EFFECTS OF GRAZING INTENSITIES ON RANGE CONDITION AND PASTORALISTS' PERCEPTIONS OF RANGELAND DEGRADATION IN EWA DISTRICT, AFAR REGION, NORTHEASTERN ETHIOPIA

MSc THESIS

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We, the undersigned members of the Board of Examiners of the final open defense, have read and evaluated Mengeste Mathewos thesis entitled "*Effects of grazing intensities on range condition and pastoralists' perceptions of rangeland degradation in Ewa district, Afar region, northeastern Ethiopia"* and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Animal and Range Sciences with specialization in Animal Production.

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I dedicate this thesis manuscript to my father Mathewos Wontamo, and my mother Ayelech Bekele for nursing me with affection, praying incessantly for this research and in the success of my life.

DECLARATION

I hereby declare that this MSc thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

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This MSc thesis has been submitted for examination with my approval as thesis advisor.

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LIST OF ABBREVIATIONS

APADB	Afar Pastoral, Agricultural and Development Bureau
CSA	Central Statistical Agency
FAO	Food and Agricultural Organization
GIS	Geographical Information Systems
IR	Islamic Relief
NDVI	Normalized Difference Vegetation Index
NPP	Net Primary Productivity
RISC	Range Inventory Standardization Committee
RRC	Relief and Rehabilitation Commission
RS	Remote Sensing
SRM	Society for Range Management
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

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Effects of grazing intensities on range condition and pastoralists' perceptions of rangeland degradation in Ewa district, Afar region, northeastern Ethiopia

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ABSTRACT

This study was conducted in the rangelands of Afar region, Ewa district, to assess the perceptions of the pastoralists towards rangeland degradation and examine effects of grazing intensities and altitudinal location on condition of the rangeland vegetation. Pastoralists' perceptions on rangeland condition and rangeland degradation were assessed using structured questionnaire (80 households, 40 from each altitudinal location), key informant interviews and group discussions. Vegetation surveys were conducted during the main rainy seasons of 2020/21. Data were collected from five nested quadrats of 20m x20m set along each of the 18 transects (9 on each altitudinal location and each measure 5km), for the total of 90 quadrats. The investigation included the assessment of grass composition, basal cover, litter cover; number and age distribution of seedlings and soil conditions (erosion and compaction), which were investigated on 1m^2 area. Herbaceous species biomass and richness, as well as woody species richness and diversity were examined. Data were analyzed using SPSS software. Analysis of variance was carried to assess the effect of grazing intensities and altitudinal location on range vegetation condition parameters measured. Cross tabulation and Chi-square tests were used to determine variations in the pastoralists' perception. Post-hoc comparisons of significant differences were done using the least square difference (LSD) method. The study revealed that pastoralists have in-depth knowledge regarding the vegetation cover changes and degradation taking place in their area and employ various strategies such as moving with their herds to overcome feed scarcity during dry/drought periods. Migration of livestock and people to areas with better grazing is the widely used strategy in the study area. The main causes for the degradation of rangeland were recurrent droughts, shortage of rain fall, inappropriate management interventions, overgrazing/over utilization and bush encroachment. The vegetation survey revealed that there was significant effect of grazing intensity on almost all range parameter measured.

However, the altitudinal differences did not show significant difference. In both altitudinal locations, grazing intensities had a significant ($P<0.05$) *influence on both herbaceous biomass and species richness, with heavy grazing intensity (HD) having a significantly* (($P<0.05$) *lower biomass and species richness than either lightly (LD) or moderately grazed (MD) sites. Similarly, there were significant differences* ($P<0.05$) *among grazing intensities for all parameters measured in upper lowland (LD >MD>HD). Grass composition, number of seedlings, age category and basal cover score were significantly different* ($P<0.05$) *among the 3 grazing intensities in the bottom lowland. The overall condition of the rangeland of the study areas was in "poor" range condition, which agrees with the results from the pastoralists perceptions who claimed their rangelands were in very poor and poor condition. In conclusion, high grazing intensities due to continued overstocking have a negative influences on the rangeland vegetation and thereby inhabitants' livelihood. The results of the present study suggest that pastoralist can utilize (either through proper grazing distribution and/or reducing overstocking) moderate grazing to improve range forage production while maintaining the range health. Having identified the environmental and human related factors that affected range vegetation of the study area, the thesis sets out possible areas for intervention.*

Key words: *Grazing intensity, range condition, species richness and diversity, Ewa district, Afar.*

1. INTRODUCTION

In Ethiopia, rangelands cover about 61% of the country's land mass and are characterized by arid and semi-arid agro-ecologies (Alemayehu, 2006; Coppock, 1994; Kidane, 1993). Among the vast rangelands of the country, the north-eastern rangelands of Afar region are one of the most important. In the Afar, the arid ecological zone, which lies at an altitude below 500 m, covers more than 80% of the region while the semi-arid, at an altitude of 500-1,500 m, covers 20% of the region's total area (Dawit, 2000). Based on the land-use and land-cover study of the Afar National Regional State, the potential vegetation area, which is 24.49% of the region, is classified into grasslands, shrub land, bush land and riverine woodland vegetation types (MCE, 2000).

These vegetation types are conventionally served as the vital grazing land for the Afar herders' livestock, in addition to a large number of wild animals. Besides supplying forage and habitat for domestic and wild animals, the Afar rangelands also have vital ecosystem services functions, for example, biodiversity maintaining, soil and water conservation and carbon storage (Alemyehu, 2006). However, because of anthropogenic and natural factors, the Afar rangelands have been degraded severely in recent decades (Beruk, 2000). Rangelands across the country and other parts of eastern Africa are facing increasing pressure due to environmental factors such as land use/cover change, overgrazing and climate change (Alemyehu, 2006; Beruk, 2000).

Particularly in Afar region, land cover change, drought and overgrazing have led to rangeland deterioration and a subsequent loss of livestock populations after severe droughts (Beruk, 2000). Livestock grazing is one of the most essential means of rangeland utilization worldwide.

Environmental degradation of rangeland systems has been seen as one of the main factors leading to the increased vulnerability of pastoral and agro-pastoral economies in Ethiopia. Maintaining productivity of rangelands requires extensive knowledge on how vegetation responds to the dominant environmental factors such as grazing and physical environment (Ayana *et al.,* 2006). In addition, soil responses to overgrazing and rangeland degradation need to be quantified to develop suitable grazing practices. Overgrazing is considered the most important cause of rangeland degradation. Overgrazing often causes a decrease of the palatable plants in favor of less palatable, undesirable vegetation and decline in soil condition (Baars *et al.*, 1997; SRM, 2005). Over the world, vegetation change is the most commonly described effect of livestock production on rangelands (Asner *et al.*, 2004). Numerous studies also described effects of grazing on soils (e.g., Solomon *et al*., 2007; Throw *et al.,* 1998).

Range condition is one of the means of studying ecological changes in the development of rangelands (Malan and Niekerk, 2005). In order to properly manage these areas (i.e., rangelands) in the future, it is imperative to better understand the site-specific changes in vegetation and soil conditions and causes underlying these changes. Vegetation changes and soil condition can vary strongly in response to management and environmental heterogeneity or variability.

The assessment of the rangeland vegetation, based on the botanical composition of the herbaceous layer, basal cover, litter cover, relative number of seedlings, size distribution of dominant grasses and soil condition (soil erosion and compaction), have long been considered the critical criteria for describing condition of semi-arid rangelands (Baars *et al.*, 1997) in Africa and woody vegetation diversity is important to evaluate current status of rangeland vegetation and understand effects of management therein (Abule *et al.*, 2007; Ayana *et al.,* 2006). It will be impossible to assess the impact of landscape change on rangeland ecosystems without consistent, accessible soils and vegetation data and how changes occur in response to stresses and disturbances. This is because vegetation and soil are the most important representations that reflect the whole natural environment (SRM, 2005).

The two most essential approaches involved in range vegetation assessment are: ecological and production (agronomic) based from which the first evaluates whether the long-term productive potential or ecological status of the site is being maintained; the later which is the most widely used, estimates condition in terms of the current productivity of the resources forgiven use (RISC,1983).

In this thesis range condition refers to the current state of health of the range. Range condition classification provides an indication of the necessary management inputs. Based on successional/climatic community concepts, analysis of range condition is designed to assess whether range sites are at acceptable standards and capabilities for livestock production (Stoddart *et al.,* 1975 quoted in Ayana *et al.,* 2006).

Rangeland assessments in Ethiopia over the past decades have relied heavily on the rangeland scientists and managers view of rangeland health, condition classification and management while pastoralists' perception and ecological knowledge (of those pastoralist located in remote areas) of vegetation changes have rarely been considered in rangeland studies. In most parts of Ethiopia, the indigenous knowledge of pastoralists is not adequately documented (Amaha, 2006; Gemedo, 2004). However, (Roba and Oba, 2008; Turner *et al.,* 2000) suggested that traditional knowledge of indigenous people is fundamentally important both in the management and evaluation of local resources. This is because pastoralists usually have a detailed knowledge of their grazing lands and other rangeland resources, acquired through extensive observation and continuous herding practice (Mapinduzi *et al.* 2003; Oba and Kotile 2001). Additionally, the use of community-based knowledge as a framework for understanding the impacts of management and land use change on the local environment may provide new insights for improving existing scientific knowledge and a basis for formulating appropriate management strategies and development policies (Ayana, 2007; Roba and Oba, 2008).

This study was conducted in arid lowlands of Ewa district, one of the districts in Afar region. As stated above, factors such as overgrazing and physical environment are considered the most important causes of rangeland degradation. In the rangeland of the study district, however, the effects of these issues on rangeland condition and the pastoralists view on vegetation changes remain insufficiently addressed.

Objectives of the study

1. Assessing the species composition and diversity to determine the existing condition of the rangeland vegetation in the study district.
2. Understanding the effects grazing intensities and altitude on range condition and related factors (herbaceous biomass, vegetation composition and soil condition characteristics) in the semi-arid lowlands.
3. Investigate pastoralists' perceptions of rangeland degradation and range condition.

Research questions

In line with the above objectives this research attempted to answer the following questions:

1. What were the effects of different grazing intensities on the range vegetation in the communal rangelands in Ewa district?
2. How do range vegetation effects of the grazing intensities under study vary with altitudinal location?
3. What were herders' perceptions of the current range condition? What indicators did the herders use for assessment of their rangelands health status?
4. What factors contributed to rangeland degradation in the communal rangelands in Ewa district?

In connection with, the results of the study can contribute meaningfully to the following areas of concern: the species composition and diversity (important indicators of range productivity potential), effect of grazing intensities and altitudinal difference on vegetation cover changes of rangeland and perceptions of pastoralists towards trends of vegetation changes of the study area. In addition, this study may help planners, policy makers and practitioner at the grass root level with important lessons for solving problems associated with rehabilitation of the range resources on sustainable base.

2. LITERATURE REVIEW

2.1. Concepts and Definition

In this thesis different terms are used in relation to the assessment of rangeland condition and degradation. Vegetation “condition” is a term commonly used to describe “the state of range health” (SRM, 1989), which can be rated as excellent, good, fair and poor range condition. Range condition measures degree of range deterioration and improvement. It evaluates present range production in proportion to production potential. Range condition analysis is used to determine whether the existing management activities are adequate or require modification in order to guard against rangeland degradation and optimize productivity. It is an essential prerequisite for designing appropriate management practices. Methods of classifying range condition have emphasized species composition, growth form composition, forage productivity or a combination of a number of different vegetation and soil attributes, such as cover, composition, palatability, litter and soil stability (Alemayehu, 2006).

In this thesis the concept is used in relation to the “range status” which the herders consider as being optimal for livestock production, while ecologists use the term to mean a departure from the assumed “climax” vegetation status. Thus in this thesis, the term “condition” is used in relation to utilization. The term rangeland degradation, in general, is defined as the reduction in the status of natural vegetation, loss of plant cover, undesirable change in herbaceous species composition (e.g. annual grasses replacing perennials) as well as changes in the soil condition that would alter the functions of natural systems. Rangelands are often considered to function primarily as a feed for livestock. "Range assessment" refers to observation of the status of various indicators that influence environmental health. Range assessments are evaluations made by comparing measurements from one sampling point in time (to generate baseline data on vegetation and soil physical characteristics) against standards or objectives. This desired state or condition of the range is also known as benchmark (SRM, 1989). The definition of benchmarks is one major challenge in range ecology, because they vary between different areas and strongly depend upon the relevant group of land users. To approach local benchmarks or to estimate the extent of occurring changes due to livestock grazing, range ecologists often investigate gradients of either grazing history or actual grazing pressure/grazing intensity.

Range assessments are often conducted by observing conditions across broad areas of rangelands. For that, range assessment needs generally applicable plant indicators that may even be employed by non-scientific (Ludwig et al. 2004). Such indicators can focus on vegetation patterns like plant composition, or biomass production and abiotic range conditions like soil texture, soil organic matter, or erosion. For herders, assessment is done more frequently across the grazing landscape to ensure an acceptable quality and quantity of fodder for multiple livestock species. Ecological assessment of grazing ecosystems is less frequent and on limited spatial scales. Observations are usually made at a series of sampling transects and plots in order to generate data that are used to generalize the status of grazing resources. The present thesis focuses on range assessment, in particular on indicators that help to assess range conditions.

2.2. Rangeland degradation in Ethiopia

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). As defined above 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 have different implications for pastoral productivity (Conant and Paustian, 2002).

2.3. Causes of Range Land Degradation

In Ethiopia, causes of rangeland degradation are heavy grazing, climate change variability, conversion of rangeland to cropland, bush encroachment, the human population pressures and the loss of traditional resource management.

2.3.1. Over-grazing

Over-grazing of rangelands is a problem worldwide and Ethiopia in particular. Increase in human population necessitates the increase in livestock population in rangelands in order to maintain survival. In pastoral areas of Ethiopia, the animal populations are growing at an increasing rate to meet the need of increasing human populations, while the pasture resource on which they depend is limited or diminishing both in terms of grazing area and range productivity (Alemayehu, 2006; Coppock, 1994).

2.3.2. Climate Change and Variability

Climate change is a major contributor to rangeland degradation through its effects on ecological dynamics of the rangeland systems (Mao *et al*., 2008; Oba *et al*., 2000). Changes in climate include increased temperatures and evapotranspiration, changes in rainfall patterns and amounts and in the available water resources. Increasing temperatures associated with corresponding reductions in precipitation and increased evaporation has large potential to trigger drought and desertification. The resultant moisture deficits (Li *et al*., 2000), consequently, decimate forage availability and quality. Climate change influences pastoral mobility trends–in search of better pastures and resources (Mussa *et al*., 2016). This is a result of extensive droughts in different parts, causing progressive decline in vegetation quantity and quality, and inadequacy of water (Amaha *et al*., 2008; Mussa *et al*., 2016). Such droughts results in loss of animals (Coppock, 1994; Willis, 1999; UNEP). The associated deterioration in poverty levels and susceptibility of rangeland-based livelihoods (Hoffman and Vogel, 2008) contributes to increased rangeland degradation. As with overgrazing, climate change can exacerbate proliferation and spread of alien species in the environment, with increased chances of causing rangeland deterioration (McNeely, 2004).

