Review [Revisión]

RANGELAND DEGRADATION: EXTENT, IMPACTS, AND ALTERNATIVE RESTORATION TECHNIQUES IN THE RANGELANDS OF ETHIOPIA[1]

[DEGRADACIÓN DE PASTIZALES: EXTENSIÓN, IMPACTOS, Y TÉCNICAS DE RESTAURACIÓN ALTERNATIVAS EN LOS PASTIZALES DE ETIOPÍA]

Mohammed Mussa[1]* Hakim Hashim[2] and Mukeram Teha[3]

[1]Maddawalabu University, Department of Animal and Range Science, Bale-Robe, Ethiopia. Email: mohammed.mussa@mwu.edu.et or mussamahammed@gmail.com
[2]Maddawalabu University, Department of Rural Development and Agricultural Extension, Bale-Robe, Ethiopia
[3]Haramaya University, Department of Rural Development and Agricultural Extension, Dire-Dawa, Ethiopia
**Corresponding author*

SUMMARY

Rangeland degradation remains a serious impediment to improve pastoral livelihoods in the lowlands of Ethiopia. This review paper presents an overview of the extent of rangeland degradation, explores its drivers, discusses the potential impacts of rangeland degradation and also suggests alternative rangeland restoration techniques. It is intended to serve as an exploratory tool for ensuing more detailed quantitative analyses to support policy and investment programs to address rangeland degradation in Ethiopia. The extent of rangeland degradation increases with time, and the productivity of rangelands are losing if not given due attention. The major drivers leading to rangeland degradation includes climate change, overgrazing, bush encroachment, population pressure, drought, and government policy, encroachment of rain fed agriculture and decline of traditional resource management institution. Degradation of rangeland has resulted in substantial declines in rangeland condition, water potential, soil status, and animal performance, livestock holding at the household level and community become destitute. Another consequence of rangeland degradation is linked to food insecurity, poverty to the extent of food aid, expansion of aridity and the need for alternative livelihood and income diversification. Moreover, it has increasingly become a threat to the pastoral production systems, and has contributed towards increases in poverty and tribal conflicts over grazing land and water resources. In spite of these impacts, the adoption of alternative restoration techniques in the country is highly insufficient. To address rangeland degradation problems, there is a strong need to substantially increase the investments and strengthen the policy support for sustainable land management.

Key words: Causes; impacts; rangeland degradation; restoration techniques.

RESUMEN

La degradación de los pastizales sigue siendo un serio impedimento para mejorar los medios de vida pastoral en las tierras bajas de Etiopía. Este documento de revisión presenta una visión general de la extensión de la degradación de los pastizales, explora sus causas, discute los impactos potenciales de la degradación de los pastizales y también sugiere técnicas alternativas de restauración. Se pretende que sirva como una herramienta exploratoria para realizar análisis cuantitativos más detallados para apoyar los programas de políticas e inversiones para abordar la degradación de los pastizales en Etiopía. La extensión de la degradación de los pastizales aumenta con el tiempo, y la productividad de los pastizales es está perdiendo si no se les presta la debida atención. Los principales factores que conducen a la degradación de las tierras de pastoreo incluyen el cambio climático, el sobrepastoreo, la invasión de matorrales, la presión de la población, la sequía y la política gubernamental, la invasión de la agricultura alimentada por la lluvia y el declive de las instituciones tradicionales de manejo de recursos. La degradación de los pastizales ha dado como resultado una disminución sustancial de la condición de los pastizales, el potencial hídrico, el estado del suelo y el rendimiento de los animales, la ganadería a nivel de los hogares y la comunidad. Otra consecuencia de la degradación de las tierras de pastoreo está relacionada con la inseguridad alimentaria, la pobreza en la medida de la ayuda alimentaria, la expansión de la aridez y la necesidad de medios alternativos de subsistencia y diversificación

[1] *Submitted August 20, 2016 – Accepted October 17, 2016.*

de ingresos. Además, se ha convertido cada vez más en una amenaza para los sistemas de producción pastoral, y ha contribuido al aumento de la pobreza y los conflictos tribales sobre los pastos y los recursos hídricos. A pesar de estos impactos, la adopción de técnicas alternativas de restauración en el país es insuficiente. Para abordar los problemas de degradación de las tierras de pastoreo, existe la necesidad de aumentar sustancialmente las inversiones y fortalecer el apoyo político al manejo sostenible de la tierra.

Palabras clave: Causas; Impactos; Degradación de los pastizales; Técnicas de restauración.

