Impact of Crop Diversity on Social Wellbeing and its Future Threats in Ethiopia

Abraha Reda and Mebrahtom Mesfin

Crop and Horticultural Case Team of Mekelle Biodiversity Center, Ethiopia

Abstract: Ethiopia is endowed with a wider range of agro-climatic condition and soil type which is credited for existence of enormous diversity in biological resources. It is considered to be one of the few countries of the world, having biological potential of immense contribution to the development of the country’s agriculture. Crop genetic diversity is the diversity of genetic resource for food and agriculture that grips diversity within and between crops and their wild relatives. Crop diversity plays crucial roles and enables to meet national nutrient, health and socioeconomic demands. Crop diversity improves soil health, enhance yield and farm biodiversity. The growing interest in high input agriculture in Ethiopia together with challenges in agro-ecosystem hastened with population pressure, poor soil management practices and climate change adversely affects current and future conservation of crop diversity. Rapidly increasing Ethiopian population will face fundamental food security challenges due to steadily increasing absolute demand for food and other related goods. Increasing number of population requires increasing in the use of land in multidimensional ways, such as production, homestead and building which often results in the conversion and destruction of natural ecosystems. Potential farmlands for expanding agricultural production is increasingly further being restricted due to competing land uses for biofuel production, urbanization and, in the longer term, climate change. Sustainable crop biodiversity conservation is very crucial to build shock absorbing resilient farming systems and to continue functioning within a set of changing circumstance. Generally providing greater emphasis on ecosystem services delivered by the ecosystem than crop production such as carbon regulation, clean water, soil maintenance and nutrient cycling are equally important in sustainable conservation of agricultural ecosystems.

Key words: Crop Diversity • Ecosystem • Production Stability • Food Security • Social Wellbeing

INTRODUCTION

Ethiopia is endowed with a wider range of agro-climatic condition and soil type which is credited for existence of enormous diversity in biological resources [1, 2]. It is considered to be one of the few countries of the world, having biological potential of immense contribution to the development of the country’s agriculture and various other sectors of development endeavors [3]. According to Vavilov [3] Ethiopia is one of the eight important primary and secondary centers of origin and diversity of many field crop species and their wild relatives serving as a useful sources of gene pool for variable economic traits and resistance genes for biological and physical stress [4]. The large variability in topography, the eco-geographic position of the country, the traditional farming practices over centuries and diverse cultural history of the country has tremendous contribution to hold a high concentration of diverse genetic characters. Thus, the species diversity in Ethiopia is simply observed within a short distance in small sized cultivated land of Ethiopian farmers in a given locality [3].

The diversity is critically crucial for current and future improvement programs in yield, disease resistance and quality enhancement [5]. Cultivated plants are products of human achievement and discovery which enabled man to provide his food and fiber needs with progressively less labor. These crops vary in their nutritional requirements, soil, weather needs and susceptibility to pests. Due to variation in environmental condition, it enables to possess an immense genetic diversity of various crop plants grown in the country. It enhanced chance for both natural and artificial selection that promote evolution of crop plant species under
isolated traditional agricultural settings. This diversity contains its own unique features derived from their variance in genetic and phenotypic characteristics of plants used in agriculture.

The variations may be in terms of seed size, branching pattern, height, flower color, fruiting time, flavor and time of physiological maturity. Maintenance of crop genetic diversity may also attribute to hold crucial characteristics like earliness, pest resistance, nutritional quality, resistance to drought and other stress conditions and characteristics especially useful in low-input agriculture [1]. All the diversities existed in Ethiopia were result of different growing conditions: a crop growing in more fertile soils is longer in height than the one growing in poorer soils. The other important source of diversity can be derived from genetic differences, i.e., a crop may have a gene conferring early maturity or high yielding or drought resistance or disease resistance [1]. Therefore, these heritable traits are special interests as transferred from generation to generation and collectively determines the overall characteristics and future potential of genetic or species diversities.

Today’s agriculture is characterized by a sharpening reduction in crop plant diversity [6]. Of the total 30,000 species of edible plants only 30 species are feeding the world with dominantly by three major crops of maize, wheat and rice [7]. Similarly, interspecific reduction of crop genetic diversity in agriculture is occurred by development of adaptive breeding programs, crop breeding contributes to reduction of intraspecific diversity, selection of best genotypes, the development of genetically uniform varieties and promotion wide range adaptive varieties [6]. Loss of intra and interspecific diversity among the cultivated crops increases risk of crop failure with the outbreak of epidemic pests, abiotic stresses and suffered with specific quality traits.

Maintaining genetic biodiversity has a fundamental contribution to social wellbeing via providing socio-cultural, economic and environmental benefits [8]. Agricultural crop productivity and medicinal crop production are directly dependant on the genetic information contained in different species of crops [9]. Genetic diversity conservation is essential to ensure food security and curb abject poverty for most detriment sections of farming households [10]. Therefore, conserving the genetic diversity of crop on farm level is of fundamental importance: 1) as a means of survival for the world’s rural poor; 2) as a mechanism for buffering against output losses due to emerging pests and diseases, even in fully commercialized agricultural systems; 3) as an input into locally sustainable, indigenous technology systems; 4) as a biological asset for the future genetic improvement on which the global supply of food and agricultural products depends and 5) as a means of satisfying the evolving tastes and preferences of consumers as economy change.