2.3.3. Invasive and alien species encroachment

Invasive species command much concern with respect to rangeland degradation. In sub-Saharan Africa, increased rates of expansion of *Prosopis juliflora* has, for example, been recorded in Ethiopia (Mehari, 2015). These species invade rangelands by rapidly spreading and establishing into new sites (Mussa *et al*., 2016). The common indigenous plant species known for bush encroachment comprise the *Acacia* family and include *Acacia melifera, Acacia seyal, Acacia drepnolobium* and *Commiphora Africana* (Ayana and Oba, 2008). Bush encroachment, in combination with invasive plant species, not only suppresses forage availability for livestock but also incurs increased management costs. Bush encroachment into rangelands has been linked to increased soil compaction that hinders proper establishment of herbaceous forage (Amaha *et al*., 2012), compromised water infiltration, reduced build-up of soil organic carbon (Li *et al*., 2016), and reductions in range forage productivity (Eldridge *et al*., 2011).

2.3.4. Breakdown of traditional management

A large proportion of rangelands in Ethiopia and other parts of Africa are communal and these are managed through traditional governance structures that constitute and enforce norms and values of their sustainable use (Mussa *et al*., 2016; Omondi and Odhiambo, 2009). However, the emphasis on formal governance structures has promoted the breakdown of these traditional institutions and weakened their capacity to manage rangeland-associated problems (Omondi and Odhiambo, 2009). Many experts argue that several policies and by-laws have greatly infringed the customary land rights and undermined pastoral land tenure systems that championed sustainable natural resource management (Ayana 2007; Mussa *et al*., 2016; Omondi and Odhiambo, 2009; Selemani, 2014). Such policies include state-sponsored resettlement schemes targeting rangelands, mostly perceived as vast and idle lands (Alemayehu, 2006; Coppock, 1994; Mussa *et al*., 2016). Changes in land tenure and resource management policies result in degradation, especially on communal rangelands (Tefera *et al*., 2002). Disorganized settlement patterns, land fragmentation, subdivision and creation of enclosures confine people and livestock to certain areas of the rangelands (Flintan *et al*., 2011), increasing vulnerability of rangelands to soil erosion and lowering productivity of such rangelands.

The breakdown of social structures leads rangelands to the "tragedy of the commons." The tragedy of the commons describes a situation where collective actions of some users of shared resources contravene the general good of the other users through overexploitation (Feeny *et al*., 1990). The free-access nature of the rangelands often makes them vulnerable to misuse, depletion, or spoiling by certain users through improper and unsustainable agricultural practices, continued overuse and overgrazing (Blewett, 1995) and excessive extraction, e.g., of wood resource (firewood and charcoal). As such, free access to rangelands is often associated with reduced abilities to effectively control grazing. Livestock pressure may not only magnify rangeland deterioration rates, but also overwhelm rangeland productivity, reduce livestock productivity, and elicit resource-based conflicts between pastoralists and wildlife as seen in the Maasai Steppe of Tanzania (Kissui, 2008), Laikipia and Amboseli in

Kenya (Gadd, 2005; Graham *et al*., 2010; Okello, 2005), and Ethiopian rangelands (Abule *et al*., 2005; Amaha *et al*., 2008).

2.3.5. Agriculture and associated developmental practices

Agriculture and the associated developmental practices in the rangelands have increasingly contributed to rangeland degradation (Han *et al*., 2008). In Sudan, (Abdi *et al.*, 2013) reported that agriculture-associated practices, such as over-cultivation of croplands, slash-and-burn practices, shifting cultivation as well as misuse of irrigation water, predisposed rangelands for degradation. Studies in China have pointed towards both agricultural and semi-pastoral rangelands being the most degraded, with practices involving vegetation clearing for agricultural purposes increasing the risks of soil erosion (Han *et al*., 2008; Huang *et al*., 2007). In East Africa, Lankester and Davis, (2016) asserted the potential of rangeland cultivation to remove dry-season pastures that are often utilized by herbivores, thus, compromising livestock productivity of the wider landscape. Agricultural activities are often associated with rangeland degradation (Flintan *et al*., 2011).

Agricultural practices are often water demanding, sometimes associated with over drafting. Increased establishment of boreholes and abstraction of underground water beyond recharge capacities continuously lowers the water table. Cultivation of rangelands can also compromise rangeland quality through nutrient mining, increased soil compaction and disturbance of soil structure (Allmaras *et al*., 1993).

2.4. Use of Pastoralists' Perception and Knowledge for Rangeland Assessment

Pastoralists have accumulated local knowledge for vegetation monitoring and assessment (Mapinduzi *et al*., 2003), which is associated with local strategies to sustain livelihood systems. For example, herders describe the status of biodiversity in relation to livestock grazing resources. Local communities harbor important information on valuable plants and vegetation dynamics (Lykke, 2000). Herders in Northern Tanzania (Oba and Kaitira, 2006) and Mali, Botswana and Kenya (Ayana *et al*., 2012), for example, used the abundance of palatable species as indicators for assessing range condition. Furthermore, these herders used the abundance of palatable species as indicators for assessing range condition. The herders' observations suggested that the dominance of unpalatable grass species and forbs are indicators of poor range condition (Ayana *et al*., 2012).

Community-based knowledge plays a significant role in rangeland resource management. Local knowledge is also widely acknowledged to be a valuable source of data on the historical distribution of species which are generally difficult to assess using classical ecological methods (Ayana *et al*., 2012; Lykke *et al*., 2004) and especially in the case when other historical and ecological information is not available (Sulieman *et al*., 2012) though these knowledge encountered constraints of perceived to be locally specific, qualitative and lacks impartiality (Oba and Kaitira, 2006). However, the knowledge of local people becomes indispensable in order to fully understand long-term changes in indigenous vegetation (Ayana *et al*., 2012). Borana pastoralists conduct seasonal assessments of range condition and trends (Alemayehu, 1998). Herders monitor changes in their plant species composition over time, based on historical knowledge (Oba and Kaitira, 2006). Local vegetation is monitored for changes in plant species composition that may affect key fodder species for livestock grazing. Monitoring focuses on land use history where past experiences serve as a baseline for comparing current changes. Herders have also valuable knowledge of land degradation. Since livestock is the main source of livelihood, herders' perceptions of land degradation are influenced by livestock production requirements. Herders not only monitor the trends of vegetation change over the long term, but they also make inferences from livestock production performance. In terms of vegetation, herders monitor both the quantity and the quality of fodder. The status of vegetation guides herder decisions for livestock management. Therefore, herder perceptions of land degradation in terms of livestock performance involve more than just describing the biophysical attributes, such as the physical characteristics of the soil and the quantity and quality of the vegetation. It involves understanding complex sets of perceptions about inherent factors in the environment that cannot be measured directly.

Ayana *et al*., (2012) reported that local people's knowledge in terms of assessing the status of indigenous vegetation using environmental indicators is relevant in conducting integrated assessments that could help to set research and development priorities. Kilongozi *et al*., (2005) noted that Maasai and Barbaigs herders perceive the knowledge of botanical composition of rangeland as of importance in rating range suitability for livestock grazing. A comparative research conducted from pastoralists in three African countries—Mali, Botswana and Kenya by Ayana *et al*. (2012) indicated that the relative abundance of species (i.e., the number of individual species per unit area) was used to classify the various landscapes according to their suitability. Borana pastoralists attributed low livestock productivity to changes in rangeland vegetation composition from desirable to undesirable forage plants (Dabasso *et al*.,2012) and perceived that botanical composition was inferred from the body condition of their animals (Ayana and Fekadu, 2003).

In recent years, growing bodies of literatures have tried to inform policy-makers and development practitioners to recognize community's knowledge for sustainable management of their environment (e.g., Ayana and Fekadu, 2003; Ayana *et al*., 2012; Gemedo-Dalle *et al*., 2005; Oba and Kaitira, 2006). These studies have also shown that communities' knowledge has a role to play in the advancement of scientific research and attainment of sustainable development goals (Ayana, 2007; Minyahil *et al.,* 2012).

2.5. Range Condition Assessment

Before range condition can be assessed, the range sites must be located. Range sites are the basic units of land of practical use. Ideally, each range site should respond to climatic variation in the same manner, have uniform topography and productivity and respond uniformly to experimental treatments (Alemayehu, 2006). Range condition is the present status of vegetation in relation to the climax plant community for that site. It is an expression of the relative degree to which the kinds, proportions, and amounts of plants in a plant community resemble that of the climax plant community for the site (SRM, 1974).

According to Pratt and Gwynne (1977), range condition is the state and health of the range and it can be assessed, among other things, on the basis of the composition of vegetation on an area, plant vigor, ground cover and soil status. The concept of 'condition' implies that an optimal or desired vegetation cover in terms of quantity and composition exists for each particular land system. However, since it will often be uncertain what the desired or 'optimum' condition is, particularly in areas which have undergone misuse for a considerable period of time, and since the optimum range condition will differ according to the manner in which the range is used (e.g. cattle, sheep, wildlife), the comparison used should be clearly stated. Again, whether comparison is based on actual measurements or simply assumed is the other side of the uncertainty. Amaha (2006) pointed out that rangeland condition is a concept that encompasses the levels of specific indicators such as plant species composition, vegetation cover (basal cover), forage production (productivity), land condition (soil erosion and compaction) and management at a particular location(s) aimed at sustained livestock production (Friedel *et al*., 2000; Trollope *et al*., 1990).

Determining the botanical composition of rangeland is an important step towards understanding the fodder value of individual species as well as their reaction to biotic and edaphic factors, which may be explained in terms of the type of species, the amount of yield, and the frequency of occurrence and density of basal cover (Baars *et al*., 1997; Mannetje *et al.* 1976). Plant dry matter yield is often directly related to animal production while the other parameters are useful to describe and quantify the plant population and the successional trends of the rangeland vegetation (DuToit and Aucamp, 1985), and to assess the rangeland condition (Foran *et al*., 1978; Tainton, 1986; Throw *et al*., 1988; Van der Westhuizen *et al*., 1999; 2001). The methods used to classify range conditions have influenced the composition of species (Dyksterhuis, 1949).

According to Gartner (1976), when overuse is excessive or continued over a long period of time, usually invaders or undesirable plants are found. The invader plants were found to be absent in the original vegetation, but with grazing pressure, they replaced the decreaser and increaser plants. In favorable years, invaders can provide considerable forage for a short period of time, but sound range management cannot be based on this uncertain forage production. The four classes of range condition are based on percentage of the production of the decreasers and increasers when compared to the original vegetation. A site composed of decreasers and increasers indicates a high condition range. Replacement of decreasers on the site with increasers and invaders means that the site needs improvement. The four range conditions are as the following. With excellent Condition, 76-100 % of allowable vegetation is mixed of original highly palatable, desirable perennial decreasers and increasers. Legumes and desirable forbs may be present. With good condition, 51-75 % of vegetation is mixed from original highly palatable, desirable perennial decreasers and increasers. Some legumes and forbs may be present in this condition. About 26-50 % of allowable vegetation is mixed of original highly palatable, desirable perennial decreasers and increasers. Some legumes may occur, but most forbs are increasers and invaders. The overall vegetation appearance is shorter, and amount of bare ground is increasing. With poor condition, less than 25 % of all vegetation is composed of highly palatable, desirable perennial decreasers and increasers. Generally, invader plants and unallowable increasers comprise the majority of vegetation

2.5.1. Estimating range condition

Range condition refers to the present ecological status of the productivity of a vegetation community relative to its natural potential for particular range site and the types of land use (SRM, 1974). In other words, the concept ‘condition’ implies that an optimal or desired vegetation cover in terms of quantity and composition exists for each particular land system. Range condition of vegetation is based on the species composition of the plant community as estimated by the percentage of the total annual air-dry weight of each species. Species must be classified as decreasers, increasers, or invaders. Each species has an allowable percentage that occurs in climax.

2.5.2. Range condition classification

Range condition classification is often included in a range inventory change. In range condition scores overtimes are usually the basis for monitoring management effectiveness. Range condition classification provides an induction of management necessary. If ranges are in good or excellent condition, maintaining them in a stable condition may be the best management strategy. However, if they are in poor or fair condition, management is aimed at “improvement “may be indicated. Generally, four or five condition classes are recognized. These are excellent, good, fair and poor. Sometimes, a fifth category is added. Many approaches have been used to determine range condition on different range sites or habitat types. Of these, the most familiar method is the developed by Dyksterhuis (1949, 1958). This approach is ecological.

Range condition is measured by the extent to which it departs from climax. The approach assumes that climax can be determined for each range sites. Excellent class would represent climax, i.e., Excellent (76-100), good (50-75), Fair (26-50), and poor (0-25) respectively. Originally, species occurring on each site were classified, by their reaction to grazing, as Decreasers, Increasers, or Invaders. Decreasers are highly palatable plants that decline in abundance with grazing pressure. Plants classified as increaser I types are moderately palatable and serve secondary forage plants.

They may increase slightly or remain stable under moderate grazing condition reaches fair condition. Other plant species are present in the climax vegetation, but those that are unpalatable may increase under grazing pressure or as site deterioration occurs. These species are classified as increaser II plants. Invaders are species that encroach on to the sites from adjacent sites in a later stage of deterioration. Type I invaders may eventually decrease if forced utilization occurs at later stages of deterioration. Type II invaders are generally unpalatable and increase though final stages of deterioration.

2.6. Vegetation Sampling

According to Shaw and Bryan (1976), knowledge of the vegetation of a region and their relations in the environment helps define suitable farming practices or agricultural activities. It also helps select sites for conducting experiments to solve problems. There are several ways by which the percentage of the composition of species occupying a rangeland can be known. As early as 1963, T'Mannetje and Haydock have distinguished four methods of making quick and accurate botanical analysis of grassland on dry-matter weight basis. These are (a) hand separation and weighting of cut herbage, (b) estimation of percentage within cut herbage, (c) estimation of percentage weight in the field and (d) estimation in unit of the weight of species in the field. Among these methods, the first one is the most accurate provider that a sufficiently large number of samples are used. Nevertheless, the method is time consuming and requires drying facilities. Generally, the weight of plants' material is expressed on the dry matter basis rather than on the fresh (green) basis. This is because, dry matter is a solid substance that is not subjected to daily fluctuation in content, unlike fresh weight (FAO, 1980). Species (or floristic) composition refers to the proportion of the plant species found in association within a given area (Tothill, 1978).