INTRODUCTION

Rangeland biomes encompassing much of the area where pastoral livestock production is a major land use, cover 51% of the earth's land area but support 78% of the global grazing area (Asner *et al*., 2004). Livestock provide food and income to the majority of the 1.2 billion people living on less than $1 per day (FAO, 2008), and livestock demand is rising to unprecedented levels (Delgado *et al*., 1999; de Haan *et al*., 2001; FAO, 2008). In addition to securing livelihoods, rangelands in developing countries provide multiple goods and services of great economic, social, cultural and biological values locally, nationally and globally (Mortimore, 2009). Nevertheless, rangelands have been facing contradictory pressures, i.e., increased demand for natural resources and animal products to cope with rising human populations. Conservative estimates indicate 10–20% of rangelands worldwide have been severely degraded with an additional 12 million ha of rangeland degraded each year (Millennium Ecosystem Assessment, 2005; Reynolds *et al*., 2007). Pastoralists utilizing degraded rangelands generally suffer from poverty and food insecurity (Donald and Jay, 2012). Thus, rangeland degradation and desertification have raised concerns globally.
Rangeland degradation is a global concern, affecting not only pastoralists who rely on healthy rangelands for their survival but others who suffer from resultant hydrological disturbances, dust storms, commodity scarcity, and social consequences of uprooted people. Rangeland health also affects biodiversity directly and indirectly because all native flora and fauna have adapted to the long-term evolutionary forces that have shaped these rangeland environments (Foggin, 2008).

The extent of degradation in developing countries is difficult to quantify because of the lack of monitoring, but certainly, concern exists that the human population is exerting significant pressure on rangeland ecosystems. It is also stressed that no general concept of land degradation exists that is uniformly applicable to all situations because it is necessary to define the factor being degraded (Reynolds *et al*. 2003). However, in general, degraded rangelands are characterized by sustained reduced biological and economic productivity associated with improper or unsustainable human land uses and the impact of this unsustainable use on hydrology, soil processes, and vegetation composition (Donald and Jay, 2012).

The causes of rangeland degradation are complex in time and space and associated with interactions between pastoralists, governance and policy, and environmental factors. Though, a number of different factors are reported as major causes of rangeland degradation in arid and semi-arid regions of the developing countries, the leading ones are cultivation and overgrazing, both of which are caused by population pressures of human and livestock (Mannetje, 2002). Based on different studies on different rangelands of Ethiopia, the possible causes of rangeland degradation are heavy grazing, recurrent drought, rangeland cultivation, bush encroachment, human population pressures, shortage of rainfall, inappropriate uses of land resources and soil erosion (Oba and Kotile, 2001; Mannetje, 2002; Belaynesh, 2006; Kasahun *et al*., 2008; Teshome *et al*., 2016).

Despite the losses of multiple services provided by rangeland ecosystem due to rapid increase in rangeland degradation and the urgent need for action to prevent and reverse land degradation and, the problem has yet to be appropriately addressed, especially in the developing countries including in Ethiopia. Adequately strong policy action for sustainable rangeland management is lacking, and a coherent and evidence-based policy framework for action across all agro-ecological zones is missing (Nkonya *et al.*, 2013). Reliable estimates on the potential impact of rangeland degradation on the livelihood of pastoral and agro-pastorals are not available. Moreover, lack of information and knowledge is considered to be one of the major obstacles for reducing land degradation and improving rangeland productivity and, facilitating the uptake of sustainable land management among pastoral and agro-pastoral (Liniger *et al.*, 2011). Therefore, the objective of this review paper was to explore the extent, causes, and potential impacts as well as the alternative restoration techniques of rangeland degradation.

RANGELAND DEGRADATION

Rangeland degradation is a widespread problem throughout the world. The combined effect of human and climatic factors on land degradation has led to

reduced production of the rangelands (Jama and Zeila, 2005). The term rangeland degradation/deterioration refers to both soil and vegetation and is generally defined as the reduction of the economic or biological productivity of lands (FAO, 2011). Loss of plant cover, undesirable change in herbaceous species composition (e.g. annual grasses replacing perennials), soil erosion of various types associated with intensification of grazing and woody encroachment have been dominant features in the Ethiopian rangelands which could have different implications for pastoral productivity (Conant and Paustian, 2002).

Extent of rangeland degradation

The sustainable use of rangelands depends on the understanding of the extent of the rangelands deterioration, and how can these grazing areas be restored (Solomon *et al*., 2006b). Most of the people working in rangeland areas have underestimated the degradation problems (Meadows and Hoffman, 2003). Rangeland degradation is not a spatially uniform process; there are substantial off-site effects. Some landscapes are more prone to degradation than others because they have erodible soils and palatable species, which attract more grazing activity or both (Pickup *et al.*, 1998).

