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Review on Climate Change Adaptation and Mitigation Mechanisms in Ethiopia

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Abstract
Climate change is the burning issue of the current world because it is considered to be one of the most serious threats to sustainable development, with adverse impacts expected on the environment, human health, food security, economic activity, natural resources and physical infrastructure. Climate change, biodiversity and forest loss are issues inextricably interlinked and need to be addressed simultaneously. Climate is the fundamental factor that determines different stages of the organism life-cycle, such as plant germination and flowering. Causes for vulnerability of Ethiopia to climate variability and change include very high dependence on rain fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, lack of awareness, etc. The objective of this paper is to examine the social, economic and environmental impacts of climate change based on their degree of existence and trends the impacts, to identify the adaptation strategies and mitigation measures and to find out the challenges to the adoption of those coping mechanisms. The effects of the changing climate are imposing impacts upon the social, economic and environmental conditions of the human beings by affecting their livelihoods causing poor living, housing, and health conditions, by reducing the number at the same time of the production of livestock. Traditional and contemporary coping mechanisms to climate variability and extreme in Ethiopia include changes in cropping and planting practices, reduction of consumption levels, collection of wild foods, use of inter-household transfers and loans, increased petty commodity production, temporary and permanent migration in search of employment, grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land, credit from merchants and money lenders, use of early warning system, food appeal/aid, etc.
Keywords: climate change, coping mechanism, and impacts of climate change

1. INTRODUCTION

1.1 Background

Climate change is a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007). The global temperature and precipitation have changed rapidly over the last century due to anthropogenic increases of greenhouse gases *(*GHGs) in the atmosphere (for example, burning of fossil fuels, like coal, petroleum and natural gasses and widespread deforestation). The Intergovernmental Panel on Climate Change (IPCC) has predicts that the global surface temperature will increase by 1.4 - 5.8°C by 2100 years due to increasing concentration of GHGs specifically carbon dioxide. Climate change affects the biodiversity, food security, water availability, and productivity levels in Africa (Hope, 2009). The Least Developed Countries (LDCs) are dependent on agriculture, climate sensitive economic sectors, which makes more vulnerable to the impacts of climate change because of its less resilient to negative external events and low capacity to adapt than other developing countries (Bruckner, 2012). Africa continent is one of the most vulnerable continents due to its high exposure and low adaptive capacity. The vulnerability of Africa continent is only due to low level of economic development that makes less and low capacity to adapt the impacts of climate changes (Bruckner, 2012). African countries are more affected by climate change because of their reliance on agriculture as well as their lower financial, technical, and institutional capacity to adapt (Nordhaus, 2006).

The warming of the climate system is unequivocal; many of the observed changes since the 1950s, such as increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level are unprecedented over decades to millennia (IPCC,2007).

Climate change, biodiversity and forest loss are issues inextricably interlinked and need to be addressed simultaneously. Climate is the fundamental factor that determines different stages of the organism life-cycle, such as plant germination and flowering. It can severely alter habitats and food sources for animals, and ultimately, could have significant impacts on biodiversity of species and ecosystems around the world (Ali El-Keblaw, 2014).

The urgent need for climate change mitigation remaining critical, putting all the necessary resources and institutions in place for future adaptation is indispensable. Even with a complete cessation of co_2 emissions, global temperature would continue to rise for some time (Gillett et al, 2011) making adaptation unavoidable. The challenge of confronting the impacts of climate change is often framed in terms of two potential paths that civilization might take adaptation and mitigation (IPCC, 2007).

1.2 Causes of Vulnerability to Climate Conditions in Ethiopia

Causes for vulnerability of Ethiopia to climate variability and change include very high dependence on rain fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, lack of awareness, etc. Vulnerability assessment based on existing information and rapid assessments carried out under NAPA has indicated that the most vulnerable sectors to climate variability and change are Agriculture, Water and Human health. In terms of livelihood approach smallholder rain-fed farmers and pastoralists are found to be the most vulnerable. The arid, semiarid and the dry sub-humid parts of the country are affected most by Drought (Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia, 2007).

