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Influence of climate change on the diversity and distribution of Enset (*Enset eventricosum)* (Welw) Cheesman*)* in Ethiopia: Implication for conservation

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Abstract

The patterns of enset genetic diversity and distribution are crucial for breeding, sustainable utilization and conservation. Different reports depicted that there were a lot of enset diversity having wider and narrow environmental adaptability where majority of them grown in the highland parts of Ethiopia. However, recent study showed the decrement of enset diversity and distribution from growing region by different factors mostly due to climate change which affect directly or indirectly the livelihood of the societies. Climate and agriculture are the two highly interlinked in which one affect the other directly or indirectly. Fluctuation of climate, that is unpredictable rainfall, distribution and amounts of rainfall have serious impact on economic, social and environment which resulted favors of persistence and existence of different diseases and insect pests which constrain enset distribution. One of the countries among the world highly affected by climate change is Ethiopia where its agriculture is fully climate dependent. There were diversified enset types in producing areas of Ethiopia. But, recent efforts conducted on climate related enset diversity revealed that distribution and diversity of enset were in declining rate as compared to previous status mostly due to climate change. So, future effort and emphasis should render in reforming moderate climate and reforesting deforested areas so that the distribution and diversities of ecosystem become reclaim.

Keywords: Climate change, Distribution, Diversity, Enset

Introduction

Enset (*Enseteventricosum* (Welw) Cheesman) (2n=18) is a perennial herbaceous, monocarpic and monocotyledonous crop that belongs to the family *Musaceae* and fruits only once in its life cycle (after 6–10 years) depending on climate and landrace. It is known as Ethiopian banana, Abyssinian banana or false banana due to its morphological resemblance with banana (Bekele *et al.,* 2013).

Musa families are widely distributed from eastern edge of great African plateau, extending northwards from South Africa through Mozambique, Zimbabwe, Malawi, Kenya, Uganda and Tanzania to west of Congo, being found in rainforests on mountains, and along forested ravines and streams. However, the genus ensete under Musa family domesticated in Ethiopia 8000 years ago with the area encompassing more than 80% of the enset production of the country (Abraham *et al.,* 2012). Enset is widely distributed and cultivated in south and southwestern part of Ethiopia and covers considerable land area within the private holdings (Figure 1). A total of 312,171.98 hectares of land was covered by enset. The number of enset trees to be harvested, in the current agricultural year, from all over the country is estimated to be 112,522,152. Thus, the total produce in the form of *amicho, kocho,* and *bulla* is 23,821,849.47 quintals, 28,329,103.94 quintals and 950,414.35 quintals respectively. Thus, enset has a strategic importance in the agricultural sector based on its contribution to food security and import substitute (Brandt *et al.,* 1997). It is a traditional staple crop for about 20 million of the population of the people living in the densely populated regions of South and Southwestern Ethiopia. It also used for livestock feed in the dry season, construction materials, and containers, medicinal and ornamental (Shigeta 1990; Tewodros and Tesfaye, 2014). In many enset growing areas, farmers described enset as their food and economic source, cloth, house, bed, feed and plate (Brandt et al., 1997). The corm and the pseudo stem are the most important sources of food (Kefale and Sandford, 1991; Neim et. al, 2017). The major food types obtained from enset are kocho, bulla and amicho. Enset fiber is used for making bags, ropes, twines, cordage, and mats.

Enset is grown at altitudes from 1500-3100 m.a.s.l, but scattered plants can also be found at lower altitudes. For optimum growth, the plant requires an average rainfall of 1100-1500 mm per yearand a mean temperature of 16-20 °C'. Enset grows well in most soil types, provided they are sufficiently fertile and well-drained. The ideal soils are moderately acidic to alkaline (p^H 5.6 to 7.3) with 2-3% organic matter (Rao and Hodgkin, 2001). The influence of climate change on diversity and distribution of enset is the most pressing questions in ecology and biodiversity conservation. The presence and distribution of enset wild relatives is closely related to their growing climate requirement (Parmesan and Yohe, 2003).

Enset diversity and distribution may be described by the genetic makeup of the crop and growing environment (Rao and Hodgkin, 2001), as a result of human factors, cultural, population pressure, ecological variation or interaction between genetic and environmental factors as well as household resources (Admasu and Struik, 2001). Currently climate change poses huge challenges to the global economy and social development. Its impacts will disproportionately affect sub-Saharan African countries such as Ethiopia because their economies are highly dependent on rain-fed agriculture. In Ethiopia, climate change and associated extreme events are causing significant damage to life, property, natural resources and the economy by affecting climate sensitive sectors such as agriculture (Yohannes, 2016).

