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Assessment of Range Land Degradation, Major Causes, Impacts, and Alternative Rehabilitation Techniques in Yabello Rangelands Southern Ethiopia. *Review paper*

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Abstract

Background: Rangeland degradation means that a reduction both in rank and status of general floral/ fauna composition, energy flow and biomass of a certain ecosystem.

Objective: The review was conducted to assess rangeland degradation, cause and its impact on local livelihood in Yabello district and also suggests appropriate methods used to rehabilitate it. **Methods:** The data and literatures were collected from different both domestic and abroad researcher research result reviewed and internet sources. The research paper review mainly addresses concepts of rangeland degradation, major causes in tropics and Ethiopia particularly in Yabello rangelands, impacts of rangeland degradation, principles of rangeland restoration and common restoration techniques.

Result: Based on those research papers and the current fact situations the major drivers leading to rangeland degradation includes climate change, overgrazing, bush encroachment, both human and livestock population pressure, drought, and government policy . Of all bush encroachment is becoming the major threat to Yabello rangelands. And this led to decline in rangeland condition, water potential, soil status, and animal performance, livestock holding at the household level and community become destitute and in the long run poverty. In spite of these impacts, the action of restoration techniques in the area is highly insufficient.

Conclusion: Generally in order to address rangeland degradation problems, there is a strong need to coordination between the local community and the scientific community for sustainable land management trough post management techniques by applying reseeding technology.

Keywords: - Yabello rangeland, degradation, rehabilitation techniques, encroachment

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1. Background

Rangelands include natural grasslands, savannas, shrub lands, many deserts, steppes, tundra's, alpine communities and marshes in which indigenous vegetation (climax or sub-climax) are grazed or have the potential to be grazed to produce grazing livestock and wildlife (Allen *et al*., 2011). The range lands of Ethiopia are estimated to cover area of 78 million hectare and most of them are found at an altitude below 1500m of elevation and generally classified as arid and semi-arid (Dawit Abebe, 2000).The rangeland of southern Ethiopia, which includes Borana rangeland is an important area of cattle production. The Borana are the dominant pastoralist group and they have been living in the region before the 13th century (Oba *et al,* 2000). 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 (Mussa *et al,.*2016).Now a days range lands have been faced many challenges and this resulting great frustration for the pastoralist communities. Because of different threats like climate change and the intensive human activities, desertification / land degradation has become the most serious problem in the pastoralist society, particularly in the ecologically sensitive arid and semi-arid areas of Yabello (Mussa *et al*, .2016). Rangeland degradation implies a reduction in rank or status of general floral/ fauna composition or a transition from one organic form to a lower organic form, and continuous reduction of productivity/biomass of the ecosystem (Barrow 1991). Pastoralists utilizing degraded rangelands generally suffer from poverty and food insecurity (Donald and Jay, 2012). 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 (Teshome *et al.,* 2016). The other problem in Yabello rangelands is crop cultivation encroachment and communities were highly involved in crop cultivation as an alternative means of livelihood (Tilahun *et al.,* 2017).

Rehabilitation attempts to return an ecosystem to its sustainable community. Rehabilitation action on the other hand is the ultimate goal of ecosystem management. In the rangelands, the most common objective is to encourage palatable, productive perennials, as they are good for animal performance and to maintain a healthy environment (Saco *et al.,* 2006). Moreover, lack of information and knowledge is considered to be one of the major obstacles for reducing land

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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 assess concepts of rangeland degradation by giving due emphasis to Yabello rangelands from data available from different studies, to know major causes of rangeland degradation and its impact and to identify and recommend the most appropriate methods used for rehabilitation of the Yabello degraded range lands.

2. Rangeland Degradation

Rangeland degradation is a decrease in plant species diversity, plant height, vegetation cover and plant productivity. Recently, degradation has also come to mean deterioration in ecosystem services and functions, such as decreased water and soil conservation, recreation values, carbon balance and so on. It also defined as the loss of utility or potential utility or the reduction, loss or change of the features of rangeland ecosystem. In general, rangeland degradation is reduction in the rank or status of natural vegetation. 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 (Yabello) rangelands which could have different implications for pastoral productivity (Chen *et al,* 2003). As result the major threats in the Yabello rangeland were loss of perennial grasses and the increase in annuals, unpalatable forbs and bush cover (Oba and Kotile, 2001).