1.3 Objectives

To review climate change mitigation and adaptation mechanisms/strategies

2. CLIMATE CHANGE ADAPTATION

Adaptation is adjustment in ecological, social, and economic systems, through changes in processes, practices, and structures, in order to reduce the vulnerability of communities, regions, and activities to climatic change, variability, and extremes (Smit and Pilifosova, 2001). Climate adaptation refers to the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007).The components of adaptive capacity, identified in Smit and Pilifosova (2001), are economic resources (assets and finance), technology (options), information and skills (knowledge about options, capacity to assess options, ability to implement options), and institutions (governance and entitlements).

Three levels of the spatial scales for climate change adaptation, identified by Smit and Pilifosova (2001), are:- Global level (cooperation between industrialized and developing countries, support from global research institutions and policy facilitation, funding and monitoring, removal of barriers to international trade, and transfer of technology, technical and managerial skills), National level (emphasis on poverty reduction, development policy geared more toward vulnerable sectors, support adaptation at local or community levels including the private sector, set up systems for monitoring and communication, pursuit of sustainable economic growth, development of adaptive technologies and innovations), and Local level (establishment of social institutions, prevent marginalization of sections of population, encouragement of diversification of income sources, risk-spreading, provision of knowledge, technology, and financial support).

2.1. Climate change adaptation in context of development and rural livelihoods

Adaptation to climate change in the context of development has been much discussed in recent years, with the discourse focusing primarily on whether adaptation is part and parcel of the development process in developing countries (IPCC 2001; Adger et al. 2003; Holmelin and Aase 2013). It has been argued that it is impossible to separate adaptation from development (Cannon and Muüller-Mahn 2010). Rural communities are mostly dependent on ecosystem services such as water, forest products, grass, and fodder for livestock, fisheries, for their livelihoods, although the priority ecosystem services may vary depending on different interest groups (Paudyal et al. 2015).

2.1.1 Climate Change Mitigation through Forestry

The increasing emissions of greenhouse gases (GHG), including carbon dioxide (CO2) is contributing to global climate change. In order to combat this trend, the 1997 Kyoto Protocol of the United Nations Framework Convention on Climate Change (FCCC) requires developed countries to reduce their aggregate greenhouse gas (GHG) emissions by at least 5.2% below 1990 levels during the years 2008-2012. One of the tools for reducing the release of carbon dioxide (CO2), the largest component of GHG emissions, is carbon sequestration the accumulation of carbon in terrestrial forms.

The burning of fossil fuels is the main reason for increasing CO2 emissions, but such energy conversion has been accompanied by deforestation in tropical latitudes. There are three methods to sequester carbon through forestry: carbon conservation, carbon-substitution, and carbon sequestration and storage. Carbon conservation seeks to maintain existing carbon pools in forests by limiting deforestation, preserving forests, and instituting improved management methods. Carbon sequestration and storage expands the storage of carbon in forest ecosystems through afforestation (establishing forest on land never forested or not forested for a very long time), reforestation (planting trees in areas where trees had recently been before, but are currently absent), urban forestry4 (planting in urban or suburban settings), and agroforestry (planting and managing trees in conjunction with agricultural crops). Carbon substitution aims at increasing the use of forest biomass as a substitute for fossil fuels and fossil-fuel products (Nilsson and Schopfhauser, 1995; Sedjo, Sohngen, and Jagger, 1998; Vine, Sathaye, and Makundi, 1999).

Carbon trading could contribute to mitigating climate change and thus relieve exposure, finance adaptation and development, and conserve the resource base of food security. Extensive carbon trading between the industrial and developing world would be a way to buy the required time to make the changes in the North, and to trigger climate-friendly development in low-income countries. In fact, global carbon trading perhaps represents the only realistic option to maintain the increase in global mean temperature below critical limits (WBGU, 2009).