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The rapid expansion of encroachment and invasion of plant species in Ethiopia has been widely reported as a common form of rangeland degradation (Ayana and Oba, 2008; Solomon *et al*., 2007; Gemedo *et al*., 2006; Abule *et al*., 2005b). Different study reported increase of rangeland degradation from time to time due to expansion of encroachment and invasion of plant species (Ayana and Oba, 2008; Solomon *et al*., 2007; Gemedo *et al*., 2006; Abule *et al*., 2005b). The study from southern Ethiopia reported rapid expansion of bush encroachment and decline of herbaceous vegetation productivity which leads to reduction in carrying capacity (Solomon *et al*., 2006b; Gamado *et al*., 2006; Ayana and Oba, 2008a; Haile *et al*. 2010). According to Assefa *et al*. (1986), about 40 % of the Borana rangelands were affected by bush encroachment in the 1980s, while the study by Dalle *et al*. (2006) have estimated the progression of bush cover to 52 %. A study by Abule (2009) reported more than 63% bush cover in the Borana rangelands. One mill ha is already covered by *Prosopis juliflora* in entire Ethiopia (Ryan, 2011), of which about 700,000 ha are located in the Afar Region (Mueller *et al*., 2010). A further rapid spread and rapid degradation is to be expected.

Similarly, the degradation of rangelands increases rapidly due to the conversion of rangeland to cropland (Diress *et al*., 2010; Teshome and Ayana, 2016). It is assumed all cropland in the agro-pastoral region was historically rangeland (Ren *et al*., 2008) and the pressure on fragmented rangeland increases rapidly and converted to bare land which leads to decline functional capacity of rangelands. In general the degradation of rangelands is progressing at an alarming rate which gives the impression of difficulty to restore it in the future if immediate attention is not given.

CAUSES OF RANGELAND DEGRADATION

A number of interacting variables and processes contributed to degradation of rangelands in Ethiopia. In general, natural and human induced with overlap between the two are known in inducing rangeland degradation and the most common ones are discussed hereunder.

Climate change

At a country level, Ethiopia is already experiencing signs of climate change. In the last 50 years the annual average minimum and maximum temperatures over the country have been increasing by about 0.25 and 0.1 °C respectively, every decade (INCE, 2001). According to McSweeney *et al*. (2008) and FEWS NET (2009) rise in temperature and fall in rainfall has been measured in the southern and eastern Ethiopia in the since 1996 years. With temperature increase has come more dry and windy periods and hence increased erosion events (Chen *et al*., 2003).

It is projected that rangelands will be more negatively affected by climate change, with implications such as change in water resources, change in rangeland productivity, change in land use systems and rangeland-based livelihoods (Hoffman and Vogel, 2008). Climate change is seen as a key ecological driver that influences the dynamics of sub-Saharan rangelands (Oba *et al.*, 2000) and hence is likely to also affect mobility trends, locally and internationally as pastoral systems transcend national borders. The country is also experiencing unusual frequency and

extensive droughts since recent decades (Kassahun, 2008). Dry lands of Ethiopia in particular are exposed to climatic change and its variability, a problem that is affecting many sectors including biodiversity (flora and fauna), agriculture, human health and water. Climate change may also increase the spread of invasive species (McNeely, 2004) and can exacerbate degradation of rangeland ecosystems and the people depending on these ecosystems.

Government policies

Government policies that were identified as causes of degradation include: settlement and resettlement program (unsystematic), investment policy, the crop-focused rural development strategies, and bans on use of fire (Beriso, 1995; Beriso, 2002). Unsystematic settlement pattern is a major cause of confusion in the pastoral land use and environmental degradation. Traditionally, pastoralists' settlement patterns reflected seasonal variation of key pastoral resources and villages systematically established to ensure availability of pasture on livestock watering and non-watering days. Currently, however, villages are concentrated one after the other in the manner that contradicts customary pastoral land use and sustainable resource management practices (Tache, 2010). In spite the knowledge available on the benefits of pastoral systems, the Ethiopian government is promoting sedentarisation as a way forward for the majority of pastoralists in the country (Fiona *et al*., 2012). This severely restricted the movements of the new villagers resulting in significant losses of livestock.

State-sponsored resettlement program, which was meant to ensure food security of highland food insecure households, has relocated millions of such households to dryland rangelands. In fact such a strategy has been used by successive governments of Ethiopia since the 1960s including the present one (Belay, 2004, Hammond, 2008). This resettlement policy measure of the government has been pointed out as a major change cause of land degradation in the lowlands of the country. For example, following the 1984 famine and more recently large numbers of families from Hararghe have been moved to the Bale lowlands. In Delo Mena *woreda* land conflicts between the settlers and the local population are common and there is generally poor integration. Many of the newcomers are agriculturalists, which has sped up the cultivation of land at the further expense of pasture (Fiona *et al*., 2012). High influx of migrants from the Tigray highlands to the Afar took place, particularly after the severe 1984/85 drought (Dires *et al*., 2010).