3. Major causes of Rangeland Degradation

Rangeland degradation, a worldwide problem, is serious in Ethiopia, especially in Southern Ethiopia. In Yabello-Borana Southern, Ethiopia, loss of perennial grass cover and increase in annuals, unpalatable forbs and bush cover are the leading cause and also conversion of rangeland to cropland, wood harvesting and over-grazing by livestock are the major causes (Musa *et al*., 2016). 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.

3.1. Climate change

Rise in temperature and fall in rainfall has been measured in the southern and eastern Ethiopia in the since 1996 years

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With temperature increase has come more dry and windy periods and hence increased erosion events (Chen *et al.,* 2003). Climate change is seen as a key ecological driver that influences the dynamics of sub-Saharan rangelands (Hoffman and Vogel, 2008). As I understand from different projected data 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. The dry land range lands of Ethiopia in particular Yabello 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).

3.2. Over-grazing

Over-grazing of rangelands is a problem worldwide and Ethiopia is no exception. According to the World Resource Institute (WRI, 1992), overgrazing is the most pervasive cause of soil degradation. In arid and semi-arid regions Africa and Australia, overgrazing causes 49 and 80 percent for soil degradation respectively. In overgrazed land the animals clip the vegetation to the bare ground, causing starvation and death of the root system (Purdon and Andreson, 1980).

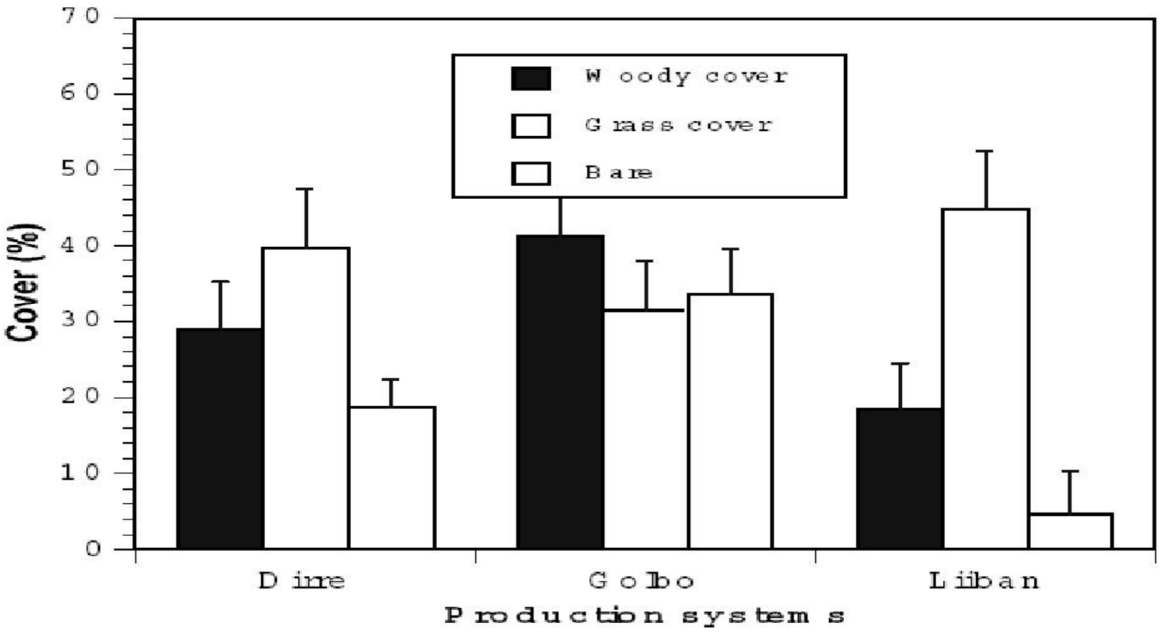

Figure1: Potential grazing capacity as a percentage of total landscapes in Liban, Dirre and Golbo production systems around Yabello district. *Source: Oba and Kotile, 2001.*

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In pastoral areas of Yabello Sothern, Ethiopia, the animal populations increasing in a very high rate in order to meet the need of increasing human populations, on the other hand the pasture resource on which they depend is limited or diminishing both in terms of grazing area and range productivity (Coppock 1994). These results imbalances in the lowland range system and have already resulted in overgrazing and range degradation (Alemayehu, 2004; Amaha, 2006; Gemado *et al.,* 2014; Teshome, 2016).