Since the 1960s, breeding activities were focused on the development of high yield staple crop varieties like wheat, maize and rice [11]. The breeding work was technically very successful by developing desired varieties of these crops and finally production and productivity. Even though sufficient food was produced globally for the rapidly growing population, so far since the inception of green revolution in the 1960s, have not been adequately addressed hunger at household level [12]. It was not accompanied with the insufficient staple food production, but it was economic inability to afford input price, lack of means to produce food, suitable land, water and natural resources for detriment poor section of the societies [13]. Green revolution brought a false yield increase with enormous exploitation of farm natural resource bases, focusing on monoculture through externalizing of ecological and environmental costs. The enhancement of yield was resulted from the combination of very few seeds of high yielding varieties, chemical fertilizers, agrochemicals, high subsides and irrigation with unreasonably high priced which is an unsustainable system of production. Similarly, environmental issues in agriculture, increasingly becomes at the fore front of public dispute related to climate change mitigation, biodiversity conservation, sustainable use of water resources and protection of cultural landscapes with varied ecosystem services.

Feeding the ever increasing population requires increasing staple food production in a sustainable manner so as to curb the degradation of farm ecosystem, ecosystem functions, lose of natural resources and biodiversity. In the future, the focus will be paid in building a more resilient, flexible and diversified production system, both at the national and regional level given the unpredictability and severity of farm biodiversity changes. Effectively addressing of poverty and hunger nationwide demands ecological intensification achieved via improving performance ecological service both at crop and soil biota level to sustain synergism. Largely, it can be achieved with the use of locally adapted farm varieties and farmers controlled biodiversity founded on practices and a system of traditional agriculture.
Varietal diversity maintenance on the farm has gained attention as a means for halting production hazards and ensuring food security at poor households with limited opportunity for warranty and trade [14].

The geographic and socioeconomic diversity of Ethiopia by itself is an opportunity for preservation of heterogeneous crops certainly on the farm, however, existing genetic and cultural diversity together with the traditional agricultural schemes are threatened by many factors and forces. These include, modern agricultural technologies making use of high yield varieties and genetically uniform crops. Hence, agricultural policy of the country is mainly concerned with final output and becomes a major bottleneck for sustainable maintenance of crop diversity on the farm. The strategies in the policy were focused on increasing of agricultural productivity through irrigation, application of chemical fertilizer; improve access to farm implements, exploitation of improved seeds and diversification of production system [15-17]. The diversification is based on specialization on some commodities at the ecological level than species diversity. The overall agricultural production practice in Ethiopia in the past is believed to be declining ecological services in many parts other than food, feed and fiber.

Relatively rising productivity and improving the well-being of the society will remain a fundamental challenge given the socioeconomic condition of Ethiopia masses in the future. The main body of the article considers the importance of genetic diversity, the issue of social well-being, food security and impact of crop diversity in agro-ecology and food security in Ethiopia.

**Crop Diversity and Soil Health:** Soil is a very dynamic living entity with its normal state is crucial for staple crop production, fiber crop production and ecosystem functioning having with a unique balance among physical, chemical and biological properties [18,19]. It is an important ecological niche for different microbial communities in the crop rhizosphere [20]. Even though, living organisms occupied around 5% of total available space in the soil, but it is considered as a storehouse of microbial activities [19]. Soil health is the capacity of the soil to function sustainably as the imperative living entity recognized by containing of biological organisms that are very crucial for ecosystem functioning within natural or managed biodiversity boundaries to sustain biological activities, maintain plant and animal productivity, preserve or enhance water and air quality, support human health and habitation [18, 21, 22].

Crop production is usually practiced at the expense and exploitation of soil natural resources such as biological, chemical and physical resources [23]. The physical condition of the soil is the medium for crop production and affects water holding capacity, aeration and workability of the soil [24]. Chemical part of the soil is crucial in supplying of essential elements required by the crop to complete its life cycle [25]. Biological part of the soil has also vital roles in decomposition residues, mixing soil masses, aeration and nutrient mineralization [20]. The goal of crop production is to increase the interaction and productivity capacity of these sources. Healthy soil functions optimally through balanced interactions amongst its biological, physicochemical and mineral components [26, 27]. A soil to be healthy, it should be capable of supporting life processes both beneath and on the soil through supplying nutrient, anchorage plant root, holding adequate water and vital properties, provide soil food webs, nutrient recycling, entertain microbial diversity, pollutant remediation, heavy metal sequestration and pest suppression qualities [20, 26, 28].

Sustainable crop production is based on long lasting maintenance of available natural resources along with crop productivity by minimizing undesirable impact on the environment [29]. As far as diversity is contained in the field, it enriches the organic matter content of soil that has a profound effect on the type and number of organisms present in the soil [27, 30]. Since microorganisms are dependent on organic matter for their nourishment, adequately enhancing enables to support numerous organisms to derive nutrients and energy from it and prolong their existence [27]. A soil supports the existence of multiple microbial organisms is an important indicator of soil health. It is simple and reasonably done by practicing of multiple cropping systems on the field [31]. Ensuring the presence of microbial organisms in the crop rhizosphere with the action of sustaining crop diversity via the practice of proper cropping system is inevitable to obtain all benefits provide by them.

The actual benefits gained by conserving of microbial diversity are; release of plant nutrients from insoluble inorganic forms, decomposition of organic residues and release of nutrients, formation of beneficial soil humus by decomposing organic residues and through synthesis of new compounds, production of plant growth promoting compounds, improvement of plant nutrition through symbiotic relationships that lead to transformation of atmospheric nitrogen (N) into plant available N, increasing root surface area for phosphorus absorption, improvement of soil aggregation through
production of binding agents such as glomalin (from mycorrhizal fungi) and polysaccharides (from bacteria), improvement of soil aeration and water infiltration, have antagonistic actions against insects, plant pathogens and weeds (Biocontrol), help in pesticide degradation and rhizoremediation (Bioremediation) [20, 26, 32].