Similarly, the investment policy that encourages commercial agriculture is driving significant dryland woodland degradation. Between 2009 and 2011 a total of 350,099 ha land, which are mostly in the drylands have been leased for agriculture-oriented investment (Bossio *et al*., 2012).

In 2009 the Government of Ethiopia launched plans for agricultural investment areas in several regions of the country to a total of 3.7 million hectares. Land already identified and secured in the government 'land bank' (or already allocated to investors) includes 409,678 hectares in the Awash River Basin, 180,625 hectares in South Omo, and 444,150 hectares in Gambella and 691,984 hectares in Benishangul-Gumuz. The evidence to date suggests that much of this are in pastoral areas along rivers, and unless appropriate measures are taken risk, this will risk the restriction of access to (or the complete removal of) key-site grazing areas and water sources.The experiences of investments already underway suggest that the needs of pastoralists and other rangeland users may not be taken into account within the establishment and development of these schemes unless appropriate measures are taken. Future threats to pastoral livelihoods come from the development of oil and mineral extractions and large water development schemes, including the building of dams and the establishment of linked irrigated-agricultural schemes for commercial investors and sedentarised communities (including ex-pastoralists).

Over-grazing

Over-grazing of rangelands is a problem worldwide and Ethiopia is no exception. Increase in human population necessitates the increase in livestock population inrangelands in order to maintain survival. In pastoral areas of Ethiopia, the animal populations are growing at an increasing rateto meet the need of increasing human populations, while the pasture resource onwhich they depend is limited or diminishing both in terms of grazing area and range productivity (Coppock 1994). These increases in livestock populations are increasing the imbalances in the lowland range system and have already resulted in overgrazing and range degradation (Alemayehu, 2004; Amaha *et al*., 2008; Gemado *et al*., 2006; Solomon *et al*., 2007; Teshome, 2016).

Decline of traditional resource management practice

The loss of traditional indigenous knowledge and decline in the participation of elders in the rangeland management are an important cause of rangeland degradation. Despite the recognition of the importance of traditional system of resource administration globally, the level of emphasis given to the system by policy makers, leaders, researchers

and development workers is still low (Abule and Alemayehu, 2015).

Herd diversification and free ranging of communal land were the common traditional rangeland and livestock management practices reported from East-African countries (Oba and Kotile, 2001). The diversification of herd composition is a response to changing environmental conditions and enhances climate resilience in the region.

Herd mobility a key strategy in response to spatial and temporal variability of rangeland resources (Oba, 2011). Mobility is used for a wide range of purposes, and the practice relies on pastoralists' knowledge and local institutions for making decisions (Oba, 2011). Mobility and opportunistic resource utilization characterized the pastoral production system. It was a very important strategy of pastoralists to exploit scarce vegetation and water resources in dry lands and a practice developed to cope with the harsh environment. Despite the benefit of mobility for pastoralists and the environment, pastoral development policy in Ethiopia emphasizes sedentarization as a way out of poverty, and this policy direction fails to recognize mobility as a means of production in the arid lands.

Population pressure

Demographic factors related to human population growth resulting from an increase in the number of communities themselves, settlements, immigrants from outside the pastoral area and from other pastoral areas are the underlying causes of rangeland degradation. The annual human population growth rate in the Borana rangelands was about 1-1.3% in the early 1970s (Homann *et al*., 2008), about 2.5% in the 1980s (Coppock, 1994) and about 3% per year in the late 1990s (Helland, 1997). However, more than the natural growth, spontaneous and planned human migration (settlement or resettlement) to the lowland is a major problem. As land access in the highlands is growing scarce and those available are degraded, many are migrating to the lowlands where there exists relatively unpopulated land. In addition, a series of government resettlement program have targeted these areas, causing a rapidly building up of human population. Between 2000 and 2004 alone, about 440,000 household heads or 2.2 million people were formally resettled in four regional states of Ethiopia, namely Amhara, Oromiya, SNNPR and Tigray, and the majority of these resettlements took place in dryland areas (Mulugeta *et al*., 2012b).

With a redrawing of regional boundaries between Somali region and Oromia due to geopolitical and domestic political processes, there has been a loss of land from the latter and ongoing conflict between the Borana and the Somali-Garri. Oromo groups have moved into neighboring Oromo communities increasing populations there. For example, the numbers of *ollas* (settlements) in Dirre district has increased from 10 to 58 (Gemtessa *et al*., 2005). This and other processes have led to a large population growth rising from 300,000 in the 1980s to over one million in 2007 (CSA, 2007). A common result of increasing population is land degradation because of higher population implies increasing demand for forest products, space for settlement, grazing and farming areas (Mulugeta and Habtemariam, 2010). From this, it can be inferred that increases in human population can aggravate pressure on the existing rangeland resources and lead to land degradation.