2.7. Rangeland Monitoring and Evaluation Techniques

Proper monitoring and evaluation is vital for effective management and restoration of degraded rangelands. Rangeland monitoring and evaluation assist in tracking significant landscape and vegetation changes, variations in rangeland health, and making informed and effective management decisions. Monitoring and evaluation can also enable the rangeland managers to discover negative range trends that need restoration actions, identify natural disturbances involving weed infestation and alterations in vegetation communities, thereby making informed remedial decisions. Numerous factors are often assessed when monitoring and evaluating rangeland degradation/restoration. Some of these comprise community/vegetation composition, vegetative biomass production, degree of forage utilization, and vegetative canopy of the forage. Several monitoring techniques (both traditional and advanced) for rangeland degradation/restoration exist.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted on Afar rangeland, Ewa district, which is one of the 32 districts in the Afar Region of Ethiopia. Ewa is part of the Administrative Zone four, and is located near the base of the eastern escarpment of the Ethiopian highlands and bordered on the south by the Administrative Zone one Chifra district, on the west by the Amhara region, on the north by Gulina, and on the east by Awra; part of its boundary with Zone one is defined by the Logiya river. Ewa is located at 11°49’20” N and 39°37’59” E. In most of the study area, the topography is lowland plains, but there is also hilly escarpment in the western edges with the neighboring Amhara region; rainfall ranges from 700-850 mm per year, the altitude range of the area is between >550-1080 m above sea level and most of the rangelands of the study district falls below 850 meter above sea level. The mean minimum and maximum temperature of the study area are 22.5 and 37.55°C respectively, and the rainfall is bimodal with erratic distribution, the dominant soil types in these areas are sandy, vertisols and deposits of silt and fine sand particles (APADB, 2006).

Based on the CSA (2013) projection, the total population of Ewa was projected to be 57, 252 by 2017. Of these 31,287 are men and 25,965 are women. The area coverage of Ewa is 1,463.89 square kilometers and has a population density of 36.87. While 2,311 or 4% are urban dwellers, the 54,941 or 96% are predominantly pastoralist rural inhabitants. A total of 7,921 households were counted in this district, which results in an average of 6 persons to a household and 8,217 housing units (CSA, 2007). Age structure of the population shows that about 48.8%, 49.7% and 1.9%, respectively, are within the age of 0-14, 15-64 and 64+. Dependency ratio is 1.02 (0.981 young dependents and 0.04 old dependents) (CSA, 2007).

The district is among the richest areas of the region in terms of livestock population, water and other natural resources. Ewa alone has 10% of the total cattle of the region and more than 6% of the camels of the region (IRE, 2017). However, due to lack access to pasture and water, inaccessibility of social services, drought induced livestock diseases and other challenges the production and productivity of the area is severely affected, and livelihood condition of the local community fell in jeopardy.

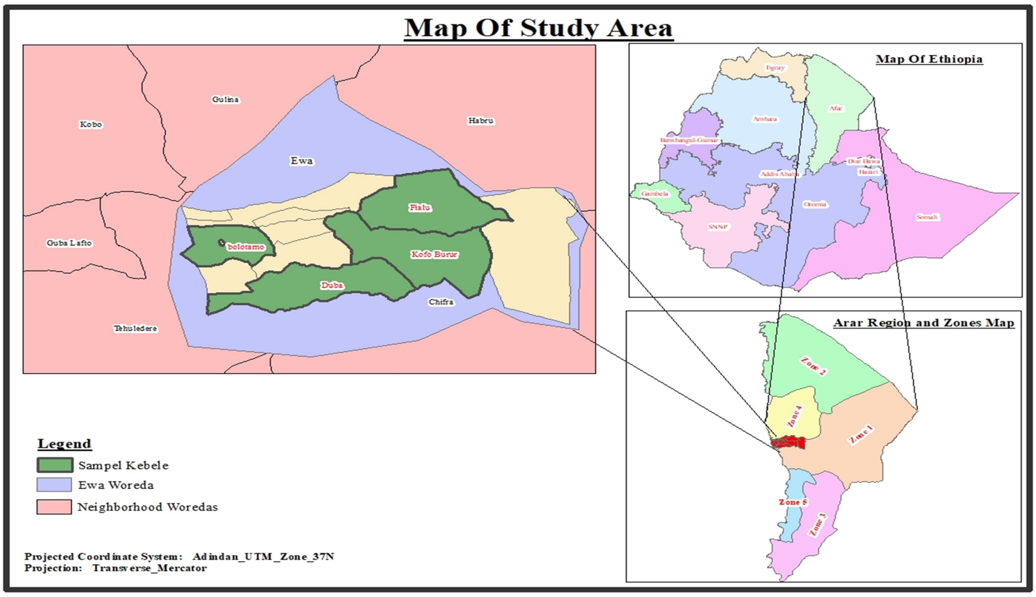

Figure 1. Map of the study area

3.2. Survey Design and Sampling Procedure

3.2.1. Site selection

Vegetation survey was conducted during the long rainy season of 2020/21 when most grass species will be at the full flowering stage, which is important for identification purpose. Prior to field work, a reconnaissance survey was conducted and contacts with the local leaders and development agents (DAs) established to have information that was assist in site selection. Both vegetation and socio-economic data were collected to capture important information in order to address the specific objectives of the study. Stratified and systematic random sampling techniques were used in the study.

First, based on defined elevation the district was stratified into two: 850-1050 (m.a.s.l) (hereafter upper lowland) and 650-850 (m.a.s.l) (hereafter bottom lowland). The threshold elevation to stratify the district was defined based on secondary data from the district pastoral development office. Then, two adjacent kebeles having both altitudinal locations were selected purposively. In each altitudinal location, 3 contrasting sites were selected purposively along a relative degradation gradient (low-medium-high) based on grazing pressures (less degraded, moderately degraded and highly degraded). Within each altitude, different degradation gradients were defined based on information on the grazing histories and level of uses of the grassland by herders. Delineation of different degradation levels were determined using distance from homestead areas. A distinct level and frequency of use characterize each degradation gradient that was defined in consultation with elder groups and development agents in each kebeles. At each site (i.e., degradation gradient), three transects (transects represent replicates), each measuring 5 km, on which vegetation and soil sampling plots locate, was randomly laid. In total, 18 transect (9 in each location) established for the vegetation and soil study.

3.3. Data Collection Method for Quantification of Pastoralists' Perceptions

For the purpose of this study, 40 households per each altitudinal location were randomly selected for a total of 80 households. In addition, a total of 40 elders, 20 per each altitude were selected. The selected elders were long-term residents who had spent their entire lives in the area and who totally depended on pastoralism for their livelihood.

Household level data was collected using a structured questionnaire. Many of the questions also included a reflective component to assess historical trends in rangeland condition and management. The questionnaire included both closed (single response) and open (multiple responses) questions. The questionnaire was pre-tested before the actual data collection, and appropriate modifications and corrections made. Interviewers were recruited and trained in an attempt to improve the accuracy of answers to questions.

Opinions of the pastoralists on rangeland condition and trends were also be gathered from group discussions with the selected elders (discussed in the previous section) of the various villages. The group discussion was conducted in an open-ended manner with sufficient time to gather details from the respondents. Where appropriate, information was also obtained from formal discussions and interviews with individual elders. Questions were asked regarding perceptions on rangeland deterioration, long-term vegetation change, its causes and other related issues. A checklist of open-ended questions prepared in advance was used to guide the discussion.

3.4. Sampling Design and Field Investigation

Vegetation measurements and soil sampling was conducted using nested plots established using systematic random sampling design. Five nested quadrats of 20m x20m size set along each of the 18 transects, for the total of 90 quadrats. The first quadrat was established randomly then the remaining quadrats were laid systematically at 500m interval. The species composition and diversity of the woody species were determined within major plots i.e., 20m x 20m. While two 1m x1 m quadrants randomly established within the major plot to measure the herbaceous vegetation. The species that occurred in each quadrat were counted and recorded. On the basis of their botanical group the species occurred in each quadrat sorted out into: grasses, herbs and sedges (herbaceous species) and shrubs and trees (woody species). Measurement of each group done as discussed in the following sections.

3.4.1. Woody vegetation layer

In each of the larger quadrats ($400m^2$) located along transects, all live woody plants present in the quadrat were counted, identified and recorded to determine individual woody species density, richness, diversity, evenness, and frequency. The woody vegetation was sampled on major quadrats of 20m x 20 m at each of degradation gradient (less, moderately and highly degradation levels), i.e. three transects (5km), 5 quadrats were established in each three sites. In total, 90 plots were sampled for woody vegetation assessment. The palatability of woody plants were determined and grouped into highly desirable, desirable, less desirable and undesirable species by interviewing the local communities.

3.4.2. Herbaceous richness and woody plant diversity

Investigation of how grazing regime affects diversity need to be made in order to understand the vegetation condition and extent of disturbance. Plant species diversity is a measure of both species' richness and evenness of the composition of plant communities. Richness is an expression of the number of species in the population while species evenness is the relative abundance of individuals within a species. Species diversity index could be calculated by using species number (richness) and abundance of each (evenness) for instance a higher number of species index indicates a more diversified community in a specific time and space (SRM, 1986). The plant species diversity of the vegetation on each site was calculated and compared (Valentine, 2002). Frequency and abundance of trees and shrubs summarized on the major plot of 20mx20m (400m2) and herbaceous species on 1mx1m ($1m^2$) plot to estimate species richness for herbaceous and woody vegetation and estimate diversity of woody plants. Calculation of species diversity was done using the Shannon and Wiener Diversity index (Magurran, 1988) from the relationship

$H' = -\Sigma p_i \ln p_i$,

Where;

H' = Shannon diversity

Pi = Proportion of individuals found in the i^{th} species in the sample

ln = Natural logarithm

Evenness or equitability which is a measure how individuals are distributed for each species was calculated from the relationship:

E= -Σ*pi lnp*i /lnS,

Where: S is the species richness (Total number of species in the sample).

Pi is the relative proportion ith species in the sample.

3.4.3. Identification of vegetation

The plant species identifications were performed on the field by using local elders, DAs, and expert of the district/kebeles who has lived around for local names of vegetation. And vernacular names were cross-checked with their scientific names by using different literatures.

3.4.4. Determination of herbaceous species composition and biomass sampling

The herbaceous vegetation layer was investigated for species composition, basal cover, litter cover and seedling number and age categories in each sub-plot of $1m^2$ area. The species composition of the herbaceous layer at each of the sub-plots of 1 m x 1m was determined, based on the frequency of occurrence. All the identified grass species were be classified into highly desirable likely to decrease with heavy grazing pressure (decreasers), desirable (inter mediate species) likely to increase with heavy grazing pressure (increasers) and undesirable likely to increase or invade with heavy grazing pressure (invaders) according to Tainton (1999) and based on the information obtained from the pastoralists and literatures. Information was gathered from pastoralists on vigor and palatability of a particular species. For herbaceous species composition score (1 to 10) points were considered based on the contribution of grasses only. After the determination of the herbaceous species composition, above ground biomass of the herbaceous species were determined on the same randomly placed two quadrats of $1m^2$ located at each main plot. Aboveground biomass (the green forage yield) of the herbaceous species were harvested completely by clipping to the soil surface and separated into green and litter material in each quadrat. Then the green biomass was weighted on the field and recorded for each sampling quadrat.

3.4.5. Range condition indicators

The factors considered for range condition scores were based on the criteria adopted by Baars *et al*. (1997). The maximum possible score was 50 points. Range condition score was interpreted as excellent (41–50 points), good (31–40 points), fair (21–30 points), poor (11–20 points) or very poor (3–10 points).

3.4.5.1. Basal cover and litter cover

Basal cover and litter cover were assessed on a scale of 0–10 points (Appendix table 1). A representative sample area of 1 m^2 was selected for the detailed assessment of both basal and litter cover. The surface of the basal cover of tufted grasses and their distribution were assessed for 1 m^2 areas, which were divided into two equal parts. One of the halves was further divided into eighths. All grasses in the selected 1 m^2 were removed and transferred onto the eighth fraction unit of the original 1 m^2 in order to facilitate visual estimation of the percentage of the basal cover within one-eighth of the 1 m^2. Only the basal covers of the living parts of grasses were considered. Scores for the basal cover of tufted grasses were considered excellent when the one-eighth fractional unit was completely filled (12·5 per cent) with the transferred grass basal cover (Baars *et al*., 1997). Basal cover was considered very poor at <3 per cent cover. The rating for litter cover within the same 1 m^2 was considered excellent when it exceeded 40 per cent and poor at <10 per cent litter cover (Appendix table 1).

3.4.5.2. Number of seedlings and age of grasses

For both the number of seedlings and age distribution of dominant grasses a score of 1–5 points was used (Appendix table 1). The number of seedlings was counted using three areas, each equal to the size of an A4 sheet of paper (30 × 21 cm) sampled at random. A maximum score of five points was given when all age categories of grasses (i.e. young, medium and old) were present (Appendix table 1). For the purpose of this study, age categories of grasses were defined as follows: (i) the term young refers to species at their early stage of growth before flowering; (ii) medium age refers to those species at flowering stage; and (iii) old refers to perennial grass species after flowering and/or those from the previous season when encountered in each sampling plot.

3.4.5.3. Soil erosion and compaction

For the soil condition, a score of 0–10 points was used, on judged by the status of soil erosion (0–5 points) and soil compaction (1–5 points) then combined (Baars *et* *al*., 1997). The extent of soil erosion and compaction were evaluated from $1m^2$ quadrats subjectively by visual observations. Soil erosion was assessed based on the amount of pedestals (higher part of soils, held together by plant roots, with eroded soil around the tuft), and in severe cases, the presence of pavements (terraces of flat soil, normally without basal cover, with a line of tufts between pavements).

3.5. Statistical Analysis

The data collected from the socioeconomic survey were summarized and analyzed using SPSS (Statistical package for social science, version 20) software. Livestock types most supported by the rangeland, botanical groups dominantly found, coping strategies for scarcity of feed, causes of rangeland degradation, and evaluation criteria of pastoralists to rate range vegetation condition were ranked by calculating an index. This is because households mentioned different parameters according to its significance. Index was computed with the principle of weighted average according to the following formula as employed by Musa *et al*. (2006):

Index = Rn*C1+Rn-1*C2….R1*Cn/∑ Rn*C1+Rn-1*C2….R1;

Where: Rn= Value given for the least ranked level (example if the least rank is 5th rank, then Rn+5, Rn-1=4 and ... R1=1)

Cn= Counts of the least ranked level (in the above example, the count of the 5th rank = Cn, and the counts of the 1st rank = C1)

Analysis of variance (ANOVA) was used to evaluate effects of grazing intensities on vegetation attributes (that included biomass, basal cover, density, species richness, diversity index and evenness of herbaceous plants) and woody vegetation variables (woody density and richness). Results were presented mainly using descriptive statistics like mean, percentage, standard deviation and graphs. For vegetation analysis, grazing intensity was considered a factor in one ANOVA. The analysis was conducted for each altitudinal location separately. Differences were considered significant at $P < 0.05$. Post-hoc comparisons of significant differences were done using the least square difference (LSD) method.