3.3. Bush encroachment

The rapid expansion of encroachment and invasion of plant species in Ethiopia particularly in Yabello 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.,* 2007). 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. In the process of bush encroached, land vegetation was shifting from herbage to bush, the coverage of herbage decreased and the area of bare land increased the spatial and temporal variability of soil water and nutrients were increased (Zhang H. *et al* ,.2001) and the process has an important impact to structure and function of the community ecosystem, which reduced herbage production, declined carrying capacity of native pasture, threaten sustainable progress of livestock production. By using different techniques both domestic and foreign scholars have done a lot of research on bush encroachment in order to monitor the distribution and change of the vegetation form as a result of its explanation on the Yabello range land area (Dalle G .*et al,* .2014). Remote sensing image data of different type of sensors had already widely applied for quantitatively represent the grade of bush encroachment, accurately accessed bush coverage of bush encroachment grassland and it is important evidenced to understand the dynamic change of bush encroachment grassland (Coppock, D. L.1994).Even though, Ethiopia has more range land area currently, most of it, especially the Yabello rangeland highly infested by the bush encroachment species dominantly by *Acacia spp.*, the cattle, sheep and other livestock cannot enter and feed, thereby reducing the livestock production (Tsegaye D. *etal,.2010*).

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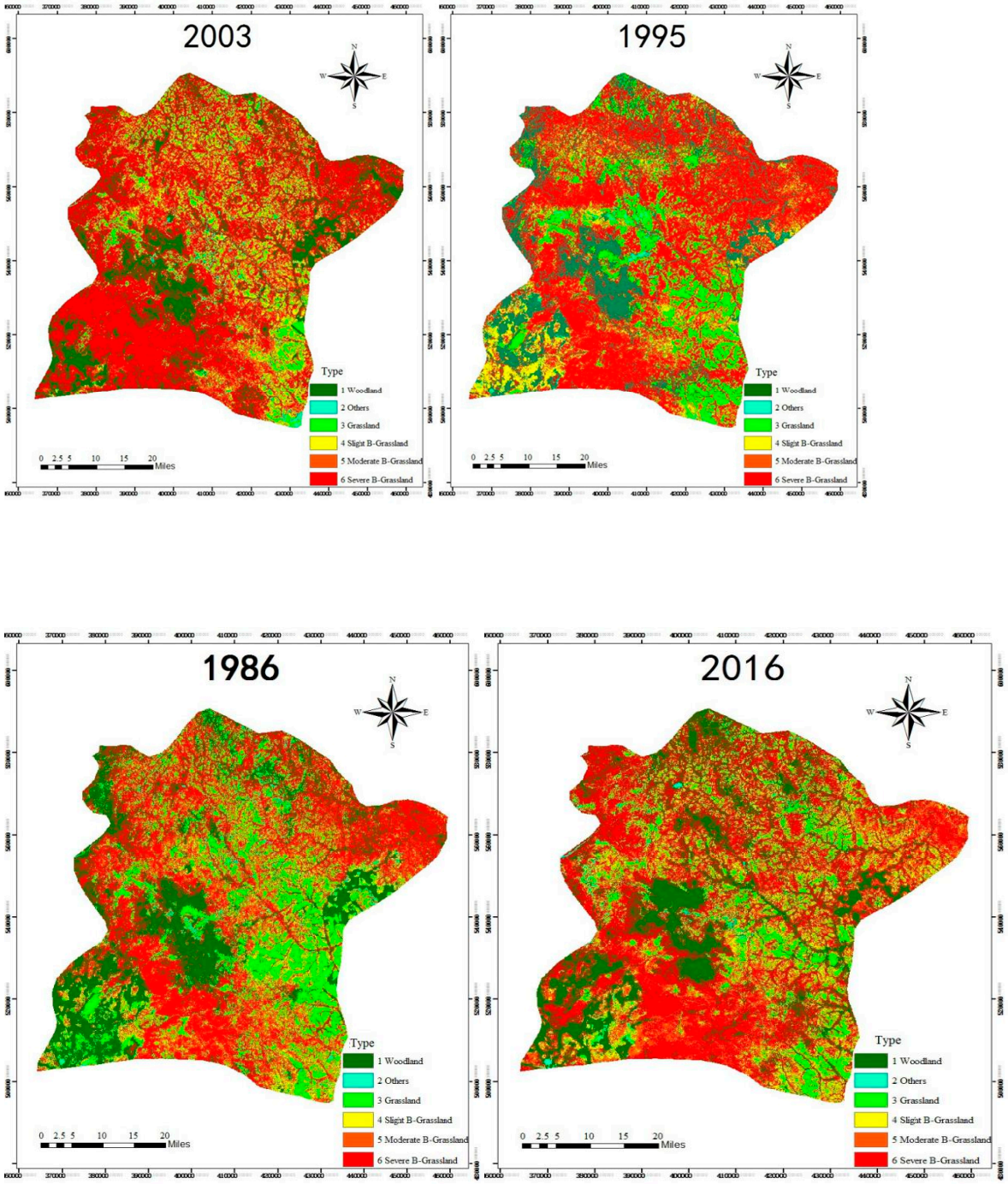