Meeting the growing demand for food too rapidly increasing population requires the intensification of crop production in a given plot which was a major challenge for the sector of agriculture in the past and will remain a forthcoming problem [33]. The continuous cultivation of one crop variety alone on the same piece of land year after year affects the soil health, reduce habitat for insects, increase the need for pesticide and disrupt soil physicochemical properties [32]. In this system of farming, soil fertility is the continual decline due to nutrient mining and results in reduction of farmers’ ability to use natural pest cycles which proceeds in exceeding pesticide demand.

The growing interest in high input agriculture in Ethiopia together with challenges in agro-ecosystem hastened with population pressure, poor soil management practices and climate change adversely affects current and future conservation of crop species. The current reliant on high yield few varieties and chemical fertilizers in Ethiopia are believed to be chemically deactivated and physically deteriorated the soil. It gives better emphasis on the soil chemical and physical properties manipulation than biology part of the soil. There is misperception among extension agents, crop production experts, researchers and particularly political leaders on issues of chemical fertilizer consumption and crop productivity. They do believe that application of inorganic fertilizers and improved high yielding varieties alone can increase yields and promotes its unwarranted utilization for alleviation of abject poverty in the country.

This argument is so powerful than the negative impact of few varieties and fertilizers on soil, environment and climate is often suppressed or treated as external costs which simply have to be accepted. Temporarily, it may be a solution to aggressively compensate the available food, fiber and oil crop demand gaps that a country requires urgently. However, crop productivity did not depend on the extensive utilization of chemical inputs only, but it also greatly depends on organic substance that sustains soil life and crop productivity, such as crop residue, compost, dead roots, root secretion and farm yard manures [20]. These organic residues are responsible for the formation of organic matter, supporting soil life, improving soil structure and plant metabolism and crop production.

New land that can be brought into cultivation is very limited and farmers holding size is small and fragmented with much of what is available is cannot support agriculture. This might be due to most farming soils are susceptible to erosion, poor in fertility and nutrient carrying capacity, poor and ineffective natural resource management. Ethiopia’s challenge for the future is on managing of cultivated soils in a sustainable manner to meet the ever increasing demand of minimum food requirement. Thereby, considerable emphasis should have to be given to soil health protection for century long mining cultivation lands to support national food production.

To address effectively complex problems in relation to Ethiopian agriculture, it needs a holistic approach in soil management. The holistic approach that considers the farm soil management with incorporating of diversified crops in the field for doubling production, minimization of environmental risk and sustenance of soil health. Crop biological diversity in the field improves soil, enhance yield and increased farm biodiversity. The system enables to have high quality soils that support dense populations of microorganisms, enhance biological control of pathogens, minimizes turnover of nutrients, encourage beneficial insects and improve soil aeration and drainage. Employment of different cropping systems, management of crop residues, conservation tillage, incorporation of farm yard manures and nitrogen fixing crops improves soil health and productivity. This approach will avoid total reliance of farmers on unaffordable chemical inputs and hybrid varieties. The future focus in Ethiopia should have to be an wisely exploitation of available landraces with minimizing dependence on external inputs such as homogeneous improved seeds, industrial inputs (Fertilizer and pesticide) and substitute with the easily accessible internal resource. This approach will reduce the burden of mass of Ethiopian poorer farming households with regard to cost of chemical inputs, improved seeds and avoids particularly unwanted input debate trap of those living in drought prone areas. At the same time it also reduces environmental degradation and pollution impact along with utilization of chemical inputs only for replenishment of soil fertility and pest control.

**Crop Diversity and Human Health:** Ecosystem function is the ability of natural ecosystem processes in providing of goods and services to address the demand of human beings [9]. Biodiversity conservation and sustainable utilization are essential for maintaining human health [34]. It was recognized when the process of loss of biological diversity alerts for rational use and conservation of living
resources to safeguard the flow of natural ecosystem and human well-being [9]. Plants are sources of essential nutrients, serving as medicinal agents, establishes a robust functional ecosystem and contribute to social wellbeing [35]. Losses of species diversity results, dietary changes and pose direct threats to human health. Major threatens conditions in containing human health are population growth, ecosystem destruction, urbanization, agricultural development, climate change and reduction of crop diversity. Agricultural development has adverse effects in hosting genetic diversity because of specialization on monoculture that have similar growing and maintenance requirements [32, 34]. Continuous farmers’ adoption of monoculture to attain higher yield unsustainably affects habitat diversity.

For the last half century, global food production kept pace with population growth largely due to increasing in the net cropped area, intensification of production, use of improved varieties and employment of best agronomic practices [36]. The per capita agricultural production was growing by 17%, while total staple food production was growing by 145% during this period [37]. Today, each person in the world has 25% more food compared to the quantity present in 1960. But this trend was not similar in every household and varied regions of the world. If we take Africa as an example, the current food security and food production status per capita is 10% lower than it was in 1960 [37]. Because of this, the numbers of peoples find nothing to eat and malnourished remains persistently high [38]. The numbers of peoples suffer with hunger and lack of adequate access to staple food in the 21st century are reached near one billion [37, 39]. Even though, increasing in quantity of production is necessary but it is not adequate by itself to achieve good health and nutrition.

Modernizing of agriculture in the globe has brought a remarkable increase in quantity production typically focus on high yielding, pest and drought resistance few distinct varieties [40]. But the advancement in technology has not led to decline the incidence of hunger and poverty as stated above. Growers having adequate access to input, knowledge and skill were produce much, but subsistence small holders in developing countries like Ethiopia lacks access to both input and output markets are penalized. Hence, the current agricultural production and productivity did not decline number of food insecure people equally across regions. Meeting the need of poor peoples, addressing shortfalls in food production and ensuring access to food products will become a major challenge of present and future agriculture [39]. This is also aggravated by crop production demands to tackle effects of climate change, competition in water and reduction of productive land.