In Ethiopia, agriculture contributes about 47% of the country's Gross Domestic Product (GDP) and more than 70 million people (85% of the Ethiopian population) depend on agriculture directly or indirectly for their livelihoods. Therefore, any effect on agriculture will significantly affect the Ethiopian economy. Smallholder farmers in Ethiopia have been facing severe climate related hazards, in particular highly variable rainfall and severe droughts that negatively affect their livelihoods. Anticipated climate change is expected to aggravate some of the existing challenges and impose new risks beyond the range of current experiences.

It is predicted that changes in climate will lead to recurrent droughts and heavy rainfall in different parts of the country, reducing the amount of land that can be used for agriculture and decreasing crop productivity Yohannes (2016). Enset diversity and distribution in Ethiopia is done; but is more or less of morphological and ethnic based (Neim et. al., 2017). Climate change based diversity and distribution is not well addressed in Ethiopia. Besides, the influence of climate changes on diversity and distribution of enset in Ethiopiais yet to be studied before.

Besides, the diversity and distribution of farmers named enset clones throughout agro ecological zones have never been assessed and that limited researchers' access to impact of climate change on enset genetic resources in the country (Admasu, 2002; Maguleet *al*., 2014). Previous study on-farm diversityand distribution of enset in associated with climate change in Southern Ethiopia (Admasu, 2002; Magule et al., 2014; Yemataw et al., 2017) confirmed the presence of significant genetic diversity and distribution of enset in Wolayita, Gamogofa zones and southern region of Ethiopia. Nevertheless, the report did not fully cover the other major enset growing areas of the country. Cognizant to these facts, this review is proposed with the following objectives; To review the influences of climate change on diversity and distribution of enset in Ethiopia.

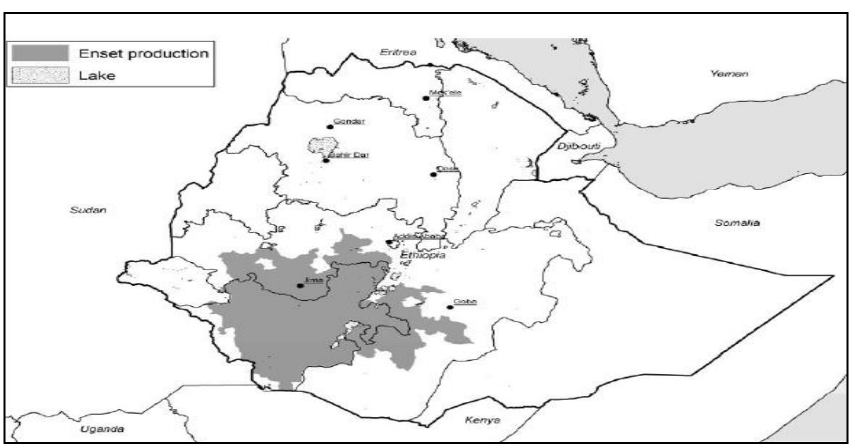

Figure 1. Geographical distribution of enset production in Ethiopia Source Horticulture strategy, 2016

Influence of climate change on Ethiopian agriculture: Ethiopia, located between 3°30’ and 14°50’ northern latitude and 32°42’ and 48° 12' eastern longitude in north-eastern Africa. Its total area is about 1.104,300 km2 with elevations ranging from 125 m below sea level (Danakil depression) to 4,620 meters above sea level (mount RasDejen). While the total population of Ethiopia about 103 million and still grows annually by 3.2% (CIA, 2013). According to the 2012 report of the UN’s world population prospects, the population of Ethiopia is expected to be around 150 million by 2050 (UN, 2013; Belay, 2014). The country is characterized by diverse climatic conditions ranging from humid to semi-arid environments. Mean annual rainfall distribution ranges from a maximum of more than 2,000 mm over the south-western highlands to a minimum of less than 300 mm over the south-eastern and north-western lowlands. The south-west and western areas of the country are characterized by a bi-modal pattern whereas the remaining parts exhibit a uni-modal rainfall pattern (World Bank 2006). The mean annual temperature varies widely, from lower than 15°C in the highlands (>1500 m.a.s.l.) to more than 25°C in the lowlands (< 1500 m.a.s.l.).

Agriculture is the main source of livelihood for about 85% of Ethiopia’s population. The sector contributes 50% of the GDP and generates more than 80% of the foreign exchange earnings (Deressa and Hassan, 2009). It is dominated by small scale crop-livestock mixed fanning systems and cereals are the most important food a crop occupying about 77% of the total cultivated area.This type of sector is highly influenced by climate change and new biotypes emerged presently. Climate variability, particularly uneven distribution of rain falland associated droughts have been causes for food insecurity in Ethiopia (Seleshi and Zanke, 2004; Rosell, 2011). Climate change is expected to pose more challenges and to further reduce the performance of the economy (Arndt et al., 2011). A study on mapping poverty and \ vulnerability in Africa identified Ethiopia as one of the country’s most vulnerable to climate variability and change (Thorntonet al., 2006). Climate and agriculture are highly interlinked, and one affects the other in many ways. Agriculture is an economic activity that is highly dependent upon weather and climate in order to produce the food and fiber (other products) necessary to sustain human life. Not surprisingly, agriculture is deemed to be an economic activity that is expected to be vulnerable to climate variability and change. Climate change is expected to have serious economic, social and environmental impacts in Africa in general and sub-Saharan Africa in particular Yohannes (2016).