Figure 2:- The infested rate of bush encroachment on the study area from Remote sensing image source (WANG Y. *et al,* .2016).

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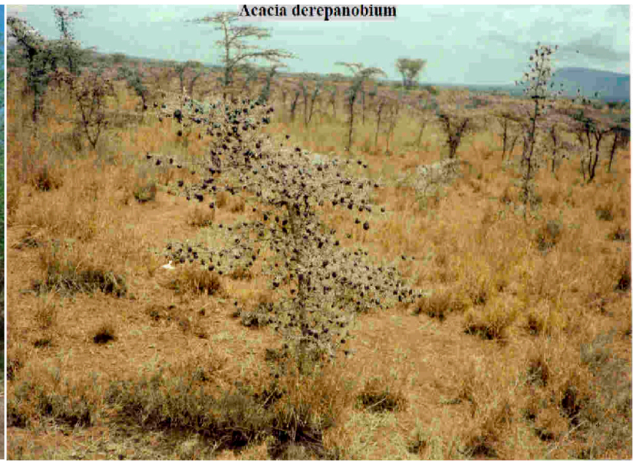

Figure 3: *Acacia mellifera* (Vahl.) Benth in Harweyu Kebele

Figure 4: *Acacia drapanolobium* (Harms ex sjostedt.) in Dharito Kebele

Table1: Means ± SE mean yields of grass species composition (% dry matter) for encroached versus non-encroached rangelands in Yabello .

Species	Encroached	Non-encroached
Aristida adiscensionis	6.6 ± 1.76^{a}	8.8 ± 1.76^{a}
Cenchrus ciliaris	18.5 ± 4.95^{a}	14.3 ± 4.95^{a}
Chrysopogon aucheri	17.6 ± 1.70^{a}	20.3 ± 1.70^{a}
Eragrostis papposa	1.9 ± 0.34^{a}	2.4 ± 0.34^{a}
Lepthotrium senegalensis	0.9 ± 1.24^{a}	5.5 ± 1.24^{a}
Panicum coloratum	9.0 ± 2.86^{a}	10.4 ± 2.86^{a}
Pennisetum mezianum	7.8 ± 2.81^{a}	0.9 ± 2.81^{a}
Pennisetum stramineum	8.8 ± 1.19^{a}	2.9 ± 1.19^{b}

***Note*:-a,b** Different superscripts within a row show significant difference ($P < 0.05$). *Source: Ayana, 2005*

3.4. Drought and shortage of rain

The frequent drought in many parts of the Africa's lowlands and notably in Ethiopia is a prominent factor which has contributed to range degradation. When there is drought and overgrazing together, the effect on the productivity of the rangeland is double barreled (Herlocker, 1999). Prolonged drought including a shortage and erratic rainfall can cause serious range degradation (Abate *et al.,* 2016). In Yabello rainfalls during drought is hardly adequate to allow grasses to grow and unable to fill the surface water ponds (Alemayehu, 2004). For

