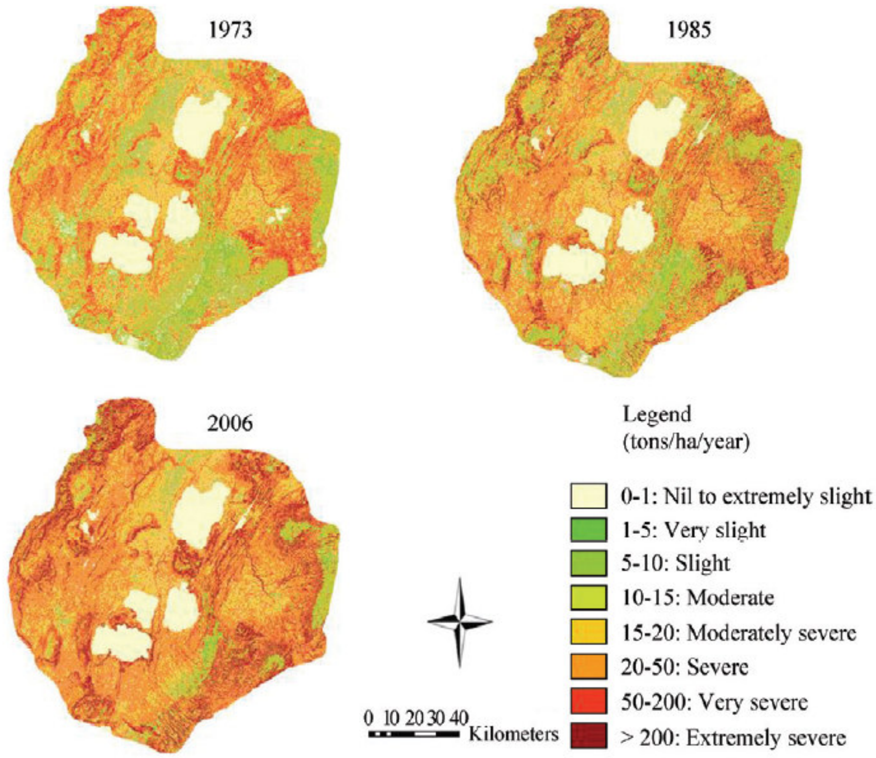

Figure 10: Potential soil loss rate map of CRV (1973, 1985 and 2006)

Climate Change Impacts on Crop and Livestock Production

Various studies indicated that the trends in inter-annual and inter-seasonal rainfall variability like declining in amount, increasing in intensity, varying in the length of growing seasons with increasing temperature are aggravating the rate of erosion, and consequently negative implication on crop and livestock productivity (Kassie *et al*., 2013, Getachew and Tesfaye, 2015).

It is obvious that the availability of pasture and water for livestock is determined by climate conditions and land use change. Increasing in temperature has a negative impact on livestock productivity as warming is expected to alter the feed intake, mortality, growth, reproduction, maintenance, and production of animals (World Bank, 2010). Even if crop residues are used for animal feed, the rapid expansion of cultivated land at the expense of grazing and shrub lands. According to Gebreslassie (2014) studies from Huluka watershed in CRV indicated that during 1973-2009, while cultivated land is expanding from 25 to 84%, the grass and the shrub lands declined from 29 to 3.5% and 18 to 4% respectively. Despite of clearly signs of overgrazing in CRV, the degraded land also dominated with less palatable plant species like *parthenium* (Jansen *et al.*, 2007). Increasing salinity in the lakes and fresh water use competition is another challenge for livestock and plant production in the area (Nigussie, 2007). The prevalence of diseases and parasites is a significant issue in livestock production, causing large scale death of animals with consequent economic as well as social impact (Raventós, 2010). Beside to this the recurring droughts and low erratic rainfall is not only responsible for loss of the livestock but also reduces the amount of manures that they would contribute to organic matter in the soil (Itanna *et al*., 2011).

Climate Change Impacts on Water Resources and Biodiversity

Water resource is one of the highly vulnerable sectors to climate change. Because changes in rainfall pattern are likely to lead to severe water shortages, flooding and soil erosion (UNFCCC, 2007). The impacts are serious to CRV lakes, which are spatially and temporally interlinked as well as they are home to many endemic birds and a wide variety of wild animals. For instance, the Meki and Katar Rivers are situated in the upstream portions discharge their water into Lake Ziway, from Lake Ziway discharged into the Bulbula River and flows to Lake Abyata which also connected with Lake Langano through the Horakelo River. So that; the lakes are more sensitive to changes in the basin, especially they are susceptible to any diversion of these feeder rivers for irrigation projects, domestic consumption etc.