Intensive agricultural efforts were applied to principal crops only due to specialization of farmers in certain crop species and significantly reduce the consumption of more diverse grains [40]. The curbing food security problem with increasing net production has been seriously affected by genetic erosion and leads to the emergence of new public health problems [41]. Adequate supply of nutritious and safe food is milestone of public health which can be effective with diversified crop production.

This proved that maintaining of crop diversity on the farm is the only feasible warranty of poorer households in developing countries. Thereby, Food security problems can be effectively addressed by maintaining greater diversity within the cropping system. Conserving more genetic diversity within species together with varied ecosystem diversity has often high overall productivity [40].

Investment in agriculture, mainly focus on improvement of yield for meeting adequately the calorie demand only and neglects vitamin and micronutrient requirement, then peoples are suffering from such nutritional deficiencies [42]. In much part of the world, particularly southern Asia and sub-Saharan Africa, peoples suffering from nutrient deficiency often called hidden hunger because affected peoples gained calories but inefficiently other nutritional elements [43]. It is recognized internationally that increasing productivity and raising income alone have limited roles in improving nutrition. Shortfall in dietary diversity is the major causes of micronutrient malnutrition in sub-Saharan [44,45]. Provision of better nutrition to maintain human health is not the outcome of economic growth and social development but it requires essential input [46].

There is harmonization between scientific conception and traditional values on the necessity of dietary diversity for human health. Changes in the environment and economy increases simplification in the diets of larger number of people to a few high energy foods presents unprecedented obstacles to human health [35]. Deficiency in essential mineral and micronutrient exposes people to suffer from anemia and other related human ailments. Intensive agriculture is highly reliant on chemical fertilizers and improved seeds to enhance productivity. The chemical based agriculture affects nutritional quality of end products by hastening maturity period of crops and adversely affects the time available for accumulation
of sufficient nutrient which later translocate into the grain and improve the quality of the product. A growing challenge today with modern agriculture a reconciliation of staple food productivity and in maintaining sustainable production system for meeting nutritional quality of products. Significantly reduce the use of plant biodiversity will enormously increase the abundance of associated biodiversity. Conservation of genetic diversity and the knowledge of its use therefore preserve the adaptive lessons of the past and provide the necessary resources for present and future health.

The current direction of the Ethiopian government is a production of the quantity of products with the intensification of agriculture to meet urgently required food demand. The intensification approach is expected to reduce the diversity of crops on the field which will later express inferiority in quality of production. It does not only affect the quality of product but it also projected to affect the quantity of production, particularly related to the affordable nature of modern inputs in intensive agriculture to detriment households. When less diversified diets were consumed, it exposes people to become vulnerable to human ailments. Therefore, it is advisable to cultivate varied crops on the field on the same cropping season to achieve both food and nutritional security especially for poorer farmers in marginal areas.

**Crop Diversity on Development and Stability of Production:** Biodiversity is the variability of all living species of plants, animals and microbial organisms existing together and interacting in the given ecosystem [34]. Naturally available biodiversity has provided a basic foundation to all agricultural animals and crops [47]. All domesticated crops in the globe are derived from wild and weedy species that has been modified through and non domestication, selection, breeding and hybridization [48]. Holding crop biological diversity is a key policy of agriculture, particularly for assisting economic growth and rural development endeavors. The main role of diversity is to render support to small scale and low income farmers in developing countries. This is achieved through providing of various prospects in risk management, subsistence, market orientation and heterogeneity in crop production, enhances in resource endowment and income generation [49].

Crop diversity is basic foundation of agriculture that enables to adapt and evolves to mitigate the persistent challenges for production of adequate and nutritious food sustainably for increasing population [46, 50, 51]. Human managed agro-ecosystem contains valuable crop genetic resources which serve as raw materials for modern crop breeding, selection, pest resistance, productivity, stability and future agronomic improvement [52]. For the last hundreds of years agricultural crops were subject to persistent domestication, selection, exchanged and improved traditionally by farmers within their agricultural ecology [53].

Agricultural development is the transformation of society and technology in the sector of crop production [54]. It is also based on the exploitation of biological resource bases with basic characteristics of renewal. Research has been listed and documented greater rate of income obtained from the use of genetically improved crops for yield, yield stability, nutritional security, quality and resistance to disease and pests and efficient utilization of resources. Improvement of crops is unthinkable without conserving and sustainable utilization crop genetic diversity. Improvement of crops using landraces has contributed not only to final productivity but also to sustainable stability in yield [55]. Varieties having yield stabilize characters provides critical significance to farming household vulnerable to extreme environmental conditions [56, 57]. Maintaining and promotion of crop diversity in farming system increases resilience and sustainable utilization of agro-ecosystem. Improvement of crops were/are still accelerating by scientists and remarkable achievement has been recorded since the time of green revolution and high productivity per unit area was recorded.

Crop production is the key to the Ethiopian economy. It provides essential support to the livelihood and largest number of subsistence famers’ nationwide and vital for poverty alleviation, rural development together with food and non food production. Diverse ecosystems having more genetic diversity within species often have more productivity than simpler once [58]. Agricultural crops contain genetic materials which are vital for ensuring food security and sustainable production to meet changes and challenges derived from both biotic and abiotic factors [46, 59]. Diversity is insurance for low input traditional farming system of poor households to maintain production stability under climate, disease and insect pest risky prone areas tend to be less productive. An experiment was conducted by Finckh *et al.* [60] in Poland to compare yields of barley at mixture and pure stand level and result indicated barley in mixture out yields the mean of variety of pure stand. Tilman *et al.* [61] in their research
verified that increment in diversity increases productivity and stability crops and they showed that plots with high diversity were 70% more stable than pure stand.