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example, the report from Yabello rangelands, during the major drought years of 1983–1984, 1992–1993 and 1999–2000, 2015-2016 the mean annual rainfall declined by 14%, 35%, 18%, 17%, 52% ,43% and 51% respectively (Musa *et al.,* 2016). As a result mobility is the most important pastoralist adaptation to spatial and temporal variations in rainfall, and in drought years many communities make use of fall-back grazing areas unused in 'normal' dry seasons because of distance, land tenure constraints, animal disease problems or conflict (Blench & Florian 1999). But

3.5. Human and Livestock population pressure

Usually, increase in human population implies increase in livestock population in order to maintain survival. Increase in the size of population and overstocking are in turn causing imbalances, for example, in Yabello-Borana range system and have already resulted in overgrazing and range degradation (Alemayehu, 2004 , Gamedo ,2014) reported that overgrazing has been one of the major factors that have caused degradation in rangeland in Yabello. The effects of overpopulation highly influenced on food availability and increased poverty have contributed to the sedentarization of pastoralists (Alemayehu, 2005). This make most of the community concentrated one centered area on permanent water supplies (Herlocker, 1999 in Alemayehu, 2005) become overuse of rangeland resources and subsequently resulted in rangeland degradation and reduced biodiversity.

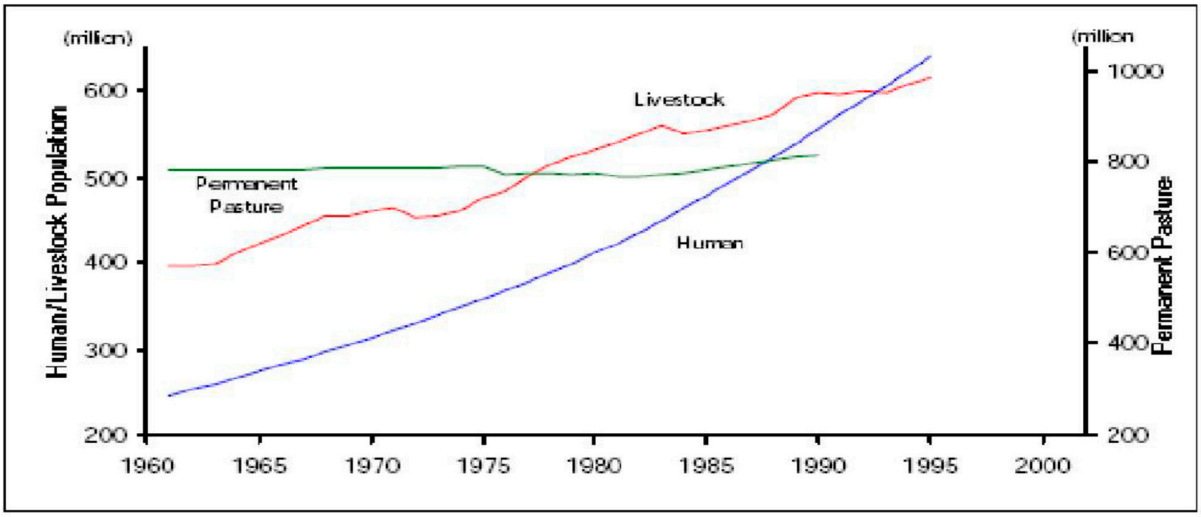

Figure 5: Trends in human/livestock population and permanent pasture in the study area (SORDU, 1990). (*Source: FAO, 1996*)

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3.6. Give less attention for traditional rangeland management practice

Less value given for indigenous knowledge and the participation of elders in the rangeland management are becoming an important cause of rangeland degradation. The recognition given by policy makers, leaders, researchers and development workers for indigenous knowledge and elders is still low (Abule and Alemayehu, 2015). Traditionally the communities used herd diversification, mobility and free ranging of communal land in order to protect rangelands from degradation (Oba and Kotile, 2001). 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. But now a day it becomes almost got less attention and the concerned body is not give appreciation and recognition rather it needs replaces by the other methods which is not successful on that area.