Climate change affects agriculture in a number of ways; including through changes in average temperatures; rainfall and climate extremes with an important impact on soil erosion (i.e. floods, drought, etc): changes in pests and diseases, changes in atmospheric carbon dioxide, changes in the nutritional quality of some foods, changes in growing season, and changes in sea level. Ethiopia is one of the most vulnerable countries to climate variability. The agriculture sector which contributes more than 45% of GDP, 80% to labor force and 85% to foreign exchange earnings is highly susceptible to climate change. More than 95% of crop production which is rainfall dependent has been produced by small holders and subsistent farmers who have less capacity to adaptation of climate change (MoFED, 2006).

From African countries, Ethiopia is one of the most at risk from climate change impacts on agricultural productivity and food security. Evangelista *et al., (*2013) reported that its low adaptive capacity, geographical location and topography make the country highly vulnerable to the adverse impacts of climate change. In addition, dependency of most population on climate sensitive sectors for livelihood i.e. worsens Ethiopia‘s vulnerability to the impacts of climate change. Over the last decades, the temperature in Ethiopia increased at about 0.2°C per decade, on the other hand, precipitation remained fairly stable over the last 50 years when averaged over the country. However, the spatial and temporal variability of precipitation is high UNEP (2011). IPCC (2007c) also reported that farmers living in Ethiopia‘s semi-arid and arid lowlands that have less diversified assets and are heavily reliant on rain-fed agriculture are, along with their livestock, particularly vulnerable to climate change. It is estimated that the 1984-85 climate induced drought reduced Ethiopia‘s agricultural production by 21 percent, which led to a 9.7 percent fall in the GDP. World Bank (2006) also point out that climate variability and change in Ethiopia has significant impact in different crop yield. In Ethiopia, climate change and associated extreme events are causing significant damage to life, property, natural resources and the economy by affecting climate sensitive sectors such as agriculture (Kinde *et al.,* 2016). The IPCC‘s fifth report indicates that future climate change will lead to an increase in climate variability and in the frequency and intensity of extreme events in Africa including Ethiopia. The changing rainfall pattern in combination with

warming trends could make rain fed agriculture more risky and aggravate food insecurity in Ethiopia.
In Ethiopia, the annual temperature has rapidly increased in the last five decades. The mean annual temperature rose by 1.3°C or by 0.28 °C per decade during 1960-2006. The frequencies of hot days and nights have also showed an increasing trend during these years. While the average number of cold days' has decreased by 5.8% between1960-2003, the average number of cold' nights per years has decreased by 11.2% (UNDP, 2008). In the coming 100 years, the average temperature in Ethiopia has projected to increase from 23.08 oC during 1961-1990 to 26.92oC in 2070-2099 (World Bank, 2008(fig 1). However, significant temperature difference is there among different parts of the country. These extreme temperatures constrain crop production by limiting water availability and growth of many plants (Temesgen *et al.,* 2007).

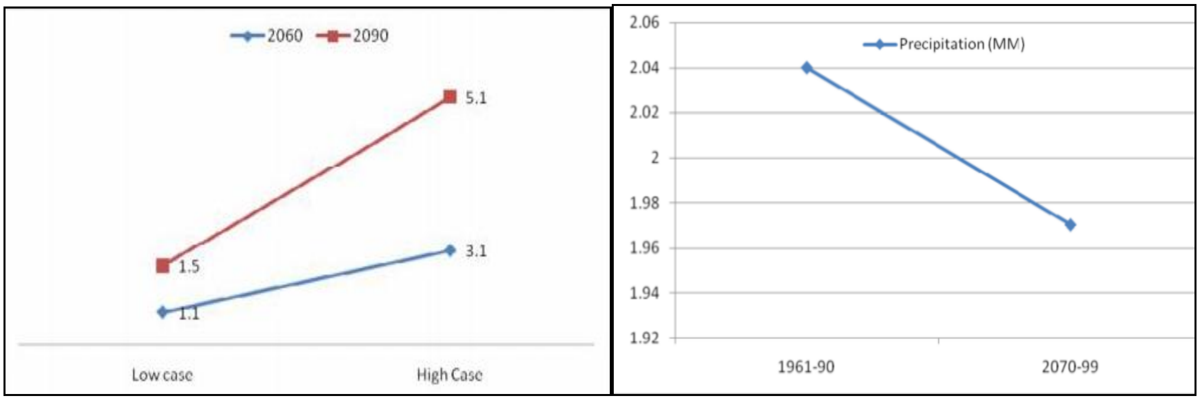

Figure 2. Seasonal precipitation in Ethiopia Source: (Assefa et al., 2006)