Encroachment of cultivation lands

In developing countries, particularly in Africa and Middle East, traditional pastoral societies have lost their relative influence within the new national states of the dry lands, where political and economic powers tend to be in the urban and agricultural sectors (Thurow, 2000). Recent encroachment of rain fed cropping into the better pasture land can be understood as a response to newly created national policies for increased food production and increased emphasis on cash crops as producers of foreign exchange (FAO, 1993). Thus valuable grazing lands have been lost and important traditional exchange relationships between pastoralists and farmers have broken down. In addition to the above reasons, the expansion of large-scale commercial farms without due consideration to the benefits of the local pastoralist is considered a threat to the livestock production system. These interventions can help the country in many ways. However, great concern must also be given to the pastoralist's welfare and the ecology of the rangelands.

Compared to the past, it can be said that there are no areas where crop production is not practiced in pastoral areas. A study in Rayitu district (Ethiopia) revealed about 30 years before, 94% of the respondents were totally pastoralists. Currently, only 36% are purely livestock herders, with 63% combining livestock and crop production (Abate *et al*., 2010). Cropping in many dry land areas is risky with crop failures in as many as 2 to 3 years out of 5, increasingly; it remains a popular diversification strategy, especially among poor herders in SSA, although, it is exceedingly difficult for smallholder crop producers to get an adequate return on investment to consistently lift them above the poverty level (Harris and Orr, 2012). As more dry areas are cropped, it typically exploits key resource patches that are vital to pastoral production, can hinder mobility and also increase the conflicts between herders, farmers and wildlife (Haan *et al*., 2014). The

conversion of rangelands in cultivated lands and loss of high potential rangelands of pastoralists concentrates growing populations of pastoralist and livestock on smaller areas of less productive rangelands, leading to increased competition for resources and overexploitation (such as overgrazing) of rangelands (Alemayehu, 2005).

Frequent Drought

The frequent drought in many parts of the world's lowlands and notably in Africa is a prominent factor which has contributed to range degradation. In meteorological terms, Pratt *et al*., (1977) suggested that drought occurred when rainfall was below half the long-term average or when rainfall in two successive years fell 75% below average. According to Coppock (1994), drought can be defined as 'when two or more consecutive dry years occur in which the length of the growing period (LGP) is less than 75% of the mean, i.e., a drought is driven by several consecutive rainy seasons in which deficient rainfall has a determinant effect on the production system.'

When there is drought and overgrazing together, the effect on the productivity of the rangeland is double barreled (Herlocker, 1993). The pastoral rangelands are periodically perturbed by episodic events such as droughts that result in mass livestock mortality (Oba and Kotile, 2001). Prolonged drought including a shortage and erratic rainfall can cause serious range degradation (Abate et al., 2012; Abate et al., 2016). Rainfalls during drought is hardly adequate to allow grasses to grow and unable to fill the surface water ponds (Alemayehu, 2004). For example, the report from Borana rangelands, during the major drought years of 1983–1984, 1992–1993 and 1999–2000, the mean annual rainfall declined by 14%, 35%, 18%, 17%, 52% and 43%, respectively (Ayana, 2007).

Bush Encroachment

The rapid expansion of encroachment and invasion of plant species in Ethiopia has been widely reported as a common form of rangeland degradation (Ayana and Oba, 2008; Solomon *et al*., 2007; Gemedo *et al*., 2006; Abule *et al*., 2005b). Bush encroachment refers to the spread of plant species into an area where previously it did not occur. Invasion on the other hand, refers to the introduction and spread of an exotic plant species into an area where previously did not occur. Thus, bush encroachment could occur even with indigenous species and it is more defined by plant density than species themselves. Whilst invasion on the other hand, although it includes plant density, focuses on the exoticism of species in question and it is, therefore, more species specific. Furthermore, while encroachment focuses on the woodiness of the species, invasion is not limited to woody species but includes the alien herbaceous species; thus, there are grasses that are classified as invaders (Trollope *et al*., 1990).

