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Impacts of Land Degradation on Crop Yields and its Management Options: A Review

Amare Aleminew[1]

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ABSTRACT

Land degradation will remain an important global issue for the 21st century because of its adverse impact on agronomic productivity of crop yields, the environment and its effect on food security and the quality of life. However, the on-site impacts of land degradation on productivity are easily screened due to use of additional inputs and adoption of improved technology and have led some to question the negative effects of extreme land degradation. The relative magnitude of economic losses due to productivity decline versus environmental deterioration also has created a debate. Therefore, land is a non-renewable resource, and the productive capacity of the land would be reduced unless proper management options would be taken at a right time. The proper management options of land degradation for sustaining the crop yields are controlling overgrazing, reduced population pressures on natural resources, using energy efficient sources, contour farming, avoiding cultivation of steep slopes for crop production purposes, afforestation and hillside tree plantations and along gullies, increasing soil fertility by adding organic matter, reducing compaction of soil structures and making soil and water conservation structures to reduce soil erosion, sediment loss and run-off.

Key words: Crop yields, Improved technology, Land degradation, Management options.

Land degradation, a decline in land quality caused by human activities, will remain high on the international agenda in the 21st century (Akinnagbe and Umukoro, 2011). Land degradation is a global problem affecting an estimated 1.9 billion hectares of land and almost two billion people due to degradation (Naseer and Pandey, 2018). Forests make up over 47% of degraded land worldwide, whereas cultivated land makes up roughly 18% of all degraded land. Commercial agriculture with natural vegetation replaced over large surfaces by monocultures of cash crops especially in African countries brings severe land degradation processes (Sonneveld *et al*., 2016). The term land degradation involves both soil and vegetation degradation. Soil degradation refers to negative changes in the physical, chemical and biological properties of the soil, whereas vegetation degradation is the reduction in the number of species and the vegetational composition (Abdi *et al*., 2013). To illustrate, about 1.5 to 2 billion tons of topsoil are lost annually in Ethiopia due to soil erosion and costing the country 3% of its Agricultural Gross Domestic Product (AGDP) (Kiptoo and Mirzabaev, 2014). If this soil is conserved, it could have produced 1 to 1.5 million tons of grain can be added to the countries harvest.

Usually land degradation is described in terms of the loss in natural resources (soil, water, fauna and flora) or in the biophysical process by which its functions. Soil can be eroded, salinized or impoverished. Water can be lost through evapotranspiration, evaporation, infiltration, run-off, pollution, or overuse. Land degradation occurs when this balance is lost. The causes of land degradation are complex, and may be the product of anthropogenic or climatic factors, such as the impact of drought and desiccation on ecosystems, the overgrazing of these rangelands, unsustainable land-tenure rights, the undervaluation of land resources, and pricing failures and numerous other social and economic processes (Kiptoo and Mirzabaev, 2014).

Due to temperature constraints, there is a cropping boundary between the upper and lower limits of agro-climatic conditions in Ethiopia. The upper limit of the Ethiopian farm land is continuously a cropping land while the lower limit is defined as dryness and which is not suitable for rain-fed cultivation of crops (Hurni *et al*., 2010). Therefore, land degradation is very much severing in the lowlands than in the highlands of Ethiopia. Land is the basic natural resource that provides habitat and sustenance for living organisms. The intensification of cultivation resulting in the opening up of new lands exposes the top soil to the elements of degradation and alters the natural ecological conservatory balances in the landscape (Akinnagbe and Umukoro, 2011). Improper management of land resources creates low crop productivity and brings poverty. Therefore, the main objective of this paper is to review the major impacts of land degradation on crop yields and to point out the major management options of land degradation problems.

[1]Department of Plant Science, Injibara University, Injibara, P.O.Box 40, Ethiopia.

Corresponding Author: Amare Aleminew, Department of Plant Science, Injibara University, Injibara, P.O.Box 40, Ethiopia. Email: amarealeminew@gmail.com

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The materials for the compilation of this paper, different literatures on impacts of land degradation on crop yields and the management options were reviewed from books, journals and proceedings from internet sources. The methods of this paper would be organizing the obtained resources from the internet and then it was written by taking the ideas of the resources what the literatures said about the impacts of land degradation on crop yields and its management options.