Not only distribution but also the variability of the rain is also the consequences of climate change in Ethiopia. According to Agricultural economists, rainfall variability greater than 30 is risky for farmers who depend on crop production which is prevalent in most parts of Ethiopia (NAPA, 2007). Annual rainfall considerably decreases towards the eastern lowlands which is source of low crop production. Rainfall is distributed differently in Ethiopia. It has both spatial and seasonal nature as the following figure shows. Few highlands in the West get rainfall for most of the months of the year (May-October). Rainfall variability measured by coefficient of variation shows most part of the country has rainfall variability with about 31-50 (Figure 2)

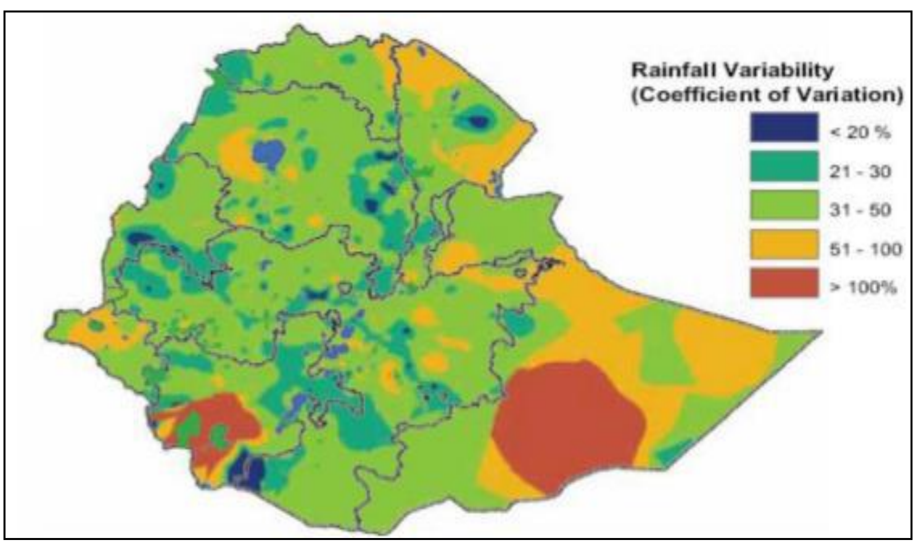

Figure 3. Rainfall Variability in Ethiopia Source: (NAPA, 2007)

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

In another case Sea-level rise is an inevitable consequence of a warming climate owing to a combination of thermal expansion of the existing mass of ocean water and addition of extra water owing to the melting of land ice (Pfeffer *et al.,* 2008). This can be expected to eventually cause inundation of coastal land, especially where the capacity for introduction or modification of sea defenses is relatively low or non-existent. Regarding crop productivity, vulnerability is clearly greatest where large sea-level rise occurs in conjunction with low-lying coastal agriculture.

Enset diversity and distribution in Ethiopia: Ethiopian highlands are center of origin for enset. Reports of landrace diversity in enset are numerous. Negash (2001) reported that farmers maintain and enrich the diversity of enset, and select or classify clones for various uses. Admasu (2002) identified enset clones from three zones; 52 clones from Sidama, 55 clones from Walayita and 59 clones from Hadiya. Moreover, Buzuayehu and Ludders (2003) 86 enset clones in the south and southwestern part of Ethiopia, respectively. Yemane and Fasil (2006), in their survey conducted at Keffa zone in two districts namely, Chenna and Decha 42 different enset varieties were identified. Melesse *et al.* (2014), characterize 111 enset clones based on quantitative and qualitative traits as well as use value it contributes. Temesgen *et al*. (2014) conducted survey in Wolaita zone and recorded 67 enset clones; of which 31 clones from lowland and 52 clones from high and mid-land area. Genet (2004) identified 111 enset clones from nine growing area of Ethiopia.Zerihun *et al.,* (2014) identified 218 enset diversities in eight zone of SNNPRS. Awole *et al*. (2014) identified 312 enset clones from eight zones in southern Ethiopia. Amare and Daniel (2016) recorded 61, and Tesfaye (2002) reported 79 enset clones in Sidama Zone, Southern Ethiopia. Recently, Neim et al., (2017) reported names of 99 enset clones in the Sheka zone southwestern Ethiopia. The result revealed that in each peasant association; enset clones were varied ranging from 2 to more than 50 clones.