The linkages between forests and adaptation are two-fold. First, adaptation is needed for forests to maintain their functioning status (adaptation for forests‘). Forests are vulnerable to climate change and implementing forest adaptation measures can reduce the negative impacts (Locatelli, et.al, 2008). Second, forests play a role in adaptation of communities and the broader society (forests for people‘s adaptation‘). Forest ecosystems contribute to adaptation by providing local ecosystem services that reduce societies ‘vulnerability to climate change (Vignola, et.al, 2009). It is increasingly recognized that well-managed ecosystems can help societies to adapt both to current climate hazards and to future climate change by providing a wide range of ecosystem services (Turner, et.al, 2009).

Table 1 Mean growth stock and annual increments of forest categories of Ethiopia (m3 ha - 1)

FOREST CATEGORY	GROWTH STOCK/FREE-BOLE VOLUME/ (M^3 HA^{-1})	MAI (M^3 HA^{-1} YR^{-1})
High forest	131.5	5.65
Woodland	21.0	0.79
Plantation	178.8	12.5
Lowland bamboo	26.0	1.3
Highland bamboo	83.0	3.9
Shrubland	14.9	0.5

Source: WBISPP (2005) and Sisay et al. (2009). Growth stock and MAI calculated based on weighted averages of sub - categories of a main forest category.

Table 2 Mean aboveground carbon density and total carbon stocks in major forest categories of Ethiopia

FOREST CATEGORY[2]	FREE-BOLE BIOMASS (TONS HA^{-1}) (A)	BEF (TONS HA^{-1}) (B)	AGB C (TONS HA^{-1}) (A*B*0.5*)	AREA (MILLION HA)	TOTAL C STOCK (MILLION TONS)
High forest	131.5	2.74	106.68	4.07	434.19
Woodland	21.0	6.9	42.75	29.55	1,263.13
Plantation	178.8	2.33	123.0	0.50	61.52
Lowland bamboo	26.0	6.19	47.5	1.07	50.80
Highland bamboo	83.0	3.44	84.23	0.03	2.53
Shrubland	14.9	8.20	36.04	26.40	951.54
Total C					2,763.70

Source: Assuming the carbon content of green wood is approximately 50% of the biomass (WBISPP, 2005). C is calculated based on the formula developed by Brown, 1997. AGB = Aboveground biomass. BEF = Biomass expansion factor.

2.1.2 Adaptation through agricultural sectors

According to Nyong (2005) several of the Africa economies depend directly on agriculture, adaptation strategies adopted include: adjustments to planting dates, changes in fertilization, irrigation applications, cultivar traits, selection of animal species, recourse to indigenous knowledge, mixed farming and multiple cropping, and, reduced utilization of marginal lands, agro forestry with mitigation benefits, limited early Warning Systems and livelihood diversification.

Agro-forestry is a practice of increasing tree cover on agricultural or pasture lands. The establishment of Agroforestry in marginal croplands offers significant potential to sequester carbon and improve the resilience of the agro-ecosystem to extreme events. The high carbon sequestration potential of agro forestry stems from the potentially large land area (several hundred million hectares) to which land-use modifications to accommodate agro-forestry is possible. These include degraded pastures, semi-arid cereal systems, secondary forest fallow, and low quality grasslands (Roshetko, Lasco, and de Los Angeles, 2007).

Agro-forestry has the greatest productive potential in humid/sub humid zones at the margins of secondary forests (Albrecht and Kandji, 2003). It has also proven critical for restoring degraded lands and managing climate risk in semi-arid environments, most notably in the recovery of agricultural lands from long-term drought, Agro-forestry has been identified as a preferred adaptation strategy in recent assessments of adaptation options, such as that by Thomas and others (2005) for a semi-arid climatic zone.