From semi arid rangelands of southern Ethiopia several study reported rapid expansion of bush encroachment (Solomon *et al*., 2006b; Gemedo *et al*., 2006; Haile *et al*., 2010). According to Assefa *et al*. (1986), about 40 % of the Borana rangelands were affected by bush encroachment in the 1980s, while the study by Gemado *et al*. (2006) have estimated the progression of bush cover to 52 %. A study by Abule (2009) revealed the bush cover in the Borana rangelands exceeds 63%. There are no accurate data on the areas covered by invasive woody plant species for Afar and Somali regions. However *P. julifolora*, *A. seyal*, *A. melifera* and *A. senegal* are of a major concern (Abule, 2003, Amaha, 2006). Especially, the spatial extension of *Prosopis juliflora* in Ethiopia is even difficult to assess since it is expanding rapidly, up to 18% per year (Felker, 2008). One million ha is already covered by *P. juliflora* in entire Ethiopia (Ryan, 2011), of which about 700,000 ha are located in the Afar Region (Mueller *et al*., 2010). A further rapid spread is to be expected. Thus, more efforts are needed in order to control its invasion and ensure sustainable resource use and management in the Ethiopian rangelands in general.

Impacts of rangeland degradation

Rangeland degradation in the pastoral communities has resulted in substantial declines in rangeland condition, water potential, soil status, and animal performance, livestock holding at the household level, while communities in general have lost their livestock asset and become destitute. Another consequence of rangeland degradation is linked to food insecurity, poverty to the extent of food aid, expansion of aridity and the needfor alternative livelihood income and diversification (Kassahun *et al*., 2008; Teshome, 2016). Moreover, it has increasingly become a threat to the pastoral production systems and has contributed towards increases in poverty and tribal conflicts over grazing land and water resources (Abule *et al*., 2005; Solomon *et al*., 2007).

Rangeland restoration

Rangeland degradation is a widespread problem throughout sub-Saharan Africa. The combined effect of human and climatic factors on land degradation has led to reduced production of the rangelands and reduced environmental quality (Jama and Zeila, 2005). Though restoration of degraded rangeland remains a challenge, studies have shown that degraded vegetation is able to recover in a relatively short time when protected (Yayneshet *et al.,* 2009).

Range rehabilitation/restoration measures take various forms, which include reseeding or allowing the progression of natural regeneration, soil and water conservation measures, and water harvesting and dryland forestry. For rehabilitation to be effective and successful, it should target the underlying causes of degradation and reverse the degradation process (Li *et al.*, 2011).

The introduction of appropriate rangeland management laws together with effective restoration/rehabilitation of degraded rangelands would contribute significantly to halting and reversing the land degradation and improving the carrying capacity of the rangeland (AU-IBAR, 2012). For effective control of degradation, management techniques involving prevention and rehabilitation are preferred over techniques of restoration which are often too expensive for widespread application (Puigdefabregas, 1998). In essence, prevention of rangeland degradation is preferred over rehabilitation not only in terms of cost but also due to the accelerating and reinforcing nature of rangeland degradation once it has reached a certain stage, and the possibility of irreversible effects (Jaap, 1990). With this in mind, it is critical that areas that are not yet degraded or are in fair condition are conserved and their productivity enhanced.

Rangeland restoration techniques

The restoration of an ecosystem, need in-depth understanding of how it worked before it was modified or degraded, and then use this understanding to reassemble it and reinstate essential processes (Blench and Florian, 1999). In general there are two types of restoration, the first one is passive restoration (restoration of degraded habitats by ceasing anthropogenic perturbations that are causing degradation) (Kauffman *et al*., 1995) and the second one is active restoration (biotic manipulation that is practiced by reintroduction of animal or plant species that have been extirpated from an area) (Kauffman *et al*., 1997).

Active restoration action may not be necessary in places where the damage is not too great since the natural succession alone may be capable of restoring equilibrium (Jackson *et al*., 1995). However, factors such as species extinction, exotic predators, and loss of hydrologic function can prevent ecosystems to attain natural dynamic system through passive restoration. In addition, the restoration of ecosystems that are sufficiently degraded to a state that would occur naturally is not possible by the implementation of passive restoration only, but need to be intervened by active restoration techniques (Kauffman *et al*., 1997; National Research Council, 1992).

Re-vegetation of degraded rangeland

In the pastoral areas of the country, prolonged heavy grazing pressures combined with the recurrent drought has changed large areas of the rangeland to bare soil. Rangelands in such situations are prone to wind and soil erosion, which in turn leads to decline in soil fertility and seed in the soil (Tessama *et al*., 2011). In such extremely degraded rangelands where soil seed bank has completely depleted or in situation where the relative proportion desirable species has fallen below critical levels (<10-15%), the land degradation problem can be reversed through reseeding (Abule and Alemayehu, 2015). Seed needs to be introduced for restoration of degraded rangeland projects to be successful in the short-term. Reseeding technology has been used successfully as a means of rehabilitating degraded rangelands in East Africa (Musimba *et al*., 2004; Tabeje *et al*., 2014) but are not common in a pastoral setting because of their high capital requirements (van den Berg and Kellner, 2005; Opiyo *et al*., 2011). The study conducted in south east Ethiopia by Tebaje et al. (2014) showed the possibility of restoring degraded rangeland with reseeding of Rhodes grass (*Chloris gayana Kunth)* with simple tillage and manure application.