Crop biodiversity is a means of sustaining and improving livelihood of farmers under the environmental condition which unfavorable for crop production [46, 50]. Maintaining of diverse crop species on the farm provides less variable yields compared to single crop in the system. This is because the performance of diverse species varies with environmental conditions and the cropping system to maintain productivity over a wide range of conditions [62]. Ethiopian farmers in central and southeastern highlands improves their livelihood conditions through ensuring food security by enhancing crop diversification on the farm [63]. Hence, variation in yield of the more diverse cropping system will be less for a mono crop. It reduces the possibility of total crop failure and enhances the stability of both yield and income of farming households due to increase resistance to insect pest and pathogens [64]. But the cultivation of the same crop subsequently on the same piece of land increases the buildup of pathogens and insect pests.

Ethiopian crop biodiversities are found in marginal agricultural production areas. High levels of diversity in such type of environment become central part of farming livelihood management strategies of farmers and means of survival of the community. Once losses of such genetic diversity will degrade farmers coping capacity during extreme environmental conditions. Precaution must be taken not to introduce non-adapted materials in stress prone areas which could fail and leads to erosion of desired characteristics of landraces. For reducing vulnerability and avoid total loss of crop biodiversity, proper management strategies should become the component of both the farmer and government in Ethiopia. If proper strategies will not be employed, in the course of time crop production becomes dependent of narrower genetic bases both within and among species.

Even though, crop biological resources possesses reproductive ability and considered to be inexhaustible, but civilization and innovative technology in all human activity results steady decline in diversity. Thereby, the world agriculture today faced greater challenges in timely accessing and providing food to ensure food security for the rapidly growing human population and minimizing the irreversible losses of biological diversity emerging at large [65]. It is recognized that presently continued reductions of crop genetic bases increases vulnerability of agriculture and becomes sources of risk to survival of farming households. The vast quantity of Ethiopian food production is highly reliant on and derived from very few crops of tef, maize, wheat, sorghum and barley [66]. These crops have accounted for 86% the total cereal production and 80% of the area under small scale holders [67]. The varietal bases of these crops are also very narrow both at interspecies and intraspecies level. It is also aggravated further by abandonment of landraces and traditional varieties in favor of high yielding new varieties.

Frequency of adverse weather occurrence is a usual event in Ethiopia and brought undesired devastation on fixed asset, crops and lives of households. Use of the diverse cropping system is the only warranty against uncontrolled weather, production and market fluctuation factors. Therefore, in the future, Ethiopia will face agricultural development challenges in providing sufficient food for its fellow citizens if there is no proper maintenance of environmental quality and economic well-being of rural household through promotion of diversity.

**Conservation Challenges of Crop Diversity:** Crop genetic diversity is the diversity of plant genetic resource for food and agriculture that grips diversity within and between crops and their wild relatives and wild edible species [68]. Previously, farmers were dependent upon their traditional knowledge, skill and resources for development of crops having economic significance to their livelihood [48]. The traditional knowledge used to conserve diversity, how to grow crops, is extremely important and used to be conserved. It was started with the domestication of valuable wild plants and proceeds with selection of plant materials for their adaptation to changing climatic conditions and human preferences [69,70]. Evolution of collecting local crop varieties was occurring through time because of interaction with their wild and weedy relatives, adapting to change environmental conditions and response to the social, economic and cultural factors that manages farmers and consumers’ priority [68, 71]. The result of this evolution will serve as a basic foundation for farmers and plant breeders for generation of new varieties today and sometime in the future.

The richness and abundance of crop diversity are under serious threat due to shifting in production conditions in Ethiopia. The national biodiversity strategy and action plan shows, agricultural intensification approach in Ethiopia is the major causes of crop biodiversity losses [72]. In the previous decades genetic diversity of agricultural crops in the world has been lost 75% of which 100-1000 folds decline through time [73].
The event negatively affects the ecosystem capability and function to provide food and other related ecosystem services\[74\]. Over the last two decades credible progress has been made in recognition of biodiversity loss and its adverse effects on the functioning of the ecosystem and livelihood of society. This is due to declining of the genetic material for breeding to enhance productivity and ensure environmental stability for production. One of the major challenges today is how to properly conserve crop diversity while meeting the rapidly growing demand for food and ecological service. Conserving crop biological diversity is affected by a different man driven determinant factors among them: adoption of improved varieties, market orientation, technological changes, income diversification, social resource endowment and heterogeneity in land resources of farmers. Changes in any of the determinant factors may lead farmers to unlikely change in choice of crop variety.

**Adoption of Improved Varieties:** Developments of high yielding crop varieties were possible by modern plant breeders due to the wider range use of genetic materials available among landraces. This breeding work has threatened the sources of genetic diversity that might utilize in the future for improvement. Use to improve varieties brought significant changes in quantity of production and meets the economic demand of the farmer and then farmers find not rewarding in the conservation of landraces. Farmers usually consider the final yield potential together with other production and consumption attributes. In fact, modern varieties are bred for high resistance to disease, insect and hence their popularity for production. In the course of time, dominantly use of improved varieties will affect the stability of production and become vulnerable to new insect pest and disease outbreaks. Improved varieties are more uniform as compared to landraces and become more susceptible to pests due to evolution of pests to overcome host plant resistance and changing environmental conditions. The evolved pests are successfully attacked a wider range of crops and increase its severity of infestation \[75\]. Generally, this is due to continuous cultivation of the same piece of land year after a year with little or homogenous varieties.