Influence of climate change on enset diversity and distribution: Globally, biodiversity is being lost and increasingly threatened through a range of anthropogenic actions. The most important notable drivers behind the current loss of biodiversity are habitat modification, overexploitation, climate change, invasive alien species, and chains of extinction, known collectively as the evil five biodiversity threats (Barlow *et al.,* 2018). Ethiopian farmers are facing severe consequences because of climate changes, and the majority population of Ethiopia is especially vulnerable to climate change impacts. Diversity disturbance of enset is of the influences of climate change. In broad sense, proper agro-ecology for production of enset is highland area within a range of 1800-2500 m.a.s.l (Neim *et al*., 2017 and Tamre, 2017).

Table 3. Enset clones diversity expressed in richness, evenness and unique clones to each district with respect to their elevation.

Districts	Richness	% ge share	H’	E=H’/lns	1-D	No. of unique clone	Elevation
Masha	69	77	3.78	0.89	0.970	14	1800-2700
Andiracha	65	72	3.68	0.88	0.967	12	1500-2500
Yaki	23	26	2.62	0.84	0.910	5	900-2000

NB: H=Shannon diversity index, E=Evenness, 1-D=Simson’s diversity index

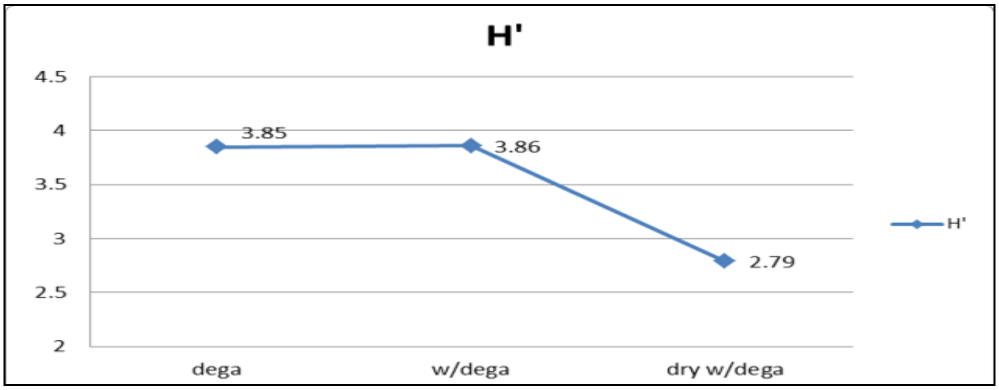

Figure 4. Shannon diversity index of enset in different AEZs. Source: Sources; Semman *et al*. (2017)

But, global climate changes are contributing the decrement of enset diversity and distribution due to increasing temperature. In line with this idea, recent evidence obtained from the survey study conducted in repository of enseti. eSheka zone revealed that the climate change shared 9% of the main constraints in enset diversity and distribution in producing areas (Neim *et al*., 2017).

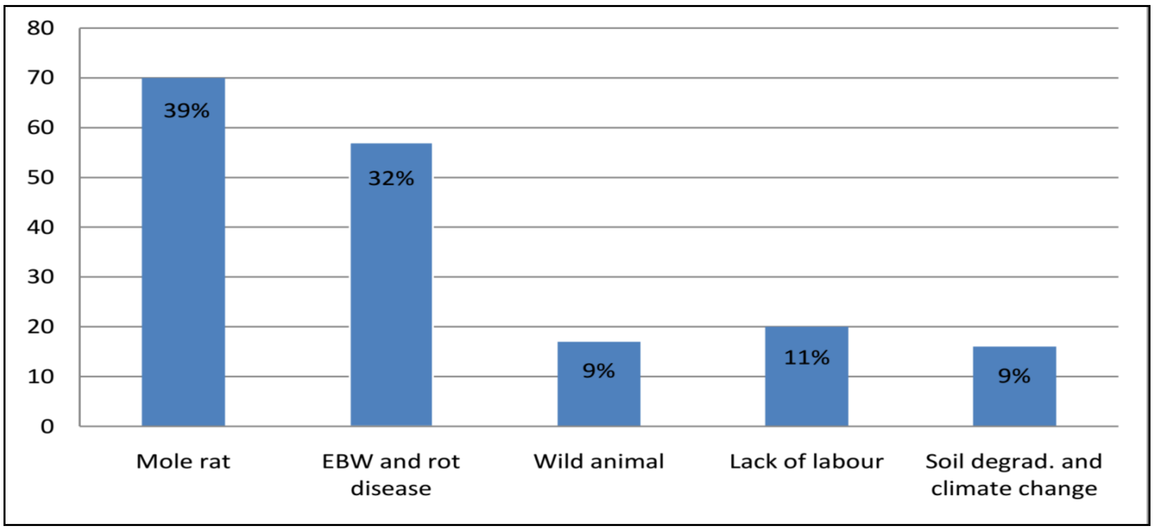

Figure 5. Percent share of factors that decline enset production in Ethiopia. Sources: Neim *et al*. (2017)

Global climate change is often considered as one of the major factors causing biodiversity loss. Recently, study has been reported that landraces of enset declining from time to time guiding into diversity studies which acquire current information on the occurrence, extent, abundance and spatial dynamics of the available diversity which is instrumental for planning and implementation of effective in situ and ex situ conservation strategies (Neim *et al*. 2017).