Reseeding involves collecting seeds from existing grasses and then sowing them on bare ground. The reseeding approach would involve ground preparation using fertilizers and ongoing nurturing, as well as encouraging pastoralists to collect enough seeds in the growing season to sow the land when needed. Native grasses are well adapted to the harsh environment of semi-arid areas. Many exotic species generally fail to persist due to drought or infertile soils (Blench and Florian, 1999). Native grasses not only provide necessary habitat for many native animals, they provide a suitable pasture base for animal production and can perform well as exotic species under harsh conditions (Oba and Kotile, 2001).

Prescribed fire

In East African savanna systems, fire is a common phenomenon that has a major impact on ecosystem structure and functioning (Higgins *et al*., 2000). The most obvious effect of fire is the removal of old, dead vegetation, which is replaced by young re-growth, i.e. green-flush. Herbivores are attracted to this re-growth (Frank *et al*., 2003) and feeding on post-fire re-growth leads to greater mass gains, as compared to feeding on unburned vegetation (Higgins *et al*., 2000). Numerous studies have shown that post-burn savanna vegetation has a higher above ground nutrient concentration than unburned vegetation during the post-fire growth season (Higgins *et al.*, 2000; Frank *et al.*, 2003).

Fire is often an essential tool for controlling woody vegetation, removing dead biomass, clearing, stimulating grass growth and palatability, hunting and controlling wildfires and pests (Herlocker, 1999). An example data set from plots burned at Dida Hara pastoral association of Borana rangeland, Southern Ethiopia in 2005 demonstrated that the cover of highly valued grass (*Themeda tiandra*) increased from 18% to 40% of the basal cover and the amount of bare ground was accordingly reduced after burning (Gebru *et al*., 2007). This study and observations suggest that if prescribed fire is implemented properly, and used in conjunction with other appropriate range management practices, prescribed fire can be used to reduce bush encroachment and increase the forage production and quality for grazing animals. Fire is an important factor in maintaining grassland ecosystems. It also has an ecological role in shaping the structure and composition of rangeland vegetation (e.g. Ayana and Oba, 2008). Without fire, organic matter and litter would accumulate and tree densities would increase, leading eventually to forested areas. Changes in fire regimes, in combination with grazing, are often associated with an increase in woody vegetation, resulting in large increases to the carbon store. Also, in many rangeland ecosystems, specific fauna and flora are fire-dependent and removing fires will result in a loss of biodiversity (Stephen *et al.,* 2009).

Pastoralists traditionally used fire to control the expansion of bush cover and ticks, to improve pasture quality, and to facilitate livestock movements. However, the use of fire was prohibited in the early1970s (Coppock, 1994). As a result, bush covers have significantly increased (Oba, 1998). The prohibition of fire resulted in bush encroachment increase in the last four decades, with negative effects on cattle production and community livelihood (Ayana and Oba, 2008), thereby accelerating the degradation of rangelands.

Bush encroachment control

Bush encroachment control is a disturbance that reduces the threat of bush encroachment by disrupting the invasive woody plant community structure through transformations of biotic environments and habitat conditions in which colonization of the disturbed microhabitat takes place. Bush control methods shift the rangeland vegetation from dominance by woody vegetation to dominance by herbaceous vegetation. This control of the bush is aimed at creating suitable habitat for grazers (Ayana and Oba, 2008). Thus, forage production of herbaceous vegetation increases with reduction of woody species.

Different types of bush encroachment control methods are available, but the most common methods are rangeland management, mechanical, biological and chemical methods. Most often, a single method is not always effective to achieve sustainable control of the rangeland weeds. Thus, integrated approaches are warranted to restore rangelands degraded by bush encroachment by combining more than one method (Lesoli *et al*., 2010; Belachew and Tesema, 2015). To address this problem, public awareness has to be developed and participatory approach to control the invasive weeds should be adopted (Patel, 2011).

Bush encroachment is now considered by many to be the major environmental problem facing pastoralists in semi-arid and arid environments. These encroachers have strongly increased in both cover and density in grasslands and savanna systems worldwide over the past century, which has been particularly visible in African savannas (Bassett and Zue'li, 2000; Sankaran *et al.*, 2005; Munyati *et al.*, 2010). These increases might trigger biome shifts from grassland to shrub land (Briggs *et al.*, 2005). This is of concern to pastoralists' and their grazing livestock since the thickening tree/shrub vegetation competes with the herbaceous forage and reduces stock carrying capacity (Abule *et al.*, 2007; Ayana andOba, 2008).