Conservations of crop genetic materials are very vital for marginal production areas where plant breeders become less successful in development of adapted varieties. Most growers in such stress areas were/are poorly threat with research and extension services. The hardness of the environmental condition forced farmers to live under poverty and to engage off farm sources affects the possibility of cultivating and on farm conservation of crop biodiversities. Plant breeders’ right also adversely affects the conservation of genetic diversities since it requires precise description criteria’s like distinct, uniform and stable feature.

**Technological Changes:** The labor productivity in crop diversity farming is lower compared to monoculture. It takes more time and requires much effort to manage crop varieties with different sowing dates, harvest time and other needed practice in relative to low diversity farming. It also requires much labor to construct and maintain physical farm structures such as water courses, physical and biological terraces that support high diversity on the farm. Most of the agricultural activities are labor intensive at a small scale farmers’ level and since farmers are dependent on family labor, they usually preferred to adopt improved agricultural technologies to reduce the burden. Eventually, it reduces the diversity and adopts uniform varieties compatible with existing technologies.

Innovation, development, diffusion and adoption of modern agricultural technologies along with knowledge have an adverse impact in crop diversity in agriculture. Advancement in agricultural technology displaces small farmers and undermines the social basis of biodiversity conservation. Expansion of irrigation, development and diffusion of high fertilizer responsive varieties lowers the demand for landraces that adapts in marginal growing conditions.

**Market Oriented Production:** The current world induces pressure towards the tendency to have a very uniform eating habit. In human history around 7000 plant species \[76\] have been identified and used as human food previously, but currently market oriented production and urbanization has significantly reduced the edible crop species diversity. Globally the number of species utilized in todays commercial agriculture is estimated to be 150 crops \[77\] mainly includes rice, wheat and maize which accounted for 60% of the food supply. For sustainably achieving food security and social well being, the Ethiopian government has provided policy support for commercial transformation of subsistence farmers. Following the adoption of agricultural development lead industrialization policy, the government has liberalized the grain market and restriction on grain market was lifted \[78\]. Farmers were starting to adopt uniform varieties to
produce market demanded quality and quantity of agricultural products. The selection and growing of crops that meets the market preference only negatively affects local landraces. The market has direct influence on the production, processing, transportation, communication and consumption of crop varieties. Since the type of variety produced is market oriented, it affects land use and crop biological diversity. Hence, it is resulted with rapid genetic erosion within each crop.

**Future Scenarios**

**Population Growth:** Rapidly increasing Ethiopian population will face fundamental food security challenges due to steadily increasing absolute demand for food. According to Ethiopian climate resilience green economy [79] 9.5% of the annual crop growth rate will be required in Ethiopia to sustain population growth, ensure food security and support to reach a middle income status in 2025. The predicted total cereal production is expected to rise from 23.6 million tonnes in 2015 [66] to 71 million tonnes in 2030 [79]. Increasing number of population requires increasing in the use of land in multidimensional ways, such as production, homestead and building which often results in the conversion of natural ecosystems and immediate destruction of the ecosystem. So far the trend indicates in Ethiopian 1.21 million hectares of natural land is converted and brought into cultivation every year [80].

The growth and transformation plan of Ethiopia also predicted a net cropped area increment by 4% per annum and hence the area will increase from 13 million hectares in 2010 to 27 million in 2030 [17]. Primarily, the population growth increases the demand for food and other necessities and secondly, the availability of land for production decreases which may lead to food deficit. The interaction between food security, agriculture, water and ecosystem services, increasing the concern of negative feedback [81]. The future demand for food will be affected as sustainable economic growth affects peoples purchasing power, growing urbanization encourage people to adapt new diets and climate change threatens both land and water resources. In order to fill the available food gap the government of Ethiopia has adopted various packages and will give emphasis on the production of cereal crops in the future. Even though, the emphasis has given rise in the production of such crops, but reduction has been also occurring on some other cereals and pulses.

Crop production will have to be boosted via improving the productivity of crops per unit area from most degraded plot lands that were under cultivation for centuries. It severely placed huge pressure on farmers, policy makers and agricultural scientists carry out preferential breeding for higher yielding and keeping only productive varieties for meeting ever increasing demands in marginal lands. Hence, crop production will get modernized with spectacular increases in productivity i.e., more cereal yields per hectare and more farm output per person employed. The success in the development of high yielding varieties will partially or totally replace landraces and consequently cause loss of genetic diversity of crops. The loss will be predominately occurring on the landraces of most staple crops like cereals and legumes. Thereby, mounting yields will take place at the expense of most crucial diversity within species which is responsible for evolution of crop species via subsequently the use of high yielding varieties in the farm only. Eventually, the approach affects both the genetic and species diversity basis in the farm ecosystem.

The use of improved farming technologies will result both positive and negative impacts on farming households and land race varieties. The positive impacts are correlated with temporarily social and economic improvement derived from yield increment per plot, increase income of beneficiary household, diversification of production and changes in food habit particularly farmers with access to irrigation. But this impact will not apply to all households with different wealth status and farm size. Those who have the economic capacity to afford inputs will produce more, but who don’t afford will affect adversely. A health impact is not also uncommon related to utilization of pesticide and herbicides. Other impacts are declining diversity of crop landraces, declining traditional soil fertility management practices due to reliance on fertilizers and pesticides, increased inequality in wealth of users and non-users.

The rural population is expected to shrink in the future with rapidly expanding of urbanization. This results in a reduction of the work force in rural domains and affects labor productivity in agriculture. Hence, this may affect conservation of crop diversity at farm level due to the significant labor requirement in order to maintain diversity.