Various study evidences showed that climate variability in combination with human threats have negative impacts on water resources and biodiversity in CRV. According to Jansen et al (2007) as the maximum daily temperature has increased by 1.5°C over thirty seven years, the potential evapo-transpiration has increased by 3 to 4 %, and the evaporation from the lakes also increased by 40 million m^3 per year which increases its salinity. In another way water resources over-exploited due for irrigation, floriculture industry, soda abstraction, fish farming, domestic use and recreation has adverse impacts on lake water qualities, levels, and river discharges. For example, since 2002, on an average Lake Ziway level has decreased by 0.5 meter per year; discharges by Bulbula River has decreased from 200 million m^3 per year into less than 50 million m^3 in 2003, then it reduced inflow to Lake Abyata which has caused a reduction into less than 60% of its original size. In addition, severe environmental degradation, mainly deforestation, over-grazing, soil erosion, waste disposal and sediment loads are the main threats of CRV Lakes. For example: The Abyata-Shala National Park, which well known for its unique ecological characteristics of consisting over 400 bird species, is gravely degraded due to human induced threats in combination with climate change impacts (Raventós, 2010 and NCAP, 2007).

In general, the magnitude of climate change impacts is quite significant in Ethiopia, particularly in Central Rift Valley. Because, CRV is a closed basin, comprises a unique ecological characteristics and wide diversity of landscapes, and it is adversely changes in land use and vegetation cover. So that, several important adaptation decisions are sensitive to these vulnerabilities.

II. Climate Change Adaptation Actions in Central Rift Valley

Globally, there are two fundamental responsive strategies to address climate change: mitigation and adaptation. According to Intergovernmental Panel on Climate Change (IPCC, 2007), defines mitigation as: 'An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases'. Whereas: adaptation defined as 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'.

Even though both approaches aimed to reduce the impacts of climate change, adaptation has now emerged as an urgent policy priority, prompting action both within and outside the climate change negotiations. Because, adaptation could be applied at local scale and less dependent on options of others, it takes effective immediately; it is necessary to protect development and vulnerable populations, can be applied before, during or after any external risks, and it is a continuous and learning process (Chia *et al*, 2015). Moreover, adaptation is not a new concept, throughout history human societies had shown a strong capacity for adapting to different climates and environmental changes. For example, the local people in Ethiopia had developed different adaptation strategies such as: early warning systems, indigenous soil and water conservation techniques, diversification of crop and livestock species, mobility and customary conflict resolution (Gebremichael and Kifle, 2009). On the other hand, various reviews decided that the most effective adaptation approaches for the countries are those addressing a range of local environmental conditions and needs of local community; those their strategies and programmes need to link with coordinated efforts aimed at poverty alleviation, enhancing food security and water availability, combating land degradation and reducing loss of biodiversity and ecosystem services, as well as those improve building adaptive capacity (World Bank, 2010 and UNFCCC, 2007).

Hence, Ethiopia's Climate-Resilient Green Economy strategy includes options to reduce greenhouse gases emission (mitigation) and adaptation initiatives to reduce vulnerability of the people and economy to climate change impacts (EPA, 2011). The country has identified thirty seven potential adaptation options to address highly vulnerable sectors mainly agriculture, water resources and health (NMA, 2007). Furthermore, as climate change adaptation is a crosscutting issue; it should also be addressed in a holistic approach through ensuring the participation of all the relevant sectors related to Natural Resources Management, for example: Integrated Watershed Management Approach. Recently, watershed management approaches have a major role to play in responding to climate change (World Bank, 2008). Thus, watershed management is used as a central adaptive strategy in Ethiopia including the central rift valley region, where these potential adaptive activities were reviewed. In addition the main adaptation options to highly vulnerable sectors were discussed in the following section.

Adaptation Actions in Agriculture

Traditionally, the farmers have long used adaptation strategies to reduce the level of risks in different date of onset of rains, soils and varying moisture regimes. For instance: The Farmers in Central Rift Valley of Ethiopia perceive seasons with early onset of rains to be of longer duration with higher water amounts to grow longer duration crops like hybrid maize variety of BH-540 or Pioneer 532 sown in early April. In late rains onset seasons, they anticipate shorter duration which limited to water supplies and to grow short duration crops like hybrid maize variety of Melkassa II sown in late June (Habtamu, 2004).