In the longer period, changing environmental situation, because of climate change and declining farm diversity of landraces are important threats to enset agriculture. Additionally, social change like urbanization, mobility and labor included as enset distribution threats which directly or indirectly lead climate change. Climate change is believed to importantly impact all agricultural systems in Eastern Africa leading in declining and more variable yields. Subsequently, several authors suggested that overall enset landraces declined on farms in Ethiopia (Borrell*et al*., 2019). Declining diversity and distribution of enset clones were the result of Ethiopia's mean annual temperature increased by 1.3^{o}Cbetween 1960 to 2006 where national mean annual temperature is projected to increase by 1.3-3.1^{o}C by 2060 and 1.5-5.1 by 2090 and historical precipitation patterns are less clear due to strong inter-annual and inter-decadal variation (Borrell et al., 2019).

Predictions of climate induced extinction rates are uncertain and expert opinions differ on the extent of loss due to the great deal of uncertainty regarding the number of crop species that exist on earth. For instance, Monzón*et al.,* (2011) found that 19 species have been extinct due to climate change. The International Union for Conservation of Nature Red List of Threatened Species predicted that 4161 species are being threatened by climate change, 33% are at the threatened species.

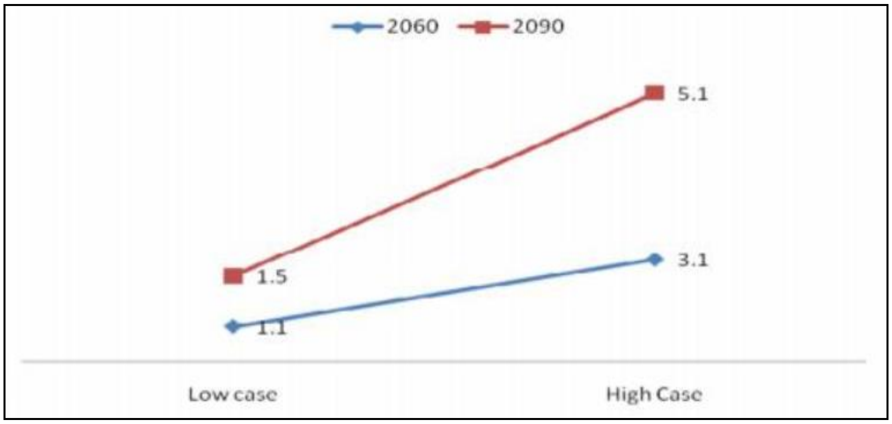

Figure 6.Evolution of average Temperature in Ethiopia. Source: (World bank, 2008)

Gute (2017) portrayed that farmers were facing many risks due to enset vulnerability to biotic and abiotic problems and global climate change. During his survey study, he indicated that almost all informants responded as population of enset was declined in recent times both in abundance and distribution majorly due to drought and climate change enhancing disease and pest persistency. In contrast, enset is in somewhat tolerant to climate change which is resilient to climate alteration (Borrell*et al.*, 2019); some enset varieties were resilient some other varieties were vulnerable to climate change but can grow at the time of stress period than other annual crops (Tamire, 2017). According to him in the last five years different climate related hazards such as drought, flood and erratic rainfall as well as natural fire were some of that occurred.