Effects of land degradation on crop yield productivity

Yields of crops were shown to decline because of soil factors, some associated with erosion, which leads to reduction in effective rooting depth; decrease in available water capacity, decline in soil organic carbon and depletion of other soil nutrients (Ajayi, 2015). Some information for local and regional scales is available and has been reviewed by Eswaran (2001). In Canada, for example, on-farm effects of land degradation were estimated to range from US$700 to US$915 million. The economic impact of land degradation is extremely severe in densely populated South Asia, and Sub-Saharan Africa. On plot and field scales, erosion can cause yield reductions of 30 to 90% in some root-restrictive shallow lands of West Africa. Yield reductions of 20 to 40% have been measured for row crops in different countries (Eswaran, 2001). Land degradation reduces the yield of crops and live stocks productivity in Ethiopia (Assemu Tesfa and Shigdaf Mekuriaw, 2014).

An annual loss of 30,000 ha due to water erosion with over 2 million ha already severely damaged (Leonard, 2003). A total loss of 4,000 ha of state farms due to severe salinization and an estimate of 1 billion tonnes of topsoil is lost per year (Mekonen, 2002) and nutrient depletion at rates of 30 kg/ha of nitrogen and 15-20 kg/ha of phosphorus (UNDP, 2002) and loss of 62,000 ha of forest and woodland per year (World Bank, 2001). The estimated range of grain yield losses through soil degradation for two important crops is shown in Table 1. The data in the Table are derived from nutrient studies in areas of high and low nutrient loss. Table 2 shows the monetary losses in those two situations. The total loss per hectare of wheat is about 400 birr (US$ 46) per hectare in areas of low loss and 4,736 birr ($ 544) per hectare in areas of high soil loss. The corresponding figures for maize are $ 31 and $ 379 per ha.

Major forms of land degradation

Generally, there are three types of land degradation. These are physical, chemical and biological land degradations. Due to high variability in climate, relief, soil type, altitude and farming systems, all types of soil degradation take place in Ethiopia. These are physical, chemical and biological soil degradations. The physical soil degradation includes soil erosion (mainly water erosion) and gully erosion. The chemical soil degradation includes soil acidity, soil salinity and sodicity and soil fertility decline. The biological soil degradation includes depletion of vegetation cover and soil organic matter (SOM) and reduction of biological activities (Tolessa and Beshir, 2009). Aw-Hassan *et al*. (2015), describes land degradation types as secondary salinization, soil erosion and overgrazing.

Causes of land degradation

The causes of land degradation can be either natural or human induced activities (Barman *et al*., 2013). The natural causes includes earth quakes, tsunamis, droughts, landslides and mud flow, volcanic eruptions, flood, tornado, wild fire. As the natural causes are uncontrollable, the human induced degradation is very important in view of sustainability. Land degradation can lead to many issues like soil erosion, soil acidification, soil alkalinisation, soil salination, soil water logging and destruction of the structure of soil which will directly affect the productivity and yields of crops (Barman *et al*., 2013). Generally, there are two ways of causing land degradation. These are proximate and root causes of land degradation.

Table 1: Calculated loss in grain yield due to nitrogen losses through erosion.

Crop	kg grain lost per kg N lost (Crop response ratio)	Range of nitrogen loss (kg/ha)		Range of grain yield loss crop (t/ha)	
		Low	High	Low	High
Maize	9.6	36	429	0.345	4.12
Wheat	6.9	36	429	0.248	2.96

Source: Leonard, 2003.

Table 2: Monetary values of crop yield losses as a result of soil degradation.

Crop	Yield loss (t/ha)		Grain price (Birr/kg)	Total loss (Birr)	
	Low	High		Low	High
Wheat	0.248	2.96	1.6	396.8	4,736
Maize	0.345	4.12	0.8	276.0	3,294

Source: Leonard, 2003.

Proximate causes of land degradation

Multiple interacting forces have been causing land degradation in Ethiopia. The proximate causes of land degradation include clearing of woodlands and forests, unsustainable arable farming techniques, the use of dung and crop residues for fuel and overstocking of grazing lands (Leonard, 2003).

Most arable land (70%) in the highland is in cereals, with wheat and barley at the higher elevations and teff (a small grain), sorghum and maize in the lower areas. All these crops leave part of the soil surface bare during some or all of the growing season, exposing the soil to erosion. The annual crops are mainly planted after the rains begin, so early rains directly impact the soil, contributing to high soil erosion rates (Leonard, 2003). Additionally, more fragile marginal lands are used as the population grows. A further result of population growth is the reduction in fallow periods in some areas from a five-year rotation to a two-year or even shorter rotation (Leonard, 2003; Bindraban *et al*., 2000). As rural populations have grown and woodland is converted to cultivation, the use of dung and crop residues for fuel has become much more important. Studies in two upland villages showed maize and sorghum stalks providing 69% of total fuel use in one village and dung providing 50% of energy use in the other. According to Samuel Benin and Pender (2002), restricting grazing lands management can reduce the negative consequences of land degradation effects.