As the crops are exposed to moisture stress during the growing season, soil moisture improving techniques like conventional tillage practices and mulching have been contributed towards achieving climate-resilient. According to Sime *et al*, (2014) experimental study demonstrated that conventional tillage provides greater agronomic and economic benefits compared with Conservation Agriculture to maize production in the central rift valley (CRV) of Ethiopia. For example: Conventional Tillage had 13–20% and 40–55% higher grain yield than Minimum Tillage and Zero Tillage respectively as well as regardless of water conservation management, Mulching had 23–33% and 14–19% higher grain yield than no mulch and planting basin respectively. They indicated this is due to temporary water logging, increasing tendency of weed density in minimum and zero tillage, and short duration of experimentation. However, the majority of maize, tef, wheat, barley, and sorghum residues were used as livestock feed and about 69% of the farmers are not retaining any crop residue mulch in their fields as soil amendment in the Ethiopian Rift Valley (Baudron *et al*, 2013).

Various studies suggested that as Crop rotations have obtained many benefits under both conventional and conservation tillage systems in Central Rift Valley of Ethiopia. Because in Crop rotation system weeds and insects are more easily controlled, and plant diseases do not build up in the soil (Taffa, 2002). For instance: a rotation system that used maize as a test crop and it increased yield by 184.4% and 140% when it followed tef and haricot bean respectively as compared to the maize mono-cropping (Worku *et al*, 2006).

Mixed farming systems, especially cereal-legume intercropping system is advanced as one of the integrated soil fertility management practices in high risk environment condition (Matusso *et al*, 2014 and Haile et al, 2014). Intercropping is the cultivating of two or more crops in the same space at the same time. The principal reasons for smallholder farmers have practiced intercropping are: profit maximization, risk minimization, improvement of soil fertility, weed, pests and diseases control and balanced nutrition.

As rangeland has been converted to cropland, crop-livestock farming system is used in CRV (Österle *et al*, 2012). Due to this combination, crop residues used as supplemental feed for livestock and their dung used as natural fertilizer as well as dung for burnt fuel alternatives to cutting firewood.

Agroforestry, which is an ecologically based traditional farming practice, integrates trees into the farming systems to increase agricultural productivity and ameliorate soil fertility, control erosion, conserve biodiversity, and diversify income for households and communities (Bishaw *et al*, 2013). The scattered tree species on the farmland is common in CRV agricultural landscape. For example, diverse Acacia species such as: *A. nilotica, A. seyal, A. senegal* and *A. tortilis*; *Faidherbia albida, Cordia africana* are the dominant trees in maize, sorghum, tef and wheat farmlands. Farmers prioritized these trees utility based on the important roles they felt on their farming systems and landscapes. For example: Tree products (for fodder, firewood, farm tools, fruits, medicine, fibre, fence, etc); Tree Services (for soil fertility improvement, shade, modify the microclimate, soil erosion control, apiculture etc) and biodiversity (wildlife) conservation. This also implies that how the local knowledge has been the power to adapt climate change.

Moreover, the adaptation in agriculture mainly indicated to increase irrigated cropland rather than rain-fed one, so the total irrigated area in the CRV is increased into around 12000 ha of water sources from Lake Ziway (31%), Ketar River (27%), groundwater (25%), Meki River (11%) and Bulbula River (4%). and spring water (2%) (Raventós, 2010). So it highlights to improve the environmental and economic performance of current irrigated smallholders.

Generally, to enhance the resilience to climate shocks of crop yields and livestock production in CRV should be improved the agricultural productivity through watershed management, on-farm technology, access to extension services, transport, fertilizers and improved seed varieties, and forecasting weather extremes.

Watershed Management

The most effective response to a warming world is a renewed commitment to the principles and practices of sound watershed management (Furniss *et al*, 2010). Because, watersheds are complex systems, which defined as the area that drains to a common outlet where water, soil, geology, flora, fauna, and human natural resource use practices interact. Consequently; Watershed Management becomes as the adaptation option and framework for enhancing collective action and equity in natural resources in Ethiopia (NMA, 2007). More specifically, it aims at conserving soil and water, increasing in vegetation cover/tree planting, rehabilitating and reclaim marginal lands, enhancing the income and employment of opportunities etc (MoA, 2011). These practices were examined in the following sections:

Soil and Water Conservation

After the famine of 1973/1974, Ethiopia has been focused on environmental management in the form of watershed protection, such as soil and water conservation, afforestation measures that aimed at reducing soil erosion and land degradation (Tilahun *et al*, 2007). It is obvious that as land degradation leading to decline in soil nutrient status which results in reduction of agricultural productivity. For example: it is estimated that there is a 1-2% reduction of soil productivity annually from the croplands in the Ethiopian highlands due to land degradation (Hurni, 1993 cited in Itanna *et al* 2011). It is a serious in Central Rift Valley which exacerbated by the soil erosion due to its steep slopes, rugged topography and intense rainfall. Annually, more than 20t/ha/ soil is lost from CRV even though rehabilitating the degraded land (by using area enclosure and planted vegetation) and installing erosion control structures (stone bund) in cropland reduced the total soil loss by 12.6% and 63.8%, respectively (Meshesha *et al*, 2012). They also recommended that it must be integrated management as the most effective approach. Moreover, properly implemented soil conservation practices can be effective in counteracting soil erosion and increasing productivity by reducing nutrient losses and conserving moisture (Biazin *et al*, 2014; Baudron et al, 2013; MoA, 2011 and World Bank, 2010). Few researches have been used to explain the extent of soil and water conservation practices as well as their effects on soil erosion control and agricultural productivity in CRV.

Forest Development
Forests have a potential to mitigate climate change; while forest cover has increased and reduced emissions from deforestation and forest degradation. Reforestation/afforestation approaches for ecological restoration, which are receiving considerable attention in Ethiopia in recent years (NMA, 2007). At present, even though the alarming rate of deforestation is 1.1% annually, forestland coverage of Ethiopia increased from less than 3% to approximately 11.9% (FAO, 2005). According to Meshesha *et al*, (2012) estimated that the woodland and forestland area of the CRV is about 5.2% and 8.8% in 2006, respectively. Few researches have been used to explain the current forestland coverage of the area and its effects on climate variables. But, various studies recommended that the CRV demands higher tree density than currently it has, to have broader area canopy cover to avert crop failure and ensure crop success, reduce livestock heat stress and improve food security in the area (Anjulo et al, 2014; Zegeye et al, 2014 and Deressa et al, 2009).

Capacity Building
Capacity building program at all levels is vital to enable developing countries to adapt to climate change. It integrates climate change into sectoral development plans, involving local communities in adaptation activities, raising public awareness and education on climate change, and enabling representation at international meetings (UNFCCC, 2007). Hence the National Adaptation Programme of Action (NAPA) of Ethiopia (NMA, 2007) anticipated as capacity building needs for climate change adaptation in the country due to inadequacy of skilled manpower, weak institutional set up and coordination, lack of specific policies on climate change adaptation, inadequate technologies and research on climate change issues. These constraints are not differing in the CRV of the country and it also needs capacity building on climate change issues.

Conclusion and Recommendation
Even though climate change impacts are the global phenomena, its vulnerability is higher in the developing countries like Ethiopia as it depends on rain fed agriculture within highly populated fragile highland ecosystems. Moreover, the magnitude of climate variability and change is quite significant in Central Rift Valley (CRV) of the country. Because, the CRV comprises unique hydrological and ecological characteristics: including a chain of lakes, streams and wetlands with extensive biodiversity, landscapes and agro-ecologies characterised by climate events, and it is adversely changed in land use and vegetation cover. It is obvious as climate change and subsequent human activities have negative impacts on the biophysical and socio-economic assets in the area, such as: recurrent droughts and floods, land degradation, declining in crop and livestock productivity, severe to water shortage, reducing in level and quality of the lakes, decreasing in the discharges of tributaries, threatening of biodiversity and ecosystem services, prevalence of invasive plant species and so on. So that, several important adaptation options have responsive to these impacts and vulnerabilities. Here, the author recommended that climate change adaptation should be addressed through ensuring the local community needs and participation in cross-sectoral integrated approaches like Natural Resources Management, Integrated Watershed Management, Soil and Water Conservation Measures, Integrated Soil Fertility Management, Forest Development and Capacity Building Program at all levels. Climate variability and change should be also addressed by focusing on highly vulnerable sectors like agriculture and water resources through effective cropping system, conservational agriculture, effective water application and use, diversification of crop and livestock species, mixed farming system, access to extensional services, access to improved farm technologies and crop varieties, access to information about weather conditions. Finally any adaptation actions should be enhancing food security and water availability, combating land degradation, reducing loss of biodiversity and ecosystem services by improving adaptive capacity to climate change.

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