Climate change has direct effects on livestock productivity as well as indirectly through changes on the availability of fodder and pastures. Climate determines the type of livestock most adapted to different agro-ecological zones and therefore the animals that are able to sustain rural communities. Climate change is expected to affect livestock at the species level. Climate changes will also affect nomadic and transhumant livestock keepers (Hahn and Morgan 1999, cited in IPCC 2001).The forestry resources are most crucial means of adaptation to forest dependent people whose lives have been depending on it (FAO, 2007). If long duration of drought persists, definitely affect to rain-fed agricultural system. In this situation, people can collect the edible fruits, roots and leaves for their life survival.

2.1.3 Indigenous knowledge in mitigation and adaptation

African communities and farmers have always coped with changing environments. They have the knowledge and practices to cope with adverse environments and shocks. The enhancement of indigenous capacity is a key to the empowerment of local communities and their effective participation in the development process (Leautier, 2004). It is likely that climate change will alter the ecology of disease vectors, and such indigenous practices of pest management would be useful adaptation strategies.

Other indigenous strategies that are adopted by local farmers include: controlled bush clearing; using tall grasses such as Andropogon gayanus for fixing soil surface nutrients washed away by runoff; erosion-control bunding to reduce significantly the effects of runoff; restoring Africa lands by using green manure; constructing stone dykes; managing low-lying lands and protecting river banks (Agrhymet, 2004).

Adaptation strategies that are applied by pastoralists in times of drought include the use of emergency fodder, culling of weak livestock for food, and multi-species composition of herds to survive climate extremes. During drought periods, pastoralists and agro-pastoralists change from cattle to sheep and goat husbandry, as the feed requirements of the latter are lower (Seo and Mendelsohn, 2006). The pastoralists' nomadic mobility reduces the pressure on low-capacity grazing areas through their cyclic movements from the dry northern areas to the wetter southern areas of the Sahel.

African women are particularly known to possess indigenous knowledge which helps to maintain household food security, particularly in times of drought and famine. They often rely on indigenous plants that are more tolerant to droughts and pests, providing a reserve for extended periods of economic hardship (Ramphele, 2004; Eriksen, 2005). In southern Sudan, for example, women are directly responsible for the selection of all sorghum seeds saved for planting each year. They preserve a spread of varieties of seeds that will ensure resistance to the range of conditions that may arise in any given growing season (Easton and Roland, 2000).

Traditional and contemporary coping mechanisms to climate variability and extreme in Ethiopia include changes in cropping and planting practices, reduction of consumption levels, collection of wild foods, use of inter-household transfers and loans, increased petty commodity production, temporary and permanent migration in search of employment, grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land, credit from merchants and money lenders, use of early warning system, food appeal/aid, etc (Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia, 2007).

2.1.4 Adaptation through Insurance

One method of climate adaptation is the encouragement of individual actions to mitigate, spread, or transfer the risk of damages. Specifically, one existing tool is insurance, for either general catastrophe or actual flooding. The idea is to allow for reactive options to rebuild communities after adverse impacts from extreme weather events. Although it can be preferable to take a proactive approach to eliminate the cause of the risk, reactive post-harm compensation can be used as a last resort (IPCC, 2001).

2.2 Mitigation

The IPCC defines mitigation as actions intended to reduce anthropogenic net emissions of GHGs (2007). Generally, this net reduction can occur in two ways through decreased outputs or through carbon capture. Common forms of decreased GHG output include using renewable energy sources that eschew the burning of fossil fuels (e.g. energy produced by solar panels); lifestyle changes that decrease the overall amount of energy use (e.g. walking instead of driving); and the use of materials that reduce energy needs (e.g. improved housing insulation to reduce heating needs).

In comparison, carbon capture includes actions that decrease the levels of existing GHGs such as methane capture at landfills or by decreasing deforestation, thus increasing the rate of photosynthesis.