Model:

$Yij = \mu + Gi + Ai + Eij$

Where;-

Yij = Range condition parameters,

μ = Overall mean

Gj= effects of grazing intensity

Ai= effects of altitude

Eij = Random error

4. RESULTS AND DISCUSSION

4.1. Household Profile and Livelihood Sources

Majority (≈94%) of the respondents were males of different age and educational level, and about 94% were married (Table 1). The sampled households had an average family size of 9.41 (SD±0.32), which is higher than the national average of 5 persons per household (FAO, 2018). The average age of respondents was 46 years (SD±1.17 years). Among the sampled respondents, more than three quarters (78.8%) of households did not have any kind of education. Just 15% of those surveyed households had primary education, while 5% had attended junior school. As in elsewhere in pastoral areas of Ethiopia, the level of education in the study area is generally low. Nearly all (96%) the households did not receive any form of farm skill training, and had not attended pastoral training center (Table 1).

Table 1– Household characteristics, Ewa district, Afar region, Ethiopia[a]

HH characteristics	Upper lowland village (N=40)	Bottom lowland village (N=40)	Study area (total sample) (N=80)
Sex of HH head (%)			
Male	92.5	95	93.7
Female	7.5	5	6.3
Age of HH head (yrs)	45.83 (±1.70)	46.33 (±1.70)	46.10 (±1.20)
Family Size (head count)	9.88 (±0.45)	8.95 (±0.45)	9.41 (±0.32)
Marital Status (%)			
Single	2.5	2.5	2.5
Married	92.5	95	93.7
Divorced	2.5	0	1.3
Widowed	2.5	2.5	2.5
Education of HH head (%)			
Illiterate	67.5	90	78.8
Primary level education	22.5	7.5	15
Junior level education	7.5	2.5	5
High school level education	2.5	0	1.2
Farm skill training			
Attended	2.5	5	3.8
None	97.5	95	96.2

[a]All the tables in this thesis are produced from the 2020/21 household survey in the study area. HH=household. Numbers in parentheses are standard deviations.

As common to most pastoral societies, livestock production remains a major livelihood activity in the area (Fig. 2). Though households in the area engaged in livelihood activities such as crop production, and non-farm activities besides livestock production, their involvement in activities other than livestock was quite low.

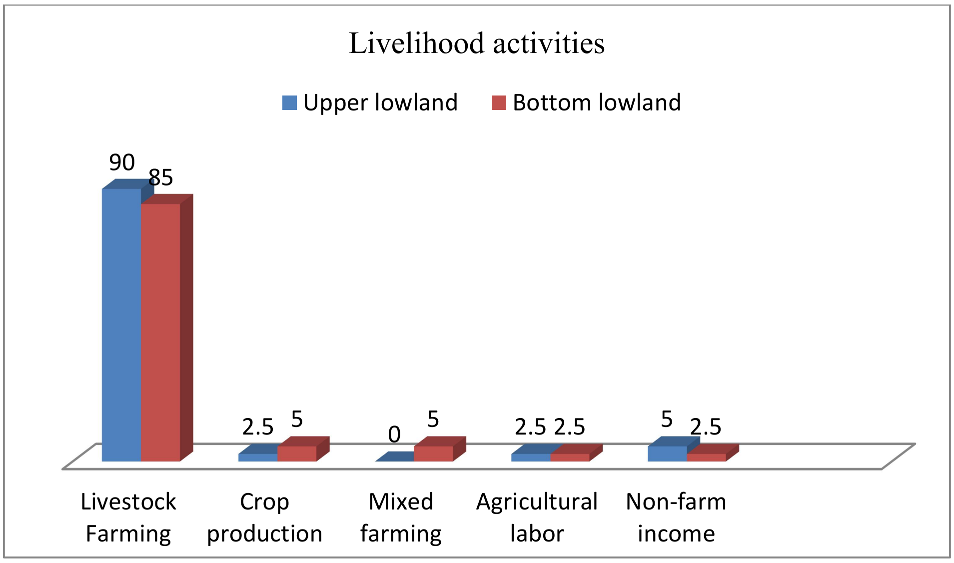

Figure 2. The main occupation of the household in Ewa district, Afar region, Ethiopia

4.2. Livestock Production and Composition

Livestock were the main assets for pastoralists, who keep around 29.71±2.95 tropical livestock units (TLU) (Table 2), with goats being the most commonly preferred followed by camel, sheep, and cattle (Appendix table 2). For the total sample, the average livestock holding per household was estimated to be 12.4±0.86 cattle, 3.42 ± 0.21 goats, 2.95±0.31 sheep and 9.41± 0.78 camels. As shown in table 2, although cattle account for the largest biomass of livestock in both altitudinal locations (hereafter location), the communities' also involved in the production of small ruminants, camel and donkey. But their contribution to livestock biomass was small. The type of livestock species kept by the households, however, differed between the two locations ($P<0.05$). Most importantly, while the mean number of cattle and sheep owned per household was larger in bottom lowlands, their biomass was reversed in the upper lowlands, where camel account for more than one-third (43%) of livestock biomass (Table 2). Camels were largely confined to the upper lowlands. The households in the upper lowlands have the largest camel holding - an average of 12.58 TLU per household. According to opinion of the pastoralists involved in the group discussions, the variation in type and composition of livestock kept by the households between the two locations was associated with indicators of feed availability such as the amount of grass cover, the type and abundance of existing feed (proportion of browse to grass in particular) sources, availability of water and vulnerability of animals to drought, in line with Abdulatife and Ebro (2015). According to Sharma *et al*., (2009) differences in elevation and the nature of slopes influence the species richness and distribution of plant species on a rangeland which might also explain the difference in type livestock species kept in upper and bottom location. Changes in vegetation cover or species composition (from grass to shrub/woodlands) as affected by environmental and/or various factors of degradation have shown to determine the pattern in holding livestock species (Aster *et al*., 2012; Coppock, 1994; Solomon *et al.,* 2007).

Table 2. Mean (±SD) livestock holdings (TLU) per household in the study district (N = 80).

Livestock species	Upper lowland (N=40)	Bottom lowland (N=40)	Study area (total sample) (N=80)	X^2	*P*-value
Cattle	9.33 ± 0.97	15.54 ±1.25	12.43 ± 0.86	15.49**	0.000
Sheep	2.33 ± 0.25	3.58 ± 0.56	2.95 ± 0.31	4.17*	0.04
Goat	3.53 ± 0.33	3.31 ± 0.27	3.42 ± 0.21		
Camel	12.58±1.29	6.25 ±0.55	9.41± 0.78	20.44**	0.000
Donkey	1.45 ±0.21	1.52 ±0.22	1.49 ± 0.15		
Total holding	29.22 ± 3.05	30.2 ± 2.85	29.71 ± 2.95		

**Significantly different at p (<0.05); **highly significantly different at p (<0.01).The TLU values for different species of animals are 1.0 for camel, 0.7 for cattle, 0.5 for Donkey and 0.1 for goat/sheep (ILCA, 1992.)*

4.3. Feed Resource Availability and Utilization

Natural pasture provides nearly 100% of the livestock feed in the study area (Table 3). The fodder grazed comprised browses, grasses, herbaceous legumes, and uncollected crop residues on cultivated fields. Grazing on communal grazing lands was a common form of feeding system in the area (Table 3). The availability and utilization of these resources vary with seasons and locations (Figure 3 and Table 4). The annual availability of natural pasture was seem to be in line with rainfall pattern and increased from June to September in the rainy season but declined as the dry season approached (Figure 3). This pattern of feed fluctuations was similar between the two locations.

Natural pasture was abundantly available for animals at the peak of the main rainy season (locally termed *karma*) (July to September) (mentioned by 67.5% of the respondents, N=80) and during the short rain (locally termed *sugum*) (January to March) (reported by 26.3% of the respondents of the total sample) (Figure 3). Feed scarcity was common during the long dry season (locally called *Hagai*) (April to June). Figure 4 shows the monthly availability of feed resources for livestock in the study area.

Though grazing on natural pasture was the main form of feed utilization, the type of forage species utilized significantly differed between locations ($P<0.05$). Grasses and herbaceous legumes were prominently utilized by the households in bottom lowlands (95%) than the upper lands (Table 3). Conversely, trees and shrubs were by far the most utilized livestock feed in the upper lowlands (reported by 85% of the respondents, N=40). Overall, majority (91% of the respondents, N=80) perceived a decline in the availability of feed resources from the rangelands over the past two decades (Table 4). This might be due to recurrent droughts, shortage of rainfall and decline of traditional rangeland management system with concomitant decline in production potential and quality.

Table 3. Major types of feed and feeding practice in Ewa district, Afar region, Ethiopia

	Upper lowland (N=40)	Bottom lowland (N=40)	Overall (N=80)	X^2	P-value
Major forage types (%)				51.717**	0.000
Native grasses and herbaceous legumes	15	95	55		
Tree forages	85	5	45		
Feeding practice (%)					
Free grazing	85	92.5	88.7		
Free grazing and stall feeding	15	7.5	11.3		

***highly significantly different at p (<0.01)*

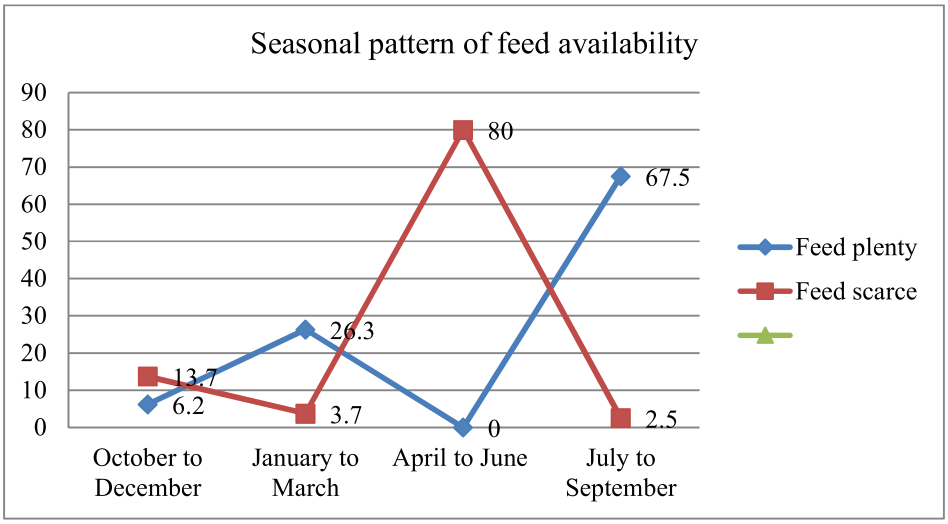

Figure 3. Seasonal pattern of feed availability in Ewa district, Afar region, Ethiopia

Table 4. Seasonal availability and trends of feed resources

Major source of feed	Upper lowland (N=40)	Bottom lowland (N=40)	Study area (total sample) (N=80)
Long dry season			
Communal grazing land	92.5	90.0	91.3
Crop residues from crop aftermath	2.5	5	3.7
Commercial feeds	5	5	5
Short Wet season			
Communal grazing land	95	92.5	93.8
Crop residues from crop aftermath	2.5	5	3.7
Commercial feeds	2.5	2.5	2.5
Trends of feed availability (both in amount and quality)			
Declined compared to 20 years ago	7.5	10	8.8
Abundant before 20 years ago	92.5	90	91.2

4.4. Traditional Coping Tool during Feed Scarcity

Communal grazing/browsing is the main feed source that the Afar livestock depend. However, the availability and contribution of both woody and herbaceous forages vary greatly with season and from site to site depending on climate and a range of other environmental factors (Kirkman and Carvalho, 2003). Besides, the feed shortage in the study area is mainly a reflection of continued overstocking by ruminants. In attempt to mitigate the problem, however, moving with their herds (mobility), transport forage from other places and supplementation of concentrates (to pregnant and lactating cows, and weak animals) (in order of declining importance) were implemented by the respondents in the area (Table 5). In line with the present study, mobility is the most widely used grazing strategy across the pastoral systems in Ethiopia (Amaha *et al.,* 2008; Aster *et al.,* 2012; Solomon *et al*., 2008). Mobility minimizes livestock pressure on natural resources as it ends to distribute the animals over a wide area, thereby reducing the concentration of animals in one particular area. It also enables the exploitation of heterogeneous environments (which is a common feature of rangelands) in space and time (Solomon *et al*., 2008). The pastoralists also use branches of trees as livestock feed to mitigate harsh condition (personal observation).

Table 5. Coping mechanisms to scarcity of feed in Ewa district, Afar region, Ethiopia

Coping mechanisms	Upper lowland (N=40)		Bottom lowland (N=40)		Overall (N=80)
	Index value	Rank	Index value	Rank	Index value
Move to another area/Mobility/	0.47	1st	0.44	1st	0.45
Transport forage from other places	0.35	2th	0.36	2th	0.35
Supplementation of concentrates	0.18	3rd	0.2	3rd	0.19

4.5. Available Water Sources in the Study Area

The source of water available for livestock has shown differences between the two locations (Table 6). While permanent river (mentioned by 60% of the respondents), pond (15%) and motorized borehole/ hand pump (25%) were the major water sources for the herders in the upper lowlands, motorized borehole/hand pump and ponds were the major ones in the lowlands.

Table 6. Source of water for livestock in Ewa district, Afar region, Ethiopia

Parameter	Upper lowland (N=40)	Bottom lowland (N=40)	Over all	X^2	P-Value
Source of water (%)				35.000**	0.000
River	60	0	30		
Pond	15	25	20		
Motorized borehole/Hand pump/	25	75	50		

4.6. Afar Pastoralists' Perceptions of Rangeland Condition and Vegetation Change

4.6.1. Perceptions of vegetation composition

Most of the pastoralists believed that the presence of significant changes in vegetation composition, particularly for the grasses to trees ratio (decline in abundance of grasses and an increase woody species), of the rangelands over the past decades. However, there were differing opinions on the current vegetation composition of the rangelands between the two locations (Table 7). The respondents in upper lowland ranked trees, shrubs (and grasses and forbs from 1 to 3, respectively (in order of their relative abundance/proportion). In contrast respondents in bottom lowland ranked grasses and forbs, shrubs and trees in order of their relative abundance (Table 7).