Ayana (2007) argued that the use of bush or shrub clearing may be important in the management and improvement of the rangelands with the practice of prescribed burning. The grass component reacted positively to the tree thinning in terms of total dry matter (DM) yield, but forbs were negatively influenced (Smit, 2005). According to Abule *et al. (*2007) and Bikila *et al*. (2014), as woody plant cover or density increases, grass diversity typically declines dramatically. Herbaceous production generally increases after the removal of trees, except in some low rainfall zones or where grazing or past land use has limited the availability of perennial grass propagules or favors exotic weeds and shrubs (Abule *et al*., 2007). Grass growth after clearing may be further augmented by nutrients released from decomposing tree residues. According to Samuel (2009), a rangeland that is encroached by acacia species has improved their under-storey vegetation production and soil fertility if they are thinned at a certain thinning intensity. As a result, the magnitude of release of herbaceous production after tree removal may be greatest on landscapes with high cover of mature, large woody plants.

Rangeland enclosures

One common technique that has been successfully tested in restoring degraded rangelands is the use of enclosures whereby grazing is excluded for a specified period of time. Experience from different

parts of Ethiopia indicates that enclosures can be viable systems for restoration of degraded land if they have clearly defined users, resource boundaries and realistic rules established locally (Mohammed *et al*., 2016). However, a study of the long-term consequences of treating land in this way also revealed that the proliferation of bush encroachment is a major threat in these enclosures over time, as compared to more regularly grazed rangelands (Ayana, 2007). Therefore, special care should be given by incorporating scientific and indigenous knowledge in the management of rangeland enclosure to prevent unwanted results.

Grazing management

The basic principles of range management require the maintenance of livestock numbers with available forage supply, uniform distribution of animals within the range, vegetation maintenance through alternating periods of grazing and rest, and use the most suitable kinds of livestock. The connection between land degradation and livestock management is an acknowledged problem in the arid and semi-arid areas, calling for improvements in livestock management strategies and hence enhancing grazing management best practice is important for sustaining the productivity and health of rangelands (Illius *et al.*, 1998; and Ash *et al.*, 2011). In degraded rangeland, the reduction of stock number and controlled grazing has been recommended to lower grazing pressure in order to facilitate rehabilitation (Wessels *et al.*, 2007 and Li *et al.*, 2011). As alluded to by Woodfine (2009), the target of sustainable land management in pasture and range managements maximization of the capture, infiltration and storage of rainwater into soils, which promotes favorable conditions for increased vegetation cover, soil organic carbon, and resulting in sustainable utilization of above and below ground biodiversity.

Controlled grazing management practice is considered beneficial in conditions of poor vegetation cover, overgrazing and degraded soils, and is considered as the most promising SLM practice to restore degraded rangelands as it enhances the vigor of mature perennial grasses (Woodfine, 2009). The use of grazing practice as a management tool for enhancing range productivity and restoration needs to consider grazing history of the degraded rangeland. This is particularly important if the degraded grazing lands havea historical trajectory of large herbivores including livestock (Papanastasis, 2009). In case of rotational and deferred grazing, it is recommended that the partitioning of land should be based on ecological variation, and the timing and duration of grazing be worked out separately for each land type and for each grazing territory in order to account for biophysical variations mainly soils and vegetation (Abel and Blaikie, 1989). Besides its significance in range restoration, improved grazing management will improve the functioning of the hydrological systems in drylands and contribute to the protection and restoration of biodiversity (Woodfine, 2009). Indeed, according to International Union for Conservation of Nature, unsustainable livestock management has been identified as a major threat to biodiversity of a high number of threatened species (Neely *et al*., 2010).

CONCLUSION

Rangeland degradation has increasingly become a threat to the pastoral production systems and has resulted in substantial declines in rangeland condition, water potential, soil status, and animal performance, livestock holding at the household level which in turn leads to food insecurity, poverty to the extent of food aid and the need for alternative livelihood income and diversification. Despite the negative consequence of rangeland degradation, the achievement of sustainable rangeland ecosystems remains a challenge for Ethiopia; rangeland degradation has not been arrested and the ecosystem services provided by the rangelands are not valued. The degradation of rangelands is progressing at an alarming rate which gives the impression of difficulty to restore it in the future. Therefore, research and development should focus on sustainable rangeland industries and to develop strategies that relieve disturbance of rangelands and permit the restoration of stressed and dysfunctional rangelands.

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