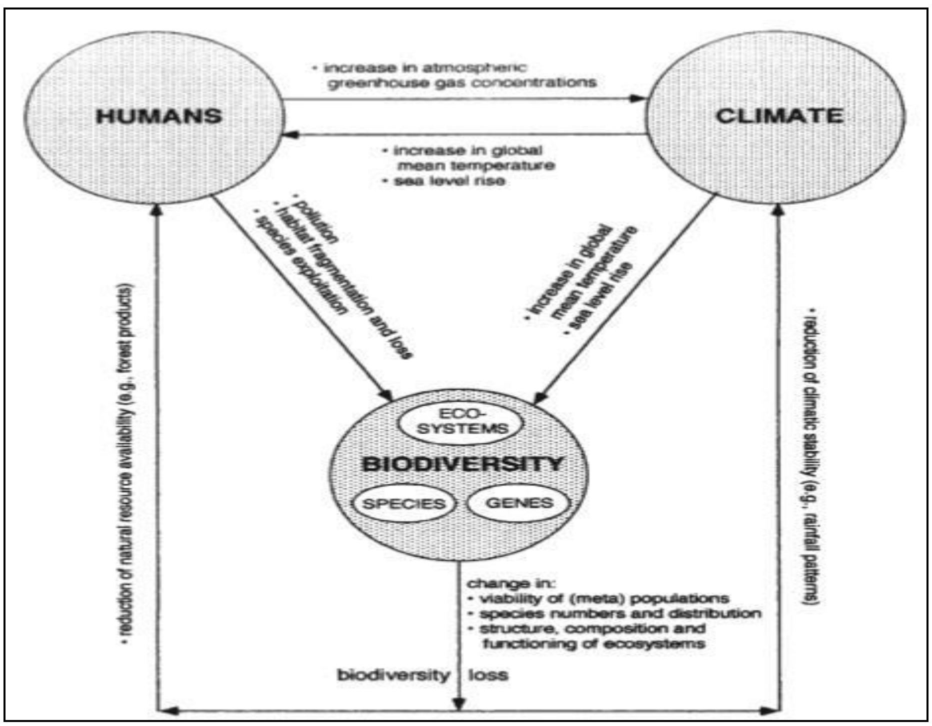

Figure 7.Schematic diagram illustrating the alleged human and climatic forces leading to loss of biodiversity.Source: Kappelle*et al.,* (1999)

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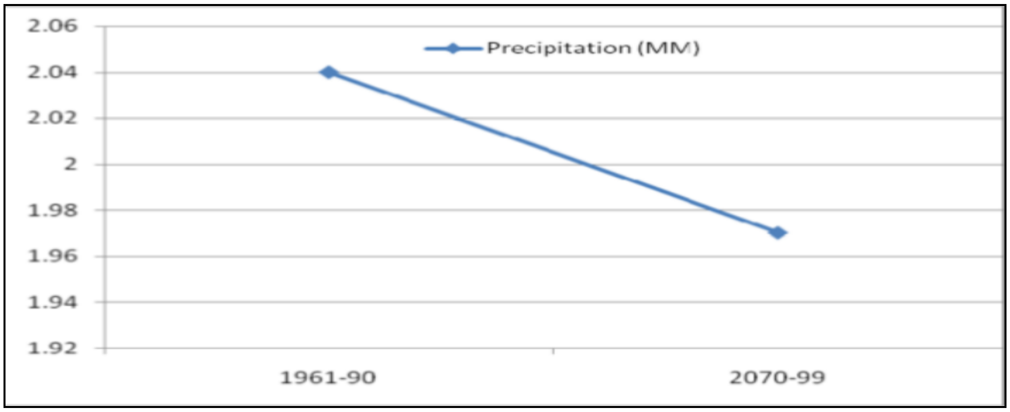

Figure 8: Perception rate over the coming 100 years Source World Bank (2008)

Species distributions are determined by a range of different factors, among which climate is one of the most important ones. It is numerously documented that species have shifted their ranges in response to the climatic fluctuations during the Pleistocene. During the last century, global average temperature has risen by approximately 0.7 °C, due to anthropogenic greenhouse gas emissions. Contemporary climate change has been shown to cause range shifts of species as well as changes in phenology, physiology or morphology (Malcolm *et al.,* 2006). When climatic conditions change, a species can respond by moving, adapting or going extinct. Changes in climate may affect the physiology, phenology and interspecific interactions between individual species, and as a consequence, shifts in geographic distributions may occur. It is acknowledged that the distributions of species and communities are strongly determined by the climatic conditions under which they have developed and climate also controls global patterns of the structure and productivity of vegetation affecting not only the composition of plant and animal species but also aspects such as phenology, migratory processes, and the temporal dynamics of distributional ranges (Rosenzweig et al., 2007).

The presence and distribution of wild species is closely related to their agro climatic requirements and how those requirements are satisfied in various environments. The presence of climate change may threaten the satisfaction of these requirements and thus for the presence and distribution of wild species (Pfeffer et al., 2008). Plant communities at mountain tops have more imposing restrictions by the increase in temperature, as well as a reduction in the available area because the peaks of mountains occupy smaller spaces (Malcolm et al., 2006), Which restrict the migration of species to areas with favorable conditions for their development. Most studies on the impact of climate change on species distributions have shown that species vary greatly in their responses. This heterogeneity in responses reflects differences in the sensitivity of species to climate (Angert et al., 2011). Geographic distribution of biological entities is limited in time and space because of the variation of their tolerance to ecological factors, so they can be successful only in a more or less restricted interval in one environmental gradient. Hence, vegetation in a given place can be related to the influence of several climatic variables. Thus, climate becomes one of themain factors at a regional scale that allows predictions of plant communities distribution patterns (Angert et al., 2011).