Table 7. Ranking of botanical groups according to their abundance in the area

Botanical groups	Upper lowland (N=40)		Bottom lowland (N=40)		Overall(N=80)	
	Index	Rank	Index	Rank	Index	Rank
Trees	0.46	1st	0.2	3rd	0.33	2 nd
Shrubs & sapling	0.32	2nd	0.31	2nd	0.32	3 rd
Grasses and forbs	0.22	3rd	0.49	1st	0.36	1st

4.6.2. Perceptions towards range vegetation condition change

When pastoralists were asked about changes, in rangeland condition (in terms of cover, distribution and quality), that they have noticed over time, nearly 99 % of them believed that rangelands have declined over time. It was agreed (reported by more than three-quarters of the respondents) that the decline in vegetation condition was prevalent in the past 16–20 years (Table 8). Minyahil et al., (2016) reported that occurrence of significant deterioration in the rangeland condition of Amibara and Gewane districts of Afar region. Aster *et al.* (2012) also reported the occurrence of tremendous changes in the vegetation of the Borana rangelands. Spread in undesirable plants, recurrent droughts, shortage of rainfall, overstocking by ruminants and over-utilization of key forage plants could likely be main factors contributing to changes in cover or species composition of the grass layer and changes in bush species composition with concomitant decline in production potential and quality.

Table 8. Trends in rangeland (cover, distribution and quality) condition in Ewa district, Afar region, Ethiopia

Parameter	Upper lowland (N=40)	Bottom lowland (N=40)	Overall (N=80)
Declining trends in rangeland (cover, distribution and quality) condition (%)			
Yes	97.5	100	98.7
No	2.5	0	1.3
Since when (%)?			
Before 5-10 years ago	10	10	10
Before 11-15 years ago	12.5	15	13.8
Before 16-20 years ago	77.5	75	76.2
Trends in abundance and distribution of key livestock species			
Declined	100	97.5	98.7
No change	0	2.5	1.3

4.6.3. Pastoralists' perception on current rangeland condition

In this study, perceptions towards current condition of the rangeland and causes for degradation were explored through focus group discussions and households' interviews. Participants involved in group discussions developed and prioritized indicators to evaluate the present range condition in their area. Consequently, feed availability, performance of animal, and variability of weather conditions especially shortage of rain fall were used as the main indicators to measure condition and degradation. This view of the pastoralists is also supported by Yosef (2007) and

Nigussie (2008). Amaha *et al*. (2008) had previously noted that the presence of unpalatable trees/grass species, scarcity of feed sources, increased frequency of droughts, combined with deterioration of body condition and decline milk yield, as key indicators of declining range condition in Somali region. Based on their own subjective judgment, when the pastoralists were asked about the current condition of their rangelands, the majority (62.5%) of them indicated that the condition of their rangelands was in a very poor condition, while 28.7% of the rangelands of the study area were perceived as poor and 6.2% in fair condition (Table 9). Abule *et al.* (2005) reported that about 73% of the condition of the rangeland in the middle Awash Valley area was in poor condition.

Table 9. The current rangeland condition as perceived by respondents in the study area

Rangeland condition (%)	Upper lowland (N=40)	Bottom lowland (N=40)	Overall (N=80)
Excellent	2.5	0	1.3
Good	0	2.5	1.3
Fair	7.5	5	6.2
Poor	25	32.5	28.7
Very Poor	65	60	62.5

4.6.4. Causes of rangeland degradation

Table 10 shows pastoralists' perceptions of the causes of rangeland degradation. As already noted, all pastoralists acknowledged the presence of rangeland degradation. In order of importance, the causes of degradation pastoralists claimed were recurrent droughts, absence of rain (decline in amount of rain), lack of range improvement interventions, inappropriate management (overgrazing (due to concentrated utilization of the rangeland due to increased confinement and poor grazing distribution)) and bush encroachment.

To deal with the above mentioned constraints of rangelands and livestock production in the area, various management interventions have been implemented the effect of which were presented in subsequent sections.

Table 10. Causes of rangeland degradation as ranked by the pastoralists in Ewa district, Afar region, Ethiopia

Causes	Upper lowland (N=40)		Bottom lowland (N=40)		Overall (N=80)	
	Index	Rank	Index	Rank	Index	Rank
Recurrent droughts	0.32	1st	0.32	1st	0.32	1st
Overgrazing	0.13	4th	0.15	4th	0.14	4th
Bush encroachment	0.09	5th	0.08	5th	0.09	5th
Absence of rain	0.28	2nd	0.28	2nd	0.28	2nd
Lack of proper management system	0.18	3rd	0.17	3rd	0.17	3rd

4.6.5. Rangeland management interventions

Various resource management practices have been promoted and implemented by the Government, NGO's and others across different periods in the Afar rangelands (e.g. Alemayehu, 2006). As revealed by majority of the respondents (mentioned by 86.7%, N=80) the establishment of enclosures was one of the popular range management practices. It was pointed out that rangeland enclosures were implemented primarily by NGOs, and were established largely for extension and demonstration purposes (mentioned by 81.3% of the respondents) thereby to enhance herders interest and its adoption, to rehabilitate degraded rangelands (reported by 13.4%) and to enhance forage production (mentioned by 5.3% of the respondents) (Table 11). However, the closing off communal rangelands and its wider use was constrained by a number of factors. Lack of sustainability (54.7%), lack of awareness of the community (22.7%), lack of adequate rain (12.2%) and animals' intrusions (10.6%) were perceived the factors constraining the successful enclosing rangelands in the area (Table 11). Apart from the uncertainty of the rangeland environment, the limited success in the adoption and acceptance of rangeland in Ethiopia has been attributed to weak extension support, poor community participation from planning to implementation and limited involvement and devotion of research institutions (Alemayehu, 2006).

Table 11. Rangeland management interventions practiced in Ewa district, Afar region, Ethiopia

Intervention	Upper lowland (N=40)	Bottom lowland (N=40)	Study area (total sample) (N=80)
Enclosures done by whom?			
Local (woreda) government)	10.3	8.3	9.3
NGOs	87.2	86.1	86.7
Community volunteers	2.6	5.6	4
Since when?			
One year	10.3	11.1	10.7
Since 5 years	82.1	83.3	82.7
Since 10 years	7.7	5.6	6.6
Reasons for establishment of the enclosure?			
To enhance forage production	5.1	5.6	5.3
To rehabilitate degraded rangelands	12.8	13.9	13.4
For extension and demonstration	82.1	80.6	81.3
Challenge linked to enclosures			
Animals intrusion	12.8	8.3	10.6
Lack of sustainability	53.8	55.6	54.7
Lack of awareness of the community	25.6	19.4	22.5
Limited rainfall	7.7	16.7	12.2

4.7. Effects of Grazing Intensity and Altitudinal Location on Range Vegetation Attributes

4.7.1. Herbaceous biomass and richness under different grazing intensities

Table 12 shows the effect of grazing intensity and altitudinal location on herbaceous biomass, species richness and composition. In both altitudinal locations (regardless of variations in locations), grazing intensities had a strong influence on both herbaceous biomass and species richness, with heavy grazing intensity (defined in the current thesis as highly degraded) having a significantly (($P<0.05$) lower biomass and species richness than either lightly (less degraded) or moderately grazed (moderately degraded) sites (Table 12). This pattern likely resulted from the difference in grazing intensities. Heavy utilization due to continued overstocking and inappropriate management (e.g., poor livestock distribution) usually leads to lower herbaceous biomass production and reduced species diversity due to a decrease in grass cover and growth of key species and their replacement by unwanted plant species. Similar results were reported by Ash *et al*. (2011). The mean species richness and herbaceous biomass difference observed among the grazing intensities in the bottom lowland showed relatively similar trends as the upper lowland (Table 12).

Table 12. Herbaceous biomass, richness and composition under different grazing intensities

Grazing intensity	Herbaceous vegetation parameters (mean(SD))							
	Upper lowland				Bottom lowland			
	Herbaceous biomass (kg./ha)	Herbaceous richness	Herbaceous composition (%)		Herbaceous biomass (kg./ha)	Herbaceous richness	Herbaceous composition (%)	
			Grass	N/G			Grass	N/G
Less degraded	125.33 (26.1)[c]	3.27 (0.76)[b]	53.57	46.43	281.33 (105.08)[a]	3.93 (1.01)[b]	75.68	24.32
Moderately degraded	49.33 (25.32)[b]	0.87 (0.61)[a]	22.73	77.27	77.33(51.32)[a]	1.27(0.81)[a]	41.38	58.62
Highly degraded	0.00(0.00)[a]	0.00 (0.00)[a]	-	-	0.00 (0.00)[b]	0.00(0.00)[a]	-	-
Overall mean	58.22 (57.62)	1.38 (1.54)	38.15	61.85	119.56 (138.79)	1.73 (1.85)	58.53	41.47
P value	0.001	0.001			0.006	0.002		
LSD value	41.95	1.12			134.90	1.49		

Within columns, means followed by different letters are significantly different at P <0.05. N/G: Non-grass

Table 13. Herbaceous biomass, richness and composition under different altitudinal location

Location	Herbaceous vegetation parameters (mean(SD))			
	Herbaceous biomass (kg/ha)	Herbaceous richness	Herbaceous composition (%)	
			Grass	N/G
Upper lowland	58.22(57.62)	1.38(1.54)	38.15	61.85
Bottom lowland	119.56(138.79)	1.73(1.85)	58.53	41.47
Overall mean	88.89(107. 81)	1.56(1.67)	48.34	51.66

N/G: Non-grass

Table 13 shows the effect of altitudinal location on herbaceous biomass, and species richness. Herbaceous biomass was lower in upper lowland (58.22 kg/ha) than bottom land (119.56 kg/ha). The high standard deviation in mean biomass indicates that there is considerable variation in herbaceous species biomass production between the two locations. Herbaceous species richness followed similar patterns (Table 13). The difference in both parameters observed in the current study between the different elevation categories may be the result of differences in environmental condition and site differences. Ayana *et al.* (2006) reported that location of the rangeland had significant effects on range vegetation parameters. These authors report revealed that bottom lands have higher range condition values than the upper lands probably due to better moisture level and soil condition status in the former, is line with the current study.

4.8. Effects of Grazing Intensity and Altitudinal Location on Range Condition Factors

4.8.1. Composition of the herbaceous layer

Overall, 10 herbaceous species were encountered within the sampled quadrats at two locations (Appendix Table 8). The grass species consisted 48.34% of the total herbaceous vegetation composition in the study area. Of the herbaceous vegetation, 8 species (3 grasses, 1 sedge and 4 herbs) were recorded in both altitudes and 1 grass like species only occurred in the bottom lowland whereas 1 herb species was only in the upper lowland. Of the herbaceous vegetation, the categories highly desirable, desirable, less desirable and undesirable species accounted for 30, 20, 10 and 40%, respectively (Figure 4). This might reflect the composition of herbaceous species has been in declining trend which probably due to increasing grazing pressure, spread of unwanted species and absence traditional management practice among other factors

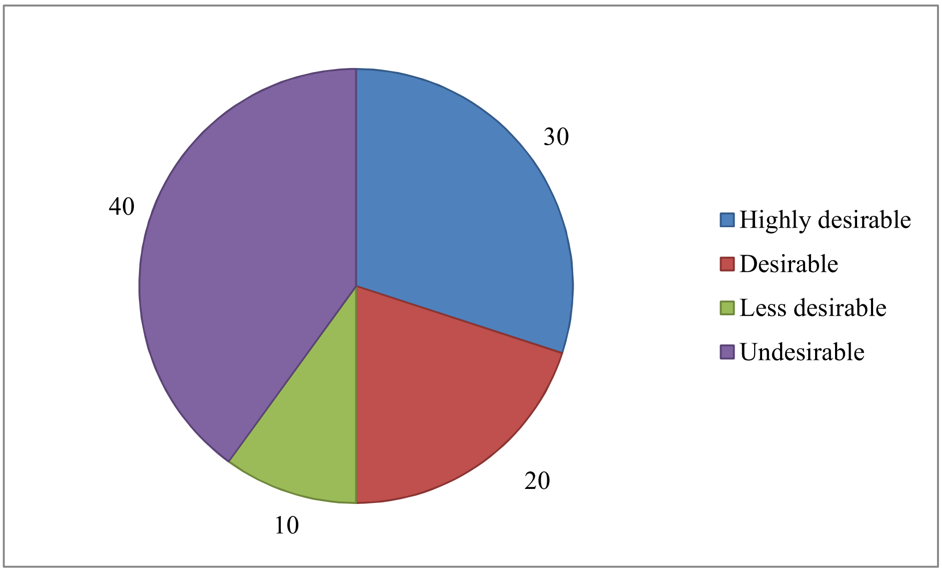

Figure 4. Proportions (%) of desirability of herbaceous species in the study area

4.8.2. Effects of grazing intensity on range vegetation condition

Table 14 shows the effect of grazing intensities on the condition of rangelands in the study area. There were significant differences ($P<0.05$) among grazing intensities for all parameters measured in upper lowland (LD>MD>HD) (Table 14). Grass composition, number of seedlings, age category and basal cover score were significantly different ($P< 0.05$) among the 3 grazing intensities in the bottom lowland (Table 14). However, ratings for litter cover, soil erosion and soil compaction showed no significance differences among the grazing intensities at this location.

4.8.3. Basal and litter cover

The vegetation survey revealed the presence of highly significant ($P<0.05$) differences in basal cover at both altitudes and litter cover among the grazing intensities of upper lowland, but no significant differences ($P>0.05$) in litter cover score of the soils among the grazing intensities of bottom lowland (Table 14). Factors such as concentrated grazing and poor management practices could be the most likely factors determining for the observed levels of basal cover in the study area. Amaha (2006) reported that basal cover become lower with poor range condition or the vegetation is under some kind of disturbance.

4.8.4. Number of seedlings and age category

There were highly significant differences in ratings for age distribution and number of seedling among the three grazing intensities (LD>MD>HD) ($P<0.05$) in both altitudes (Table 14.). This indicated that appearance of seedlings was very low where mismanagement (e.g., poor livestock distribution/heavy concentration) and continuous grazing existed.

4.8.5. Soil erosion and compaction

The result of this study revealed that, soil erosion and compaction scores showed highly significant differences ($P<0.05$) among grazing intensities (LD>MD>HD) of upper lowland; but no significant differences were observed ($P>0.05$) between grazing intensities of the bottom lowland (Table 14). Several studies in semi-arid rangelands (Amaha, 2006; Asheber, 2009; Fikirte, 2008) reported high levels of bare soil due to the hoof action of grazing animals, overgrazing and mismanagement considered as an important factors for the soil erosion and resultant decline herbaceous species composition and biomass.