3.7. Government policies

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. In Ethiopia, rangeland policies were designed on the basis of the ranch model as an alternative to the communal rangelands without understanding the consequences of changing land use on the environment (Ayana, 2005). The Yabello-Borana rangelands in southern Ethiopia have been substantially altered with the advancement of bush encroachment. The expansion of bush encroachment has been attributed to the official banning of fire due to the policy of forest land conservation in the form of enclosures to foster the regeneration of naturally occurring plant species. Fire was banned as a result of inappropriate management policy. The policy never considered the implications in terms of the threat of bush encroachment on pastoral production (Gemedo *et al.,* 2006). As a result, the density of bush encroachment has been increased to the extent that the capacity of grazing is reduced. The official banning of fire had previously assumed that the use of fire would be damaging to the rangeland ecosystems. According to the data collected by T. Abate *et al*, (2016), all the cause of range land degradation is ranked as follows.

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Table2. Possible causes of poor range condition and rangeland degradation as ranked by the responses of the sampled households in Yabello district (n = 90).*Source (T. Abate et al, .2016)*

Causes	Current range condition	Rangeland degradation
	(%)	(%)
Drought	90	87
Overgrazing	49	45
Bush encroachment	34	25
Population pressure	52	36
Increased settlement	11	27
Decrease in livestock mobility	-	33
Limited knowledge of rangeland management	37	27
Soil erosion	-	18
Lack of burning	1	7

4. Impacts of rangeland degradation

Rangeland degradation has a great impact in the pastoral communities and in the country level that 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. And this results food insecurity for the local community and become burden for the government due to the need for alternative livelihood income and diversification (Teshome, 2016).In the long run it results poverty and tribal conflicts over grazing land and water resources (Solomon *et al.,* 2007).

5. Rangeland rehabilitation techniques

Due to the combined effect of both human and climatic factors rangeland degradation spread fast and led to reduced production of the rangelands and reduced environmental quality (Jama and Zeila, 2005).As a result rangeland rehabilitation is becoming an increasingly important tool in humanity's attempt to manage, conserve and repair the degraded rangeland ecosystems (Schlesinger, *et al.,* 1999).The main objective of rehabilitation is not in the establishment of aboveground vegetation but in the return of a community that is dominated by native species. In order to rehabilitate the dreaded rangeland in-depth understanding of how it worked before it was modified or degraded, and then use this understanding to reassemble it and reinstate essential

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processes highly needed (Blench and Florian, 1999). In general based on the damaged rate there are two types of restoration, the first one is passive restoration (restoration of degraded habitats by ceasing anthropogenic perturbations that are causing degradation) 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).

For effective rehabilitation of the rangeland we can take different techniques like reseeding or allowing the progression of natural regeneration, soil and water conservation measures, and water harvesting and dry land forestry focus on the underlying causes of degradation and reverse the degradation process (Li *et al.,* 2011). Some of the most common methods that used for to rehabilitate the degraded rangelands are listed here below.

A. Reseeding (Introducing Seeds)

This technique is highly applicable and very important for areas faced prolonged vegetation decline to successful rehabilitated in the short period by introduced native grasses are well adapted to the harsh environment of that area and become not only provide necessary habitat for many native animals, they also provide a suitable pasture base for animal production (Oba and Kotile, 2001). Grass reseeding technology has been used successfully as a means of rehabilitating degraded rangelands in East Africa (Tilahun *et al.,* 2017)).Reseeding rangelands has been shown to be both successful and economically feasible by many (e.g. F.P., 2007, Mganga, 2009). Successful reseeding, however, has been shown to be dependent upon aspects such as prevailing weather conditions; weed control; seedbed preparation; and sometimes, pre-treatment of seeds to enhance germination (Mganga, 2009)

B. Grazing management

This method mostly focused on the balance between the numbers of livestock number with the forage availability. Enhancing grazing management best practice in relation to number and also type of livestock considering the type of vegetation is important for sustaining the productivity and health of rangelands (Ash *et al.,* 2011).It is the best practice inarea which is 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). Timely grazing management based on considering grazing history of the area and

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ecological variation can have a positive impact on rangeland condition as well as improve the functioning of the hydrological systems in drylands and restoration of biodiversity in the ecosystem (Neely *et al.,* 2010).