2.2.1 Forests and Mitigation

Forests can contribute to achieving the UNFCCC‘s ultimate goal of avoiding dangerous interference with the climate system. Mitigation strategies through land use, land use change and forestry (LULUCF) have been defined in a number of UNFCCC Conference of the Parties (COP) decisions as well as by the IPCC (Watson, et.al, 2000). The IPCC LULUCF report distinguishes three types of mitigation activities in the forestry sector (Watson, et.al, 2000.): afforestation (converting long-time non-forested land to forest); reforestation (converting recently non-forested land to forest); and avoided deforestation (avoiding the conversion of carbon-rich forests to non-forested land). Deforestation and forest degradation cause about 17% of global GHG emissions. Reducing deforestation and promoting afforestation and reforestation may provide up to 30% of the cost-effective global mitigation potential (Stern, 2006).

Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forest products for bio-energy to replace fossil fuel use. By 2030, forest mitigation technologies will include: tree species improvement to increase biomass productivity and carbon sequestration. Improved remote sensing technologies for analysis of vegetation and soil carbon sequestration potential, and mapping land-use change (IPCC, 2007).

2.2.2 The Introduction of Alternative and Renewable Energy Options

The links between gender, energy and climate change are context specific and strongly influenced by prevailing socio-economic and environmental factors, which manifests differently across countries, regions, communities, households and individuals(Knox-Hayes et al, 2013). Similarly, individual preferences are influenced by power relations and the social constructs that influence the processes of creating ‘common knowledge’ and collective action (Ishihara and Pascual, 2009). Power relations can result in marginalized individuals, particularly women, being excluded or having limited input in decision making processes within the household, as in the case of energy practices (Ishihara and Pascual, 2009).

According to Cherni et al (2007), the gender differences in energy practices and preferences within households can be used in energy policy and the development of technology, which may improve on uptake. Von Borgstede et al (2013) assert that people are more likely to adopt environmentally- friendly behaviors when costs are minimized, emphasizing importance of attitudeson energy profiles. Yet, awareness and attitudes alone do not alter people’s energy behavior as these decisions are a product of social processes, for example, socio-technical systems and the collective transformation processes driving climate change and energy policy (Wilson and Dowlatabadi, 2007). Prevailing social norms and material culture contribute to shaping individual choice and understanding of technologies and energy practices (Stephenson et al, 2010). Scholars such as Kok et al (2011) claim that understanding the relationship between technology and human behavior is key in changing people’s desired energy choices, however, policy often neglects the non-financial influences which are essential in relation to successful energy policy.

Energy efficiency and utilization of renewable energy offer synergies with sustainable development. Energy substitution can lower mortality and morbidity by reducing indoor air pollution, reduce the workload for women and children and decrease the unsustainable use of fuel wood and related deforestation. Renewable energyis obtained from the continuing or repetitive currents of energy occurring in the natural environment, and includes non-carbon technologies such as solar energy, hydropower, wind, tide and waves, and geothermal heat, as well as carbon neutral technologies such as biomass.

Mitigation options in the energy sector may be classified into those that improve energy efficiency and those that reduce the use of carbon-intensive fuels. The latter may be further classified into domestic and imported fuels. IPCC (2007) reported that in the buildings sector, energy efficiency options may be characterized as integrated and efficient designs and siting, including passive solar technologies and designs and urban planning to limit heat island effect. Considering energy efficiency as the guiding principle during the construction of new homes results in both reduced energy bills -enhancing the affordability of increased energy services- and GHG abatement.

In the transport sector, the energy efficiency measures may be categorized into those that are vehicle specific and those that address transportation planning. Vehicle-specific programs focus on improvement to the technology and vehicle operations. Planning programs are targeted to street layouts, pavement improvements, lane segregation, and infrastructural measures that improve vehicle movement and facilitate walking, biking and the use of mass transport. Cost-effective mitigation measures of both types have been identified that result in higher vehicle and/or trip fuel economy and reduce local air pollution. Institutionalizing planning systems for CO_2 reduction through coordinated interaction between national and local governments is important for drawing up common strategies for sustainable transportation systems (IPCC, 2007).

In the industrial sector, energy efficiency options may be classified as those aimed at mass-produced products and systems, and those that are process-specific. The potential for cost-effective measures is significant in this sector. Measures in both categories would have a positive impact on the environment. To the extent the measures improve productivity; they would increase economic output and hence add to government tax revenue. Higher tax revenue would benefit national, state and local government fiscal balance sheets (Nadel et al., 1997; Barrett et al., 2002; Phadke et al., 2005; IPCC, 2007).