Table 14. Range condition parameters under different grazing intensities in upper lowland and bottom lowland

Grazing intensity	Range condition parameters (mean(SD))							
	Upper lowland							
	GC	SN	AC	BC	LC	SE	SC	TS
Less degraded	1.33(0.23)[c]	0.73(0.23)[a]	1.00(0.20)[a]	1.93(0.50)[c]	1.67(0.70)[b]	4.20(0.80)[a]	4.60(0.70)[a]	15.46
Moderately degraded	0.87(0.23)[b]	0.47(0.12)[a]	0.73(0.23)[a]	0.93(0.12)[b]	0.80(0.00)[a]	3.13(0.42)[a]	3.87(0.12)[a]	10.80
Highly degraded	0.00(0.00)[a]	0.00(0.00)[b]	0.00(0.00)[b]	0.00(0.00)[a]	0.00(0.00)[a]	1.87(0.46)[b]	1.87(0.64)[b]	3.74
Overall mean	0.73(0.61)	0.40(0.35)	0.58(0.47)	0.96(0.88)	0.82(0.80)	3.07(1.13)	3.44(1.31)	10.00
P value	0.000	0.003	0.001	0.001	0.007	0.008	0.002	
LSD value	0.38	0.30	0.35	0.60	0.81	1.17	1.10	
	Bottom lowland							
	GC	SN	AC	BC	LC[ns]	SE[ns]	SC[ns]	TS
Less degraded	1.27(0.31)[a]	1.20(0.35)[b]	1.13(0.50)[b]	2.20(0.40)[c]	1.07(1.22)	4.47(0.76)	4.67(0.31)	16.01
Moderately degraded	0.80(0.53)[a]	0.27(0.23)[a]	0.53(0.31)[ab]	1.26(0.61)[b]	0.27(0.46)	3.60(0.00)	4.27(0.12)	11.00
Highly degraded	0.00(0.00)[b]	0.00(0.00)[a]	0.00(0.00)[a]	0.00(0.00)[a]	0.00(0.00)	3.93 (0.64)	4.47(0.12)	8.4
Overall mean	0.69(0.63)	0.49(0.58)	0.56(0.57)	1.16(1.02)	0.44(0.81)	4.00(0.62)	4.47(0.24)	11.80
P value	0.01	0.00	0.02	0.00	0.27	0.25	0.13	
LSD value	0.70	0.48	0.68	0.84	1.51	1.15	0.40	

GC= Grass composition; SN= Number of seedlings; AC= Age category; BC= Basal cover; LC= Litter cover; SE= Soil erosion; SC= Soil compaction; TS= Total score; ns= no significant difference. Within columns, means followed by different letters are significantly different at $P < 0.05$.

4.9. Effect of Altitudinal Location on Range Condition: Upper Lowland Vs Bottom Lowland

Though the differences were not statistically significant, there were differences between locations for all parameters measured. Overall, while these differences were somewhat inconsistent, in most of the parameters and the overall scores for rangelands at bottom lowland were higher than that of the upper lowland. Bottom lands are relatively fertile and good in moisture content which may be the reason for difference. However, the difference in range condition between the two altitudinal locations was minimal probably because the slope variations were small, and may be confounded by the differences in grazing pressure based on availability of water, differing livestock composition and grazing strategy of the pastoralists. As shown in Table 2, the population of grazing species (cattle and sheep) was very large in bottom lowlands while camel and goats were larger in upper lowland. Similar observation was also observed by Ayana *et al*. (2006) who reported minimal difference between elevations in range condition factors in Borana. The total score showed that the condition of the rangeland at both locations was in "poor" range condition (Table 15).

Table 15. Range condition parameters under different altitudinal location

Location	Range condition parameters (mean(SD))								Range condition class
	GC	SN	AC	BC	LC	SE	SC	TS	
Upper lowland	0.73(0.61)	0.40(0.35)	0.58(0.47)	0.96(0.88)	0.82(0.80)	3.07(1.13)	3.44(1.31)	10.1	Poor
Bottom lowland	0.69(0.63)	0.49(0.58)	0.56(0.57)	1.16(1.02)	0.44(0.81)	4.00(0.62)	4.47(0.24)	11.49	Poor
Overall	0.71(0.60)	0.44(0.47)	0.57(0.51)	1.06(0.93)	0.63(0.81)	3.53(1.01)	3.96(1.06)	10.8	Poor

The total rating was interpreted as follows: very poor (≤ 10); poor (11–20); fair (21–30); good (31–40); and excellent (41–50) points.

4.10. Density and Diversity of Woody Vegetation Layer

4.10.1. Density of woody vegetation layer

Numerically density of tree and shrub vegetation showed differences among the grazing intensities of upper lowland and altitudinal differences (Table 16). Density: which refers to the total number of stem of a species ha^{-1}, and calculated by summing up all the stems across all sample quadrants and translated to hectare base for all the species encountered in the study quadrants. According to vegetation survey result, the total mean densities of all woody plants were found to be 433 and 27 individual's ha^{-1} at upper lowland and bottom lowland respectively. Similar view of pastoralists was reflected on group discussion. This could be largely the result of human activities on land management and resource utilization.

Table 16. Density per hectare of seedling, saplings and trees in both altitudes at different grazing intensity

Location	Grazing intensity	Seedling	Sapling	Tree	Total
Upper lowland	Less degraded	53	65	153	271
	Moderately degraded	17	43	87	147
	Highly degraded	0	0	15	15
Total					433
Bottom lowland	Less degraded	3	2	15	20
	Moderately degraded	0	2	5	7
	Highly degraded	0	0	0	0
Total					27

4.10.2. Diversity of the woody plant species

The mean Shannon diversity is higher for upper lowland than bottom lowland altitude (Table 18). Diversity of the woody plant species, which was calculated, based on the species richness and evenness showed a significant ($P<0.05$) difference between the grazing intensities (LD, MD and HD) in the upper lowland but no significant difference was observed between the grazing intensities (LD, MD and HD) in bottom lowland (Table 17). Furthermore diversity, evenness and richness of woody plant species have shown differences between altitudinal (upper lowland and bottom lowland) locations. The upper lowland was higher in all tree vegetation parameters (Table 18). This was indicating the level of disturbance on woody plants on lowland altitude. Belaynesh (2006) and Feyera (2006) reported also low woody species richness in areas where there are anthropogenic disturbances in agreement with the present study. This also agrees with what the pastoralists said during group discussion ‘‘grasses species than woody tree species were dominantly found in bottom lowland’’. They mentioned also mismanagement, felling trees, firewood collection and charcoal making for sale were the cause of reduction woody plant species in the area. In line with the present study Belaynesh (2006) observed over utilization of trees and/shrubs for fuel and construction material resulted in loss of woody vegetation with the resultant deterioration of rangelands in semi-arid rangelands of Jijiga. A total of 14 species of woody and/or shrubs species were recorded in both altitudes (Appendix Table 7).

Table 17. Tree evenness, diversity and richness under different grazing intensities (within location)

Grazing intensity	**Tree vegetation parameters (mean(SD))**					
	Upper lowland			**Bottom lowland**		
	Richness	Evenness	Diversity	Richness	Evenness	Diversity[ns]
Less degraded	5.33(0.10)[a]	0.73(0.03)[a]	1.35(0.17)[a]	0.53(0.42)[b]	0.11(0.10)[b]	0.13(0.13)
Moderately degraded	3.53(1.92)[a]	0.63(0.29)[a]	0.99(0.52)[a]	0.20(0.20)[ab]	0.00(0.00)[a]	0.00(0.00)
Highly degraded	0.53(0.42)[b]	0.06(0.11)[b]	0.09(0.15)[b]	0.00(0.00)[a]	0.00(0.00)[a]	0.00(0.00)
Overall mean	3.13(2.37)	0.47(0.35)	0.81(0.63)	0.24(0.33)	0.04(0.07)	0.04(0.09)
P value	0.010	0.008	0.008	0.121	0.095	0.13
LSD value	2.54	0.36	0.66	0.53	0.11	0.15

Table 18. Tree evenness, diversity and richness under different altitudinal location

Location	Tree vegetation parameters (mean(SD))		
	Richness	Evenness	Diversity
Upper lowland	3.13(2.37)	0.47(0.35)	0.81(0.63)
Bottom lowland	0.24(0.33)	0.04(0.07)	0.04(0.09)
Overall	1.69(2.21)	0.26(0.33)	0.43(0.59)

5. CONCLUSION AND RECOMMENDATIONS

The rangelands of Afar region are important resources for the inhabitants of this area and their livelihoods. They are also important because they provide numerous ecosystem services that benefit the population living there and in the lower lands. Therefore, their sustainable use and management, and their conservation are of local and national importance. Through a combination of household surveys, focus group discussions, key informant interviews, and vegetation survey, this study examined pastoralists' perceptions on rangeland degradation and condition, and investigated effects of environmental factors on rangeland condition in Ewa district of Afar region. It was believed this study although limited both in its coverage and scope, provided valuable information to all concerned that involve in the interventions on pastoral areas so that they could make well-informed decisions and management interventions for use by pastoralists.

One of the major conclusions to be drawn from this study is that the rangelands of the study area are severely deteriorated and changes in the vegetation composition were prevalent. Nearly all pastoralists in the district viewed that their rangelands were severely degraded and that degradation is worsening over that past two decades due to recurrent droughts, shortage of rain fall, inappropriate management interventions, continued overstocking and over utilization (due to increased confined grazing and poor grazing distribution) and bush encroachment. The change in vegetation composition (decrease of valuable grasses and increase of unwanted species) and decline in condition are posing a serious threat to livestock production in the area. The pastoralists also claimed that the majority of rangelands were in very poor and poor condition. The above stated factors, as well as the impact of growing grazing pressure due to large livestock population, points to a perceived decline in condition of rangelands in the area with concomitant decline in production potential and quality.

The range condition assessment revealed strong effects grazing intensities (degradation levels) in most range condition parameters measured. As expected heavy grazing intensity (defined in the current thesis as highly degraded) resulted in lower herbaceous biomass and species richness than lightly or moderately grazed (degraded) sites. Grass composition, number of seedlings, age category and basal cover were also lower in heavily grazed (degrade site). The overall condition of the rangelands at both locations was in "poor" range condition, which agrees with the results from the pastoralists perceptions.

Overall, the study showed how the current management systems in rangelands and environmental factors such as climate change is worsening the deterioration of range vegetation in the study district.

Therefore, to sustain the socioeconomic condition of the inhabitants and the pastoral production system in the area, prevent rangeland from further decline and degradation, the following recommendations are made:

1. Trained range management personnel to start with extensive range management activities at field level are a prerequisite to radically improve conditions in the rangeland. Currently, both at national and regional levels, there is a shortage of trained staff in range management at both professional and technical levels. The Regional or Zonal Bureau of Pastoral development should take the lead to fill these technical and professional positions to implement quick and effective measures to improve the range resource in the area;
2. Since the major feed resource on which the pastoral communities primarily relied for their livestock is from the rangeland forage, conservation and improvement intervention of rangelands through proper management needs to be given priority. Furthermore, the conservation of the rangeland resource must receive priority, whether the land is used for conservation, livestock production or any other form of production. The community should also be aware that continued overstocking is causing range deterioration and implementation of remedial measures to overcome the problem should be a priority. As such an integration of indigenous knowledge with modern conservation approaches in the planning and implementation process is crucial for the likely local participation in the conservation process of the rangeland and to ensure sustained livestock production;

3. Management of natural resources is necessarily a site-and objective-specific endeavor. It is thus essential to focus on strengthening of the traditional resource management system, and provision of both technical and technological support to pastoralists. All stakeholders must be involved in the planning and execution of management strategies with full participation of pastoralists and government and non-governmental organizations as well other development practitioners.

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7. APPENDICES

7.1. Appendix I. Tables used to Present Results and Related Tables

Appendix Table 1. Criteria for scoring the different factors determining range condition (Baars *et al*., 1997).

Score	Grass composition (GC)	Grass basal cover (BC)	Litter cover (LC)	Grass seedlings (no.) (NS)	Grass age distribution (AG)	Soil erosion (SE)	Soil compaction (SC)
10	91-100% decreasers	>12%, no bare areas	>40%				
9	81-90% decreasers						
8	71-80% decreasers	>9%, evenly distributed	11-40%, evenly distributed				
7	61-70% decreasers	>9%, occasional bare spots					
6	51-60% decreasers	>6%, evenly distributed	11-40%, unevenly distributed				
5	41-50% decreasers	>6%, bare spots		>4 seedlings on A4 paper	young, medium, old	no soil movement	no compaction
4	10-40% decreasers, $\geq$ 30% increasers	>3%, mainly perennials	3-10%, mainly grasses	4 seedlings on A4 paper	two size categories present	slight sand mulch	isolated capping
3	10-40% decreasers, <30% increasers	>3%, mainly annuals		3 seedlings on A4 paper	only old	slope-sided pedestals	>50% capping
2	<10% decreasers, $\geq$50% increasers	1-3%	3-10%, weeds/tree leaves	2 seedlings on A4 paper	only medium	steep-sided pedestals	>75% capping
1	<10% decreasers, <50% increasers	<1%	<3%	2 seedlings on A4 paper	only young	pavements	almost 100% capping
0		0%	0%	no seedlings		gullies	

Appendix Table 2. Livestock types ranked in order of preference by the respondents in the study area

Livestock types	Upper lowland (N=40)		Bottom lowland (N=40)		Overall (N=80)	
	Index	Rank	Index	Rank	Index	Rank
Cattle	0.17	4rd	0.21	3rd	0.19	4th
Sheep	0.20	3rd	0.27	2nd	0.24	2nd
Goat	0.30	1st	0.31	1st	0.31	1st
Camel	0.26	2th	0.15	4th	0.21	3rd
Donkey	0.07	5th	0.06	5th	0.07	5th

Appendix Table 3. Major indicators used to evaluate range condition

criteria of vegetation condition	Upper lowland (N=40)		Bottom lowland (N=40)		Overall (N=80) All	
	Index	Rank	Index	Rank	Index	Rank
Availability of feed resource	0.45	1st	0.44	1st	0.45	1st
Variability of weather condition	0.20	3rd	0.19	3rd	0.19	3rd
Performance of livestock	0.35	2nd	0.37	2nd	0.36	2nd

Appendix Table 4. Ranking Causes of Abundance and distribution of palatable species decrease for livestock

Causes	Upper lowland (N=40)		Bottom lowland (N=40)		Overall (N=80)	
	Index	Rank	Index	Rank	Index	Rank
Over stocking	0.45	1st	0.46	1st	0.45	1st
Frequent drought	0.34	2nd	0.33	2nd	0.34	2nd
Absence of rain	0.21	3rd	0.21	3rd	0.21	3rd

Appendix Table 5. Pastoralists perception towards rangeland degradation

Pastoralists perception towards rangeland degradation	Upper lowland (N=40) (%)	Bottom lowland (N=40) (%)	Overall (N=80) (N=80) (%)
Very degraded	70	62.5	66.2
Fairly degraded	2.5	2.5	2.5
Somewhat degraded	25	35	30
Not Degraded at all	2.5	0	1.3

Appendix Table 6. List of trees and shrub species recorded in the study area

Vernacular name	Scientific name	Life Form	Desirability
Adgento	*Acacia seyal*	Tree	HD
Keselto	*Acacia nilotica*	Tree	HD
E'ebi	*Acacia tortilis*	Tree	HD
Udayito	*Balanites aegyptiaca*	Tree	D
Kusra	*Ziziphus spina-christi*	Tree	HD
Maegharto	*Acacia melifera*	Tree	D
Adayito	*Salvadora persica*	shrub	LD
Gerento	*Acacia nubica*	Tree	D
Segento	*Tamarix aphylla*	Tree	UD
Gela'ato	*Calotropis procera*	Shrub	UD
Adengelita	*Cadaba rotundifolia*	Shrub	UD
Gersa	*Dobera glabra*	Tree	LD
Ayrobit	*Senna obtusifolia*	Annual shrub	UD
Bunayito	*Senna occidentalis*	Annual shrub	UD

Appendix Table 7. List of herbaceous species recorded in the study area

Vernacular name	Scientific name	Life Form	Desirability
Durfu	*Chrysopogon plumulosus Hochst*	Perennial grass	HD
Edoletenkisi	*Chloris barbata*	Perennial grass	HD
Democracy	*Parthenium hysterophorus*	herb/annual	UD
fi'a	*Cyperus esculentus*	perennial sedge	D
Olayito	*Aerva javanica (Burm.fil.)*	perennial herb	UD
Aytiadoyta	*Tetrapogon tenellus (Roxb) chior*	Annual grass	D
Kokadawuto	*Amaranthus spinosus L.*	annual herb	UD
Mussa	*Unidentified*	Perennial grass	HD
Bunkat	*Tribulus terrestris*	Annual herb	LD
Bang	*Xanthium orientale*	Annual herb	UD

Appendix Table 8. Frequency count of each herbaceous species in the different categorized degradation areas in the study area (LD= Less degraded MD= moderately degraded HD= highly degraded).