**Landholding:** Nearly 77% of Ethiopian populations are aggregatedly inhabited at altitude, situated (>2000 masl), which cover 37% of the geographical area with sparsely populated in low lands [82]. Farmers located in this part of the country are extremely suffered with land shortage and landholding per household is falling from 0.5 ha in 1960 to
only 0.2 ha by 2005 [83]. Expansion of farming towards steep slopes brought deforestation that causes soil erosion and widespread environmental problem. The farming practice is characterized by highly dependent on the erratic nature of rainfall, traditional farm implements, high population pressure, deforestation and severe land degradation combined with low productivity. The predominant quantity of production is still obtained from this section of the country and accounted for 90% of Ethiopian economy [2]. But with further increase in population, existing plot of lands gets split more and become difficult to hold diversified crops in the field.

Efforts to increase productivity will take place in marginal lands with little room for expansion of arable lands. The comprehensive approaches in Ethiopia in efficiently converting agricultural inputs into output have its own drawbacks during past and present trends [80]. The country has both low crop and labor productivity compared to rest of the world. Thereby, negatively affects the possibility of genetic conservation at both community and individual household level. Thus, further fragmentation of plot of land adversely affects coping option of poorer farmers on marginal lands for varying environmental conditions and biotic factors. Potential farmland for expanding agricultural production is increasingly restricted due to competing land uses for biofuel production, urbanization and, in the longer term, climate change. Sustainable crop biodiversity conservation is very crucial to build shock absorbing resilient farming systems and to continue functioning within a set of changing circumstance.

**Farmers and Consumers Preference:** Farmers having access to diversified genes will remain important in sustainable conserving and enhancing agricultural productivity. But there are economic and epidemiological reasons to say that variety choice of farmers may lead to hold less diversity in agriculture with the impact of globalization and market liberation resulted with boosting in the price of agricultural products. This market opportunity has leverage on the type of crop variety to be grown by growers. It leads to wider spread adoption of high yielding and preferred crops by end users. The recent example in Ethiopia is development and distribution Quncho tef variety based on consumers’ preference. The variety becomes popular for its white seed and it is found to replace other local varieties in the country. So, it adversely affects not only genetic diversity between species of crops, but also the most desired diversity within species.

Agroecological constraints and quality of land are other determinant factors that influence farmers in the selection of varieties to be grown. A household owned and cultivate marginal lands will decide to adopt new varieties to augment productivity. This is because modern varieties naturally perform better than landraces under marginal farming conditions for the confined time period. The introduction of new varieties into the farming system will affect conservation of land races at community level. The affluent peoples in Ethiopia are anticipated to increase enormously and with it, per capita calorie intake will expected to increase. At the same time the demand for various diets that include animal proteins such as egg, milk and meat products requires more land to produce. This also puts its own pressure on the land available for crop production and genetic conservation.

**Market Demand:** Ethiopian economy is heavily reliant on agriculture as the main source of employment, income and food security for a vast majority of its fellow citizens. It is the source of 83% of the employment, 45% of the GDP, 90% of the foreign exchange earnings and means of ensuring food security in the nation [4]. The sector of agriculture is expected to produce and provide adequate food to fellow citizens, adequate raw material for domestic booming industries, surplus capitals to be invested in other sectors and exportable commodities to meet the hard currency demand of the nation [84]. To achieve all these, increasing agricultural productivity becomes the main goal of Ethiopian government and also stimulated with considerable increase in staple food price almost over the last 10 years both locally and internationally.

Ethiopian government had formulated a policy support to expand production for domestic consumption, ensure universal food security and for export purpose [16]. Crop productivity will depend on efficient utilization of production factors. Thus, the expansion of the high tech utilization and intensification of crop production will accompanied with efficient use of resources to enhance productivity factors. Crop diversity will get narrower and the number of crops grown in the country will be also reduced as farmers specialized and intensified in production. Hence, changing is inevitable in the cropping system when farmers are adopting new crops and varieties on the field. Narrowing of crop biological diversity both at genetic and species level has consequences on productivity, stability and resilience of food insecurity.

Intensification and expansion of agriculture to meet the market demand is associated with building pressure that leads to resource degradation and have an adverse impact on the environment at large. Concentrating on
Climate Change: The new challenge is currently taking place, particularly in the sector of agriculture derived from climate change that will cause loss of agro-biodiversity and affect the demand for sustainable resource management in crop production [10]. Many components of climate change are anticipated to affect almost all levels of biodiversity from single cell to complex higher living organisms [46]. Climate change projection indicated that in the recent future increasing in frequency of weather events is growing; temperature is expected to increase and rainfall is to decrease in Africa that proceeds up to drying of water bodies [10, 85]. Farmers will start to adopt new varieties that may tolerate partially or permanently the impact of climate change for timely basis. While doing so, it will bring irreversible lasting genetic losses and poses future threats in finding traits for breeding and adaptation. Irreversible loss of the plant gene pool will pose severe threats to global food security in general and to Ethiopia in particular. The major concern is decrements of various strengths and forms of fitness usually articulate at varying levels and may have effects on genetic diversity, ecological networks, resilient and ecosystem function. The effect of climate is anticipated to become more significant for a small number of staple crop species for those more breedings were conducted previously to boost productivity.

Currently climate change poses unprecedented disputes on sector of agriculture to secure food supply for dramatically increasing population while looking for minimizing adverse impacts of environment and reduce use of non-renewable resources. Fluctuation in temperature and rainfall patterns adversely affects production and productivity. It also greatly affects the type of crops to be grown in a given agricultural ecosystem and forced the sector to become fast enough to adapt to change in climate and to shift in production practices to mitigate the impact on crop production. Climate change and rapid increase in population also placed pressure on land use changes. It is impossible to feed the population with existing cultivated lands, hence requires bringing naturally protected areas into crop land. Soil degradation causes to abandon more cultivated lands in the highland part of the country and brings forest lands into production. This condition will exacerbate conservation condition of cultivated crops their wild and weedy relatives.