C. Management Bush encroachment

This methods used for reduce the threat of invasive woody plant community structure and shift the rangeland vegetation from dominance by woody vegetation to dominance by herbaceous vegetation to create suitable habitat for grazers (Ayana and Oba, 2008).To do this we can use different rangeland management like, mechanical, biological and chemical methods by considering for better achievement of degraded rangeland rehabilitation using integrated approaches is more recommended (Belachew and Tesema, 2015).To achieved this goal consider indigenous traditional knowledge of the local community and awareness creation and integrated approach should be adopted (Patel, 2011).

This problem become a very serious issue in Africa savanna and also in Ethiopia particularly in Yabello rangeland and shifts the grassland to shrub land by competes with the herbaceous forage and reduces stock carrying capacity (Abule *et al.,* 2007). Abule *et al.,* (2007), argued that in most case the growth of grass on the clearing area of woody plant if they are thinned at a certain thinning intensity by increasing soil fertility.

D. Rangeland enclosures

The ways that made free from grazing of degraded rangeland area to specified period of time and it is highly practiced in different part of Ethiopia (Mohammed *et al.,* 2016).But in the long run it revealed that the proliferation of bush encroachment is a major threat in these enclosures over time, as compared to more regularly grazed rangelands if it is not incorporated scientific and indigenous knowledge (Ayana, 2005).

E. Prescribed fire

The method that conducted at the proper time, and in a safe manner, to meet specific management objectives (Schlesinger, *et al.,* 1999).It makes removal of old ,dead vegetation and replaced by young re-growth vegetation which gives greater mass gains, as compared to feeding on unburned vegetation (Higgins *et al.,* 2000). Timing of fires can be used to favor desirable

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grasses and suppress undesirable grasses plants that reproduce solely by seeds because seeds can be killed by fire if their growing points at the twig tips are exposed to lethal temperatures. It can yield many benefits if it is used with other sound management practices like increase grass nutritive quality, palatability and availability because the fire removes dead plant material and improves access to new growth. And the best example for this is the action happen in Ethiopia Borana rangeland 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).It has also structure and composition shaping of rangeland function for ecological role.

6. Conclusion

Currently the achievement of sustainable rangeland ecosystems remains a challenge for Ethiopia and particular for Yabello district. This is due to ecosystem services provided by the rangelands are not clearly valued by the people in general or Governments in particular. The stresses imposed on rangeland by livestock production continue to rise at an alarming rate and this is not the problem only the community of Yabello area, rather it is shared by the whole community of the country. It is time in Ethiopia to focus research and development on sustainable rangeland management and to develop regional strategies for connecting grazing/cropping/forage systems that relieve disturbance of rangelands and permit the repair of stressed and dysfunctional rangelands. And based on the result of both local and abroad researcher result I highly recommended that there is a high possibility of restoring degraded rangeland especially with reseeding of locally domestic grass found around the area in Yabello rangelands with simple tillage and manure application, so further research will be done on this regards should be highly encouraged.

7. Authors' Contribution

Available data collection , writing up and gap assessment was done by Yeneayehu Fentehun while grammar edition as well as some necessary thing that had been included were performed by Professor XU-Xinwen and Dr.Wang Yong-dong.

8. Competing interests

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PThe authors declare that they have no competing interests

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13. Legends of listed figures in the text

1. Figure 1:- Potential grazing capacity as a percentage of total landscapes in Liban, Dirre and Golbo production systems around Yabello district. Source: Oba and Kotile, 2001.

2. Figure 2:- The infested rate of bush encroachment on the study area from Remote sensing image source (WANG Y. et al, .2016).

3. Figure 3: Acacia mellifera (Vahl.) Benth in Harweyu Kebele.

4. Figure 4: Acacia drapanolobium (Harms ex sjostedt.) in Dharito Kebele

5. Figure 5: Trends in human/livestock population and permanent pasture in the study area (SORDU, 1990). (Source: FAO, 1996)