Herbaceous species name	Afar Common name	Frequency count					
		Upper lowland			Bottom lowland		
Perennial grasses		LD	MD	HD	LD	MD	HD
Chrysopogon plumulosus Hochst	Durfu	7	1	0	8	0	0
Chloris barbata	Edoletenkisi	5	0	0	6	3	0
Unidentified	Mussa	0	0	0	10	5	0
Sub-total count		12	1	0	24	8	0
Total Perennial grasses count		42					
Annual grasses							
Tetrapogon tenellus (Roxb) choir	Aytiadoyta	3	4	0	2	4	4
Sub-total count		3	4	0	2	4	4
Total annual grasses count		17					
per*ennial sedge*							
Cyperus esculentus	fi'a	0	0	0	3	3	4
Sub-total count		0	0	0	3	3	4
Total perennial sedge count		10					
Annual herb							
Tribulus terrestris	Bunkat	2	0	0	0	1	4
Xanthium orientale	Bang	3	4	0	0	2	2
Amaranthus spinosus L.	Kokadawuto	2	5	0	1	1	3
Parthenium hysterophorus	Democracy	3	4	0	3	2	4
Sub-total count		10	13	0	4	6	13
Total Annual herb count		46					
perennial herb							
Aerva javanica (Burm.fil.)	Olayito	3	4	0	1	0	0
Sub-total count		3	4	0	1	0	0
Total perennial herb count		8					

Appendix Table 9. Frequency count of each Tree/shrub species in the different categorized degradation areas in the study area (LD= Less degraded, MD= moderately degraded, HD= highly degraded).

Herbaceous species name	Afar Common name	Frequency count Upper lowland			Bottom lowland		
Tree		LD	MD	HD	LD	MD	HD
Acacia seyal	Adgento	8	5	0	1	0	0
Acacia nilotica	Keselto	13	6	1	3	0	0
Acacia tortilis	E'ebi	10	5	0	0	0	0
Balanites aegyptiaca	Udayito	7	6	0	1	0	0
Ziziphus spina-christi	Kusra	7	2	0	0	0	0
Acacia mellifera	Magarto	5	3	0	0	0	0
Acacia nubica	Gerento	9	8	0	1	0	0
Tamarix aphylla	Segento	0	1	0	1	2	0
Dobera glabra	Gersa	4	3	1	0	1	0
Sub- total count		63	39	2	7	3	0
Total tree count			104			10	
Shrub							
Salvadora persica	Adayito	4	2	1	0	0	0
Calotropis procera	Gela'ato	2	1	0	2	0	0
Cadaba rotundifolia	Adengelita	2	3	1	0	0	0
Sub- total count		8	6	2	2	0	0
Total shrub count			16			2	
Annual shrub							
Senna obtusifolia	Ayrobit	6	7	4	0	0	0
Senna occidentalis	Bunayito	3	2	0	0	0	0
Sub- total count		9	9	4	0	0	0
Total annual shrub count			22			0	
Upper and bottom lowland tree/shrub total count			142			14	

Appendix Table 10. Criteria used in rating rangeland condition by perception of pastoral groups in upper lowland and bottom lowland altitudes of Ewa district in Afar region

Condition	Criteria
Very poor	Most of the grazing areas have gullies and capping
	Large area covered by unpalatable species
	Absence of water source and long dry season of weather condition
	Very far from vicinity
	Very poor performance of livestock
	Very high incidence of disease for human and livestock
Poor	Most of the grazing areas covered by annual grasses
	Large area covered by unpalatable species
	Absence of permanent water source short wet season of weather condition
	Far from vicinity
	Poor performance of livestock
	High incidence of disease for human and livestock
Fair	Moderate amount of palatable perennial grasses are available
	The area is moderately covered by unpalatable species
	water source is available non- reliable weather condition
	Fair performance of livestock
	A little bite far from vicinity
	Incidence of disease for human and livestock
Good	Most of the grazing land covered by important legumes and promising perennial grasses
	Availability of important browsing species
	water source is available throughout the year and reliable weather condition
	Near to their vicinity
	Good performance of livestock
	Less incidence of disease for human and livestock
Excellent	Most of the grazing land covered by important legumes and perennial grasses
	Commensurability of composition of browse and grass species
	water source is available with good weather condition throughout the year
	Near to their vicinity
	Excellent performance of livestock
	Less incidence of disease for human and livestock
	Easy access of health center

7.2. Appendix II. Questionnaire Used for Socioeconomic Survey

Questionnaire for assessing Pastoralists' perceptions on rangeland degradation and current range condition of Afar region, Ewa district (individual households)

Background information

Questionnaire No ________________________

Name of enumerator ______________________

Date of interview ________________________

Location: Region ______________ Zone ___________District _______

Kebele______________________

Altitude (meter above sea level) ________________________

Altitude category: 1) Upper lowland 2) Bottom lowland

A. Household socioeconomic and demographic characteristic

1. Name of Household head ____________________Age __________ years

1.1 Sex: 1) Male 2) Female

1.2. Family size ___________

1.3 What is your marital status? 1) Single 2) married 3) Divorced 4) Widowed

1.4. Level of education: 1. Illiterate 2. Primary 1-4 3. Junior 5-8 4. High school 9-12

1.5. For how long have you been residing at the current home? ______

1.6 Have you ever undergone any livestock training in your lifetime? 1) Yes 2) No

1.7. What is the main occupation of the household? **(Note:** an occupation is considered main if approximately more than 50% the household income comes from that source.) 1) Livestock Farming 2) Crop production 3) Mixed farming 4) Agricultural labor 5) Non-farm income

B. Livestock Holding & production system

1. How many animals (including young ones) do you have in each category (No.)?

1. Cattle_____2. Sheep______3. Goats________4. Camel_______ 5. Donkey________ 6. Others, specify________________

2. What is the main reason for keeping each type of livestock? (Tick "√" the approprierte box)

Purpose	cattle	sheep	goats	camel	donkey
Milk for sale					
Milk for home consumption					
Sale live animals					
Draft purpose					
For social value					

4. What changes have there been in the number of animals over the last 10-20 years in the area? 1). increased 2). Decreased 3). No changes

5. If increased, which species 1. Cattle 2.Sheep 3. Goat 4. Camel 5. Donkey

6. If decreased, which animal species 1. Cattle 2.Sheep 3. Goat 4. Camel 5. Donkey

C. Feed source, availability and feeding strategies

1. What are the major types of feeds for livestock (excluding chicken)? 1) native grasses and herbaceous legumes 2) tree forages, 3) crop residues 4) improved forages 5) others, specify
2. What are the major sources of forage for livestock and when are they used?

Feed type	Source	Long dry	Short dry	Long wet season	Short Wet season	All year
Grazing	*Own pasture (private paddock)*					
	communal land					
Cut and carry grass and Crop residues	*Own pasture (private paddock)*					
	communal land					
	Crop aftermath					
Commercial feeds	Industrial by products					
Other (specify)						

3. What is/are the feeding system/s practiced in the area? Free grazing 2) Tethering 3) cut and carry/stall feeding 4) Free grazing and stall feeding
4. Indicate which months of the year that each of the above livestock feed resource is available at the source?

Feed resource/type	Months most available 1. October to January 2. February to May 3.June to September	Months when least available or absent 1. October to January 2. February to May 3.June to September
Grazing land		
Own pasture (private paddock)		

Communal land		
Crop aftermath		
Commercial feeds		

5. Do you experience a shortage of feeds for your animals? 1. Yes 2. No If Yes, when?

1. October to January 2. February to May 3. June to September

6. How do you perceive the amount and quality of feed available throughout the year now and before 20 years ago?

6.1 Quality and quantity of feed availability is good enough now 1. Yes 2. No

6.2 Quality and quantity of feed availability is good enough before 20 years ago 1.Yes 2. No

7 What are the common grazing systems in your area? 1. Freely grazing on range land 2. By cut and carry system 3. Supplement concentrates

8 If yours animal freely graze on range land; is there ample forage on rangeland?

1. Yes 2. No

9. If no, what is the reason for the absence of ample forage on the range land? (Rank 1-5) 1. Because of recurrent drought 4. Absence of rain

2. Because of overgrazing 5.Lack of Rangeland management system

3. Bush encroachment 6. Other specify______________

10. If there is scarcity of feed, what did you do (to dealing with the problem) (rank in order of Importance) (Rank 1-3)

1. Move to another area/Mobility/ 2. Transport forage from other place

3. Supplement concentrates 4. Other specify____________________

D. Rangeland Vegetation Condition

1. Did the rangeland support all types of livestock? 1. Yes 2. No

2. If No, which livestock types are most supported by the rangeland at the moment /Rank1-5/ 1. Cattle 2. Sheep 3. Goat 4. Camel 5. Donkey

3. To what extent do you consider the current states of the communal rangeland?

1. Very degraded 2. Fairly degraded
3. Somewhat degraded 4. Not very degraded
5. Not degraded at all 6. Difficult to tell

4. What do you think are the possible causes for the degradation? (Multiple response possible)

1. Not degraded
2. over grazing
3. Frequent drought
4. Expansion of Agriculture or crop Encroachment
5. Allocation of land to other development activities
6. Expansion of Invasive plants
7. Expansion of settlement
8. Allocation of land to private investors/youth associations
9. Community conflict
10. Other specify ________________

5. What are the consequences/impacts/ of the rangeland degradation in the area (Rank in order of importance)

1. Affect the species composition of the range resources
2. Reduce the productivity of the rangeland and livestock
3. Affect soil status/erosion
4. Change in herd composition

5. Increased incidence of conflict
6. Increase in degree and frequency of mobility
7. Decline in livestock holding
8. Other specify__________________

6. Did your community/clan allocate rangeland according to season?

1. Yes 2. No

7. On your perception what is the current condition of the rangeland in the area?

1. Excellent 2. Good 3. Fair 4. Poor 5. Very poor

8. What evaluation criteria do you consider to rate very poor, poor, fair, good and excellent range vegetation condition? /Rank1-3/

1. Availability of feed resource 3. Variability of weather condition

2. Performance of livestock 4. Other specify___________________

E. Botanical Composition and Trends of vegetation change

1. Have the cover, distribution and quality of Rangeland vegetation been diminishing?

1. Yes 2.No

2. When the range vegetation resources have to start decline?

1. Before 0-5 years ago 3. Before 11-15 years ago

2. before 6-10 years ago 4. Before 16-20 years ago

3. Which Botanical groups are dominantly found in your rangeland? /Rank1-3/

1. Trees 2. Shrubs & sapling 3. Grasses and forbs

4. Have the abundance and distribution of palatable species for livestock decreased?

1. Yes 2. No

5. If yes, what are the causes? /Rank1-3/

1. over stocking 2. Frequent drought 3. Absence of rain

6. Have the abundance and distribution of invasive species increased? 1) Yes 2) No

7. If yes, what are the causes of the increase in invasive species in the area? 1. Because of non -palatable 2. By wind-blown 3. By carried by animals

8. Did you the rehabilitation of rangeland like area closures practiced in the area? 1. Yes 2. No

8.1. If Yes, the enclosures done by whom? 1) Woreda (Government) 2) NGO 3) Community Volunteers 4) by self

8.2. Since when? 1. since a year 2. Since 5 years 3. Since 10 years 4. Since 20 years

8.3 Reasons for establishment? 1. To get ample forage for livestock 2. To rehabilitate the rangeland 3. To get model work for the rangeland 4. Other specify________________

8.4. What related problems encounter on enclosure? 1. Livestock enter in to enclosure 2. Lack of sustainability 3. Lack of awareness of the community 4. Less rainfall

9. What other range rehabilitation practices implemented to increase the vegetation cover in the area? 1. Soil and water conservation works 2. Reseeding 3. Proper grazing system 4. Bush control 5. No other rehabilitation practices

F. water Resource Utilization

1. What is your main source of water for drinking and cooking, by season? (Tick one per column)

No.	**Source of water**	**Rainy season**			**Dry season**		
		People	(drinking	Proximit	People	(drinking	Proximit

		(drinking, cooking(A)	) for animals (B)	y to water source 1=<2km 2=2-5km 3=>5km	(drinking, cooking(A)	) for animals (B)	y to water source 1=<2km 2=2-5km 3=>5km
1.	River						
2.	Runoff water?						
3.	Pond or lake						
4.	Pond/lake/ fenced						
5.	Rainwater harvesting						
6.	motorized borehole/Hand pump/						

2. How is the different water sources managed? 1) individually 2) communally 3)By Government
3. Are there any traditional rules that govern the use of water sources? 1) yes 2) No
4. What changes (over the last 10-20 years?) have there been in the amount and quality of water resources in the study area? 1) Good in quality and amount 2) Not

good in amount and quality 3) Good change in amount but not quality 4) No change at all

5. What seems the trend of rainfall (over the last 10-20 years?)

   1. Increase in amounts and seasonal distribution

   2. Decrease in amounts and seasonal distribution

   3. Not changed in amounts and seasonal distribution

6. What changes (over the last 10-20 years?) you perceive in river/ run off flow, 1. Increase the Level of river and run off 2. Decrease the level of river and run off 3. Decrease the level of river but increase frequent flood

6. Is there motorized borehole or wells in your area? 1. Yes 2. No

7. If Yes, the boreholes or wells done by whom? 1. Regional government 2. Federal government 3. NGO 4. Specify others____________

8. What changes (over the last 10-20 years?) you perceive in amount and quality of wells and boreholes 1. Increase in amount and quality of developed wells and boreholes 2. Decrease in amount and quality of wells and boreholes 3. Increase in amount and decrease in quality (increase salinity, pollution) of wells and boreholes 4. No change in amount and quality of wells and boreholes

9. Source of irrigation water in your area 1. Motorized borehole 2. Rainwater 3. Runoff water 4.River

8.1 Is irrigation water used for livestock production? 1. Yes 2. No

8.2 Is irrigation used for forage development? 1. Yes 2. No

8.3 If No, why? 1. Lack of interest 2. Lack of awareness 3. Give priority for other crops

Checklist for group discussion (Elder, Youth and Women group)

Date______________________/2020 G.C

Location: Zone________________ District______________

Kebele (Pastoralist association) ___________________

Group:-______________

1. What is the history and pattern of settlement in the area? (Scattered, densely populated etc.)
2. What are the main livelihood/production activities during the rainy/dry seasons (i.e. what are the main things people do for subsistence or to earn a living)?
3. What is the history and pattern of land use in the area?
4. Describe the source and availability of forage in your area?
5. According to your perception what are the importance of knowledge of plant species?
6. Is there limitation related to range vegetation resource? If yes, what are the causes to limit the range vegetation?
7. What are the criteria used for classification/characterization of your pasture/grazing areas into _______________?
8. In your opinion what is an ideal grazing site?
9. How could you assess the botanical composition of you grazing areas? What are the indicators used?
10. Is there ample amount of species of grazing and browsing? What are the dominant species in your rangelands? Rank them on the basis of their abundance.