Access for crop genetic diversity will become a precondition to safeguard the farmers’ ability to adapt local and changing environmental conditions. The exchange of local varieties among farmers will be affected and have a substantial adverse impact on the evolution of genetic diversity in agriculture. An important debate is also still going on among scientists in ecological effect of climate change is whether or not species will adapt quickly enough to the rapid pace of changing in climate [86, 87]. The challenge may guide importance of conservation of plant genetic resources for the development of adaptive varieties from broad based genetic pools. To address successfully growing climate change threats, conservation and sustainable utilization of plant genetic resources for food and farm ecology management are essential. To adapt current and future changes of climate efficiently, it is very important to conserve the diversity bases and increase its use in a sustainable manner.

Decrement of Suitable Production Area: In Ethiopia, climate change is projected to affect and relocate suitable production areas of different staple cereal crops [79]. The temperature in Ethiopian has been warmed over the past century and anthropogenic induced climate changes will also expect to bring an additional warming in the coming century at an unprecedented rate. Climate models predicted that, Ethiopia will warm in all season in the range of 0.7-2.3 °C by 2050 and of between 1.4 to 2.9 °C by the year of 2050 [88]. The projected rise in temperature scenario forced plant species to relocate from their growing zone into new areas to remain within an optimum thermal zone. The major staple cereal crops of barley, maize, teff and sorghum will be lost and relocated from the current suitable area of production in 2050 by 37, 14, 11 and 7% respectively [89]. Most crop species in the future will reach the maximum temperature of tolerance and slight temperature increment beyond this upper limit will relocate them from the current adaptation area. Thus, eventually reduces suitable land available for growing and conservation crop genetic diversities in Ethiopia. The future scenario of conserving diversity of staple crops under farmers’ field will become questionable and beyond...
their capacity. Hence, genetic resources will be under serious threat in the future agriculture.

**Rainfall Variability:** Changes in the distribution nature of rainfall during the main rainfall seasons for longer periods and or occur more intensity in short periods is expected across the globe. This may result with extreme weather events that may cause economic catastrophe. A deficit of rainfall during the growing season are projected to increase in duration and frequency. This will affect the availability of moisture for rain based crops and directly affects productivity. Such type changes are more pronounced in arid, semiarid and sub-humid areas of sub-Saharan African that are already subject to climate variability.

Crop production in Ethiopia is overwhelmingly 95% of the cultivated area are under small scale rain-fed based production system and accounts for 95% of the gross grain produced per annum [80]. The dependence of Ethiopian crop production on rainfall, it severely affected by seasonal variation in rainfall and temperature. Historical record indicated that there have been severe and frequent droughts that results from seasonal rainfall failure and causes chronic food shortage and hunger due to partial/total loss of production. The impact of rainfall on crop production is mainly through affecting the growth period, critical time of growth rate and hence productivity. It is expected to become sever in arid and semiarid regions which already have a few growing period for crop production [90]. The frequency and severity of the event occurrence have become more frequent in recent years [91]. Such type of shocks brought hardship on well-being of farmers and forced them to consume local crop seeds preserved for next cropping and start to adopt introduced crop seeds. Adoption by introducing seeds significantly affects the biodiversity conservation on the farmers’ field.

**CONCLUSION**

Plant resource diversity plays crucial roles to enable to meet national nutrient, health and socioeconomic demands. It has important contribution in addressing several challenges related to food security and climate change. On farm diversity in Ethiopian is declining from time to time and urgently needs to devise mechanisms for effective, wide range and most efficient ways of reversing this trend. Comprehensive knowledge of benefits of biodiversity is almost unavailable, so far at all levels in the country. Developing a system of conserving of agro-biodiversity to ensure sustainable food security is important for societal well-being. Understanding the factors that influence crop diversity and composition will render support in devising mechanisms of their management. Maintaining of diversity on the farm has positive impacts on farmers’ livelihood by increasing stability of yield, reduce risks, for extended use of farm labor, in the use of a variety of soils and climatic conditions, increasing resource productivity over time and diversification of production. Most of living organisms are found beneath the soil than on the soil and it performs its function as a household of organisms. Thus, it is very vital sustaining the biological productivity of the soil. Production of health food requires healthy soil that provides adequate nutrients, water and air to enable the crop to complete its life cycle.

Previous and present agricultural practices in Ethiopia exacerbate soil vulnerability to degradation processes such as erosion, acidification, Salinization, soil structure decline and contamination. The degradation process declines functional capacity of the soil at all levels, particularly with diminishing quantity and quality of water across streams and rivers. Thus, draining of both quantity and quality of water due to degradation is a major indicator of poor soil health in Ethiopia. Enhancing farm ecosystem functioning assists significantly to resist changes impose by disturbance and their resilient potential following degradation.

Crop diversity has used full social value and able to improve the livelihood standard of farmers and assist them to lead a satisfactory life. Ethiopia is abundant with crop plant genetic resources which are highly tolerant to shock of extreme temperature, drought, insect pest and disease resistance. Preservation of these resources is very vital in developing of climate resilient crops, high water efficient crops, early maturing species, generate high yielding and improve market access potential in the future. Arresting of human interaction with varied ecosystem and life form to manage crop biodiversity so as to maximize benefits provide today and preserve their potential for meeting the coming generation aspiration is inevitable. Therefore, preservation of local landraces by farming households is crucial and providing support to farmers is also advisable for maintenance of diversity and benefit sharing.

**REFERENCES**


44. FAO (Food and Agricultural Organization), 2013a. The State of Food and Agriculture: Food Systems for Better Nutrition. Rome, Italy.


88. EPA (Ethiopian Environmental Authority), (2012). Ethiopia’s vision for a climate resilient green economy.