Another policy response to climate change, known as climate change mitigation (Verbruggen, 2007) is to reduce greenhouse gas (GHG) emissions and/or enhance the removal of these gases from the atmosphere (through carbon sinks). Even the most effective reductions in emissions, however, would not prevent further climate change impacts, making the need for adaptation unavoidable (Klein et al., 2007).

In a literature assessment, Klein et al. (2007) assessed options for adaptation. They concluded, with very high confidence, that in the absence of mitigation efforts, the effects of climate change would reach such a magnitude as to make adaptation impossible for some natural ecosystems. For human systems, the economic and social costs of unmitigated climate change would be very high.

2.2.3 Innovative Financing for Carbon and Biodiversity

REDD+: reduction of emissions from deforestation and forest degradation; promotion of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries. However, some other meanings given to the acronym have been accepted; for example, the one linking financial incentives to forest protection and reduction of deforestation and degradation (Hall, 2008; Leach, 2008; Nasi et al., 2009) Causes for vulnerability of Ethiopia to climate variability and change include very high dependence on rain fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, lack of awareness, etc.

Vulnerability assessment based on existing information and rapid assessments carried out under NAPA has indicated that the most vulnerable sectors to climate variability and change are Agriculture, Water and Human health. In terms of livelihood approach smallholder rain-fed farmers and pastoralists are found to be the most vulnerable. The arid, semiarid and the dry sub-humid parts of the country are affected most by drought.

3. CONCLUSION

Rising global temperatures have been accompanied by changes in weather and climate. Many places have seen changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. The planet's oceans and glaciers have also experienced some big changes - oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising. As these and other changes become more pronounced in the coming decades, they will likely present challenges to our society and our environment.

Climate change, biodiversity and forest loss are issues inextricably interlinked and need to be addressed simultaneously. Climate is the fundamental factor that determines different stages of the organism life-cycle, such as plant germination and flowering. It can severely alter habitats and food sources for animals, and ultimately, could have significant impacts on biodiversity of species and ecosystems around the world. Climate change will have a number of impacts on biodiversity, from ecosystem to species level. The most obvious is the effect that flooding, sea level rise and changes in temperature will have on ecosystem boundaries. Habitats will change as rainfall and temperatures change, and some species will not be able to keep up, leading to a sharp increase in extinction rates. The challenge of confronting the impacts of climate change is often framed in terms of two potential paths that civilization might take that are adaptation and mitigation.

Human-induced climate change has contributed to changing patterns of extreme weather across the globe, from longer and hotter heat waves to heavier rains. The only solution to climate change is to slow the flow, to stop altogether, and re-absorb greenhouse gas emissions. Many solutions have been suggested, such as cap and trade systems, carbon capture and storage, renewable energy, and geo-engineering. Likely a combination of all of these solutions must be tried if we are to protect our planet from the most severe predicted effects of climate change. In general the more mitigation there is, the less will be the impacts to which we will have to adjust, and the less the risks for which we will have to try and prepare. Conversely, the greater the degree of preparatory adaptation, the less may be the impacts associated with any given degree of climate change.

4. FUTURE LINE OF WORK

According to this review the climate change has several negative impact on livelihood resources of community and community themselves generally in Globe and particularly in Ethiopia, due to less capability to adapt the impact. In our review, we have seen the current coping a mechanism of climate change impact is not sufficient because of most of local communities didn't practice this coping mechanism. Therefore, practicing conservation agriculture, developing more diversified livelihood practices, developing community based integrated watershed management practices, experience sharing of best practices through community participation, civil society engagement, and the participation of academic and research institutions, with regular monitoring to identify promising practices for scaling up. The main thing is that, coordinated or integrated involvement of stakeholders in any developmental activities and climate change impact reducing activities that brings green economy to our country.

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