10.1 Do you perceive that there is a vegetation change in botanical composition of herbaceous species'?

10.2 Do you perceive that there is a vegetation change in botanical composition of browse species'?

11. What do you perceive on trends of vegetation cover change? Is it increasing or decreasing or no change? If decreasing since when? What are the causes and impacts/consequences/ of vegetation changes in your area?
12. What are the traditional coping mechanisms for the challenges of shortage of feed resources for the livestock and also the related to its consequences
13. What seems current traditional status of management practices of rangeland vegetation resources?
14. Have you ever noticed the key forage species disappeared due to the effect over grazing?
15. How the changes of composition of the rangeland affect the productivity of rangeland as Well as livestock output, and also on your livelihood?
16. Would please suggest the possible mitigation measure that should be considered to rehabilitate the range vegetation resources in the area?
17. How did you categorize your rangeland area or your kebele into different agro ecological zones? Describe the criteria employed to classify. Is there any difference in on vegetation composition along the altitudinal zones?
18. What is your major needs and give priorities of the activities should be do in the future to rehabilitate the rangeland vegetation and to maximize the livestock out put on sustainable base?

<u>Woody vegetation sampling format</u>

Date ________________Name of District: _________Kebele: ____________Altitude category: ________________________

Level of Degradation: _____________________

Location: Longitude __________Latitude __________Altitude ____________ Transect No.____________Quadrate No. ________

Woody spps. category	Vernacular Name	Scientific Name	Desirability				Tree/ shrub number			Tree/ shrub/ Composition per quadrant score
			H	D	L	U	Tally	sum	Score	
mature trees (>2 m height)										
Saplings (0.5-2m height)										
Seedlings (<0.5 m height.)										
							Tot. No.			
							Codes: Tree/ shrub number (score 0-10) 0= <5 1=6-10 2=11-15 3=16-20 4=21-25 5=26-30 6=31-35 7=36-40 8=41-45 9=46-50 10= >50			Codes: Tree/ shrub composition (score 0-10) 0= >70 non required 1= <10 required 2= 10-20 required >60 non required 3=20-30 required >50 non required 4=30-40 required >50 non required 5= 40-50 required >40 non required 6= 50-60 required 7= 60-70 required 8= 70-80 required 9= 80-90 required 10= 90-100 required

H= Highly desirable; D= Desirable; L =Less desirable; U =Undesirable; %age= Percentage

Herbaceous vegetation and soil sampling format

Date _______________Name of District: _________Kebele: ___________Altitude category: ______________________

Level of Degradation: ___________________

Location: Longitude _________Latitude __________Altitude ___________ Transect No.___________Quadrate No. _______

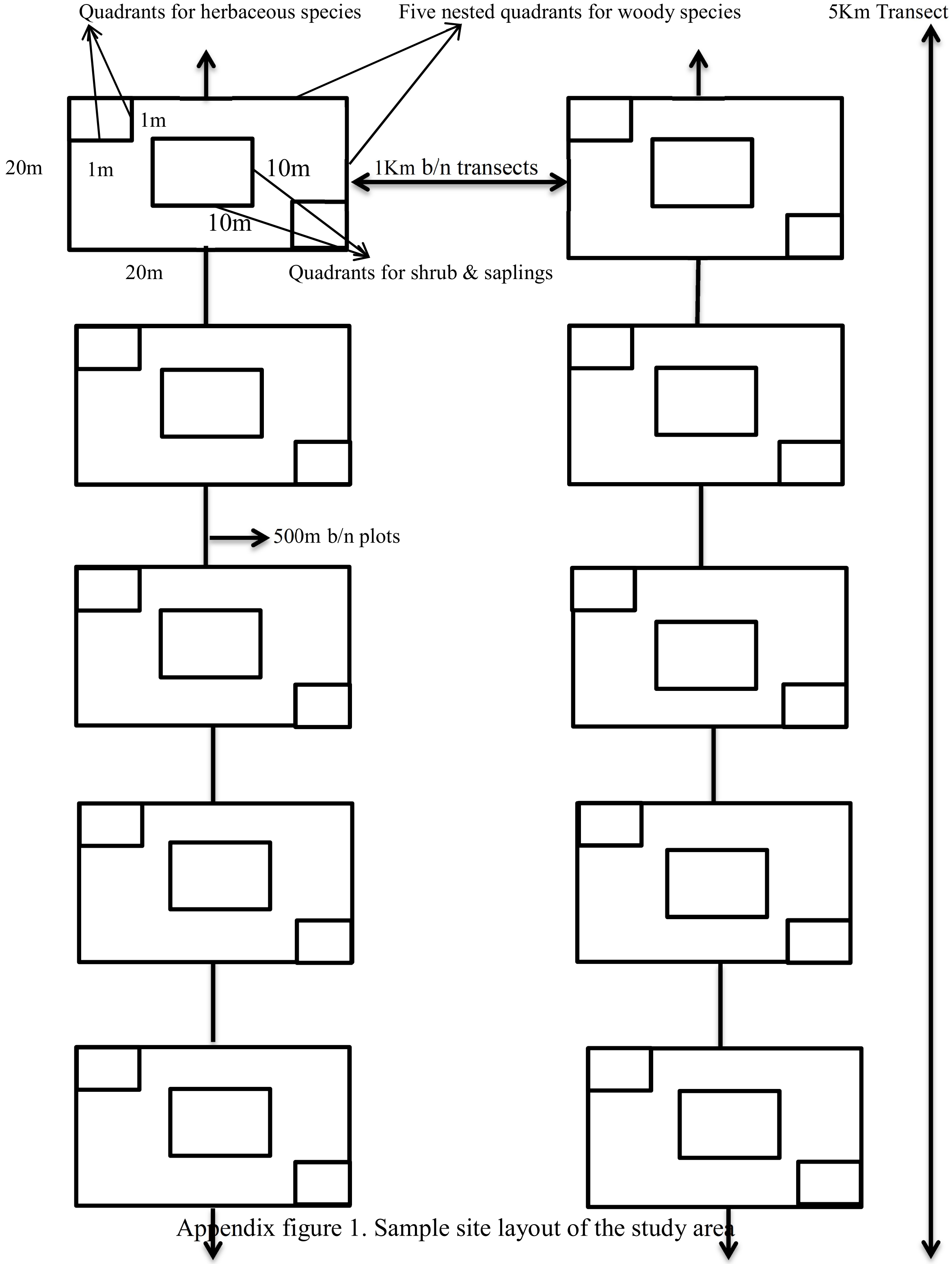
Live weight (Biomass) of herbaceous per $1m^2$ quadrant ____________ Dried biomass weight __________

S.N	Local Name	Scientific Name	Life Form	Spp. Count(Freq.)/quadrant			desirability				Factors to be assessed						
											Grass					Soil	
				Tally	total	%age	H	D	L	U	BC	LC	AC	NS	HSC	SE	SC
1.																	
2.																	
3.																	
4.																	
5.																	

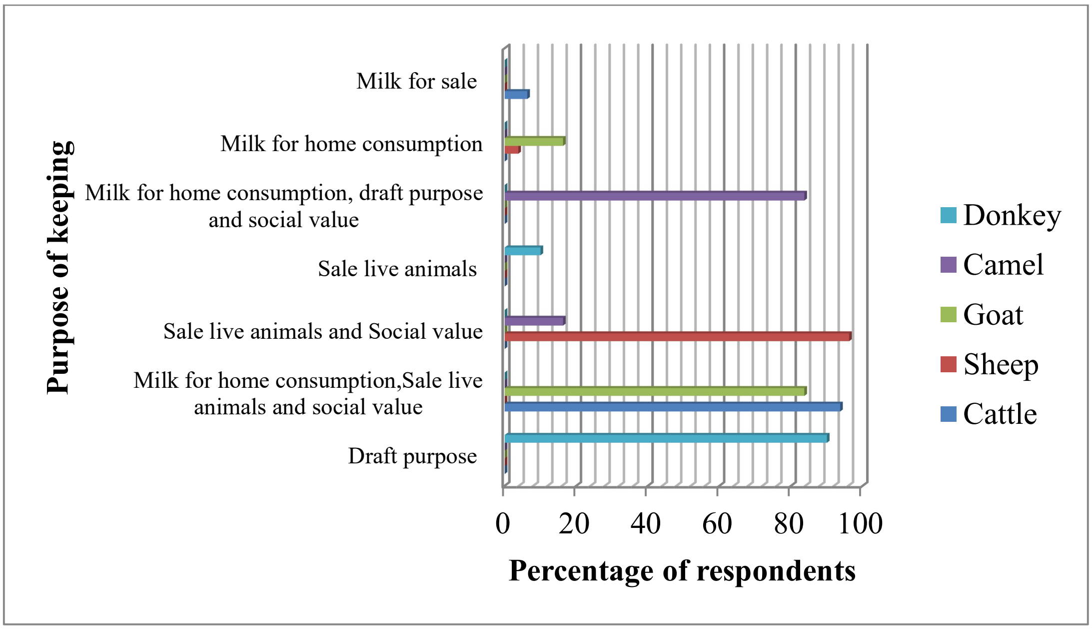
Codes: LF	Codes: HSC (score 1-10)	Codes: NS (score 0-5)	Codes: AC (score 1-5)	Codes: BC (score 0-10)	Codes: LC (score 0,2,4,6,8& 10)	Codes: SE (score 0-5)	Codes: SC (score 1-5)
1= annual 2= perennial	1= <10% decr <50% incr 2= <10% decr >50% incr 3=10-40% decr <30 incr 4=10-40% decr >30 inc 5=41-50% decreasers 6=51-60% decreasers 7=61-70% decreasers 8= 71-80 %decreasers 9=81-90% highly desirable grasses 10= 91-100% highly desirable grasses	0=No seedling 1=1 seedling on A3 paper 2= 2 seedling on A3 paper 3= 3 seedling on A3 paper 4= 4 seedling on A3 paper 5= >4 seedling on A3 paper	1= only young plants 2=only medium-aged 3=only old 4=Young and medium aged (20% and 50%) 5=young, medium aged and old	0= 0% 1= <1% mainly of annuals 2= 1–3% mainly of annuals 3= >3% mainly of annuals 4= >3% mainly of perennials 5= >6% bare spots 6= >6% evenly distributed 7= >9% occasional bare spots 8= >9% evenly distribute 9= >12% with slightly bare spots 10= >12% with no bare spots	0= <3% weeds or tree leaves 2= 3–10% weeds /tree/ leaves 4= 3–10% mainly of grasses 6= 11–40% mainly of grasses and unevenly distributed 8=11–40% mainly of grasses and evenly distributed 10= >40% mainly of grasses and evenly distributed	0= Gullies 1= Pavements 2= Steep sided pedestals 3= Slope sided pedestals 4= Slight and mulch 5= No soil movement	1= Almost 100% Capping 2= >75% capping 3= >50% capping 4= Isolated capping 5=No compaction

S/N= Serial number; **H**= highly desirable; **D**=desirable; **L**=Less desirable; **U**=Undesirable; **LF**= Life form; **HSC**= Herbaceous species composition; **NS**= Number of seedling; **AC**= Age Categories; **BC**= Basal cover; **LC**= Litter Cover; **SE**= Soil erosion; **SC**= Soil compaction

7.3. Appendix III. Figures of Sample Sites Layout and Features of the Study Area



Appendix figure 1. Sample site layout of the study area



Appendix figure 2. Purpose of keeping livestock in the study area

Appendix figure 3. Determination of herbaceous species composition and biomass sampling

Appendix figure 4. Sample of range Condition factors

Appendix figure 5. Plant species identification with inhabitants

Appendix figure 6. Camel forced to graze at bottom altitude of the study area

Appendix figure 7. Traditional coping tool during feed scarcity

Appendix figure 8. Household interview

Appendix figure 9. Group discussions with the selected elders

Appendix figure 10. Determination of woody Density with in sample area

BIOGRAPHICAL SKETCH

The author, Mengeste Mathewos, was born in December/ 1984 from his father Ato Mathwos Wontamo and his mother W/ro Ayelech Bekele in Gebirasu zone 3; Amibara district; Melkasedi town in afar national regional state. He began his education at Melkasedi Elementary School. He completed his Secondary School at Lucy Secondary high School in the 2001/02 and he joined then Agarfa Agricultural TVET College in 2003/04 and graduated with Diploma in Animal science in July 2006. The author then was employed in Amibara district Agricultural and rural development office as animal production junior expert. After serving two years, he joined Hawassa University College of Agriculture in summer season and graduated with Bachelor of Science in Animal and Range science in September 2011. Following his graduation, he has joined the federal democratic republic of Ethiopia Ministry of Agriculture sustainable development goal project as Animal and range development expert since 2011/12. However, again in July 2018, he joined the school of post-graduate studies of Hawassa University for MSc, Degree in Animal production.