Root causes of land degradation

The root cause of land degradation is poor land use practices. Land degradation represents a diminished ability of ecosystems or landscapes to support the functions or services required for sustaining livelihoods. When agriculture is introduced in place of natural vegetation and is then intensified to maximize yields, farmers simplify agro-ecosystem structures by limiting the variety of vegetation. Such vegetation changes immediately affect water use and cycling in landscapes and result in biodiversity loss and the development of a less complex network of ecosystem interrelations than occurs naturally (Bindraban *et al*., 2000). The major root causes of land degradation are natural conditions (Nyssen *et al*., 2014; Kang *et al*., 2009 and Leonard, 2003), population growth (Nyssen *et al*., 2014), land ownership (Abate *et al*., 2012), institutional issues (Assemu Tesfa and Shigdaf Mekuriaw, 2014), rural markets (Leonard, 2003) participation and extension (Leonard, 2003) and low-technology agriculture.

Management options of land degradation

According to Asrat (2014), land management is a result of a continuous adaptation of the environment to meet the need of the community. These adaptation involves controlled livestock husbandry and irrigated system based on flood harvesting, integrated soil and water conservation practice includes stone terraces, tied ridges, thrash line, agro forestry, intercropping, fallowing, green manuring, shifting, decomposition of debris and crop residues management, minimum tillage and commercial fertilizer. The divisions of soil and water conservation measures include agronomic, vegetative, and structural land management measure is arbitrary.

Potential and research needs for the Ethiopian highlands, all have emphasized in their approvals the need for conservation-based integrated development as a strategy to overcome the degradation of land resources and improve agriculture and forestry development in Ethiopia. According to the study of Reed *et al*. (2015) stated that reorienting the land degradation towards sustainable land management through adequate policy support and economic mechanisms. Moreover, priorities indicate that the initial effort be directed to areas where the environmental degradation is high and food production returns are low. To overcome deforestation and land degradation on the Ethiopian highlands and provide the people with food, fuel wood and fodder on sustainable bases the following natural resource management strategies are proposed:

- Implementation of agroforestry and social forestry in the rural areas where subsistence farming is practiced.
- Expansion of plantation forestry both industrial and non-industrial on currently uncultivated and sloping lands.
- Conservation of the remaining natural forests to conserve species and biodiversity.

Agroforestry and social forestry

The role of agroforestry in satisfying the basic needs of the rural peoples of Ethiopia is large, but little research has been initiated to identify suitable agroforestry technologies and appropriate tree species for specific areas of Ethiopia (Badege Bishaw, 2009). However, based on the work done by the Technical Committee for Agroforestry in Ethiopia, alley cropping, fodder tree planting on unproductive pasture and degraded hillsides, tree planting in home gardens and woodlots, tree planting as living fences on farm boundaries and roadsides and tree planting on contour structures, inside and along gullies are the agroforestry technologies appropriate for the land-use systems in the Ethiopian highlands.

CONCLUSION

Land management is the management of soil quality and productivity, infrastructure, farming methods including conservation practices, size of land parcel for available agricultural activity, proximity to other protected land for critical mass to achieve effectiveness and importance to local agricultural and economic vitality. Therefore, within the sphere of agriculture, land management includes maintenance of soil productivity to sustain the crop yield productivity. This requires the combination of soil treatment including application of mineral and organic fertilizers with soil and water conservation measures like implementation of agronomic, soil management and physical measures such as contour ridging, terracing or providing ground cover

through mulching, use of plants and leaving crop residue and agro-forestry practices on the specified land use types.

RECOMMENDATIONS

Land degradation is the most dangerous event that reduces the productivity and yield of crops so that crucial management options should be addressed in order to tap the productive capacity of the land. Therefore, the following recommendations should be practiced to sustain the crop productivity under land degradation situation:

- Putting good land holding certification to keep the natural resources in a sustainable way so as to protect the land from degradation and improving the land resources in a productive manner.
- Mineral and Bio-fertilizers use, crop residue management, cover crops and cropping systems (crop-association and crop rotation).
- Proper management of animal manure and green manuring.
- Agro-forestry, gully stabilization, woodland protection and tree species to reclaim degraded lands.
- Developing a long-term, locally acceptable set of land management rights and responsibilities.
- Giving high priority to fuel supply on a regional basis through conservation, woodlands, use of conservation technologies.
- Improving extension capacity especially with respect to sustainable land management and improving market infrastructure, both physical (roads) and pricing.
- Developing diversified rural enterprises in the context of an enhanced pattern of local and regional markets so as to use energy saving stoves.
- Improved productivity of the livestock sector by cut and carry system of feeding rather than free grazing.
- Greater participation of local farmers and herders in the identification of local land degradation issues and their remediation.

Conflict of interest: None.

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