The broad conclusion of literature results shows that many species have shifted their geographic ranges in response to rapid changes in temperature and precipitation regimes, generally pole ward, toward higher elevations. (Hopkins et al., 2007) found that in terrestrial environments, plants and animals moved toward higher elevations at the rate of 0.011 km per decade and to higher latitudes at the rate of 16.9 km per decade. Climate change has resulted in dramatic shifts in the geographical distributions of east African species and ecosystems. Climate change has already affected a wide array of taxa (Walther et al., 2002, 2005), causing distributional shifts or even extinctions of plant and animal species and, further, leaving fingerprints'' across ecosystems and biodiversity. Climate change has been reported to force plants to move toward higher elevations and latitudes, and to lead to habitat loss and fragmentation and range contractions of species (Hicklinget al., 2005). These impacts could alter species distributions and biodiversity patterns, and plants' geographical ranges become small and isolated, leading to high risks of extinction.

Species affected by climate change may respond in three ways: change, move or die. Local species extinctions or a rapidly affected ecosystem as a whole respectively might move toward its particular tipping point‖, thereby probably depriving its services to human society and ending up in a global crisis. Climate change may have already resulted in several recent species extinctions. Many speciesranges have moved pole ward and upward in elevation in the last century (Parmesan et al.,2013). Local communities are disaggregating and encompassing more warm-adapted species. Phenological changes in populations, including shifting breeding cycles or deferred peaks of growth periods, are decoupling species interactions. Phenological shifts in flowering plants are potentially initiating the incompatibilities between plant and pollinator population. This may lead to the extinctions of both the plants and the pollinator with expected consequences on the structure of such mutualistic networks (Walther et al., 2002). The multiple components of climate change i.e., temperature, rainfall, extreme events, carbon dioxide concentrations and ocean dynamics are anticipated to affect all levels of biodiversity: gene, species and habitat-diversity. At the very basic level of biodiversity, climate change is able to lessen genetic diversity of populations due to directional selection, genetic drift, population differentiation and rapid migration. As a consequence the probability of population adaptation to new environmental conditions is reduced and thus the risk of extinction increases. Furthermore, altered species compositions and interactions are considered to directly affect ecosystem functioning and resilience (Walther et al., 2002). According to Gute (2017) observed that farmers continue to face many risks because of enset's vulnerability to biotic and abiotic problems due to global climate change which enhance development of new biotic and abiotic problems. From his survey he indicated that almost all informants stated that the population of enset has declined in recent times both in abundance and in distribution. The factors purportedly responsible for this decline were both agriculture and natural (disease and pest) and drought (climate change). Global climate change already had large effects on populations and distributions of species across the globe (Chen et al., 2011) and the shifting distributions and abundances of species will have important consequences for the future of biodiversity (Pachauri et al., 2015).

There are several ways in which species can respond to climate change: adapt, move in different directions in order to track suitable climates, (i.e. towards higher latitudes and elevations, or to the east and west) and go extinct locally, regionally, or, in a worst case scenario, globally (Chen et al., 2011). Changes in geographical distributions of vegetation at the local and regional scales can impact community composition, ecosystem function, and genetic diversity, which can make plants even more vulnerable to on-going environmental change (Parmesan et al., 2013). Climate is one of the determinant factors for species distribution. Species ranges shift due to climate change are determined by: abiotic ally limited relicts in which their distribution and physiological activities is constrained by lack of sufficient environmental variables related to climate change; biotical limited relicts in which biotic perturbations such as competition is minimal for climatic reasons; and biotical sustained relicts which require a host or mutualistic limited to climate change for their existence (Hampe and Jump 2011). Several species are relocated from their native place without human assistance in response to climate change (Parmesan 2006). The range of species and their composition has been changing due to several factors, mainly global climate change.

In general, climate change based declining distributi on of enset is currently observed in Ethiopia. In some part of the country the enset production is shifting to the high land areas due to the changing climatic conditions.

Some of the clones are struggling for tolerance of th e changing environment, while others shift toward higher altitude; the others are unable to with stand the changing climatic condition and are enforced to die.

Conservation strategy: Enset becoming endangered crop in Ethiopia due to climate change. In major enset growing areas farmers named landraces eroded by biotic, abiotic and socio economic reasons. For sustainable utilization of enset genetic resource, development of different strategies such as i) collection of enset genetic resources from major growing areas, ii) morphological and genetic characterization of the resources, iii) promotion of enset diversity with emphasis on production locations where the diversity is high and iv) training and capacity building, particularly on cultivation, management and post-harvest practices are crucial.

Conclusion

Ethiopia is the center of origin and diversity of many important crop species. Enset is the one of food security and economical important crop grown diverse agro-ecologies and having resilient growth habit. Currently, the diversity and distribution of ensetthroughout the growing regions are in declining an alarming rate due to climate change. This dramatic loss of such indigenous genetic diversity in joint with fast population growth will lead to unexpected starvation. So, the future effort should focus on rehearsing the reclaiming way of reforestation.

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