RESPONSE OF COMMUNAL GRAZING LAND TO SELECTED RANGELAND IMPROVEMENT PRACTICES AT LUBUNGO VILLAGE IN MVOMERO DISTRICT, TANZANIA

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A DISSERTATION SUBMITED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN TROPICAL ANIMAL PRODUCTION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

This study consisted of two experiments, (i) Assessment of pasture composition and productivity during dry season, (ii) Assessment of the response of communal grazing land to selected rangeland improvement practices (oversowing, manure application and furrows for rain water spreading) on pasture composition and productivity was conducted at Lubungo village in Mvomero district, Morogoro Tanzania. In study one, data of vegetation ground cover, dry matter yield of pasture and tree density were collected by using tape measure, quadrat and Point centered quarter method respectively in three transect lines. Study two, adopted completely randomized design and the treatments were manure, oversowing and furrrowing. The results showed that the rangeland had low dry matter yield of pasture during the dry season (806.77±29.9 kg DM/ha) due to high tree density of about 1500 trees/ha with total canopy cover of 67.4%. Bare soil patches had high soil seed bank density mainly comprised of annual grasses, few perennial grasses and several undesirable and unedible annual forbs. The assessment of the response of communal grazing land to selected rangeland improvement practices indicated fast growth in plots treated with combination of manure, oversowing and furrowing as rain water spreading, followed by manure and furrowing and thereafter manure alone. High dry matter yield was attained in plots treated with manure, oversowing and furrowing (8.4±0.19 t DM/ha), manure and oversowing (6.4±0.19 t DM/ha), manure and furrowing (5.8±0.19 t DM/ha) and manure alone 5.1±0.19 t DM/ha). Dry matter yield were low in plots treated with furrows and oversowing (3.1±0.19 t DM/ha), furrows (2.8±0.19 t DM/ha), oversowing (2.6±0.19 t DM/ha) and control (2.6±0.19 t DM/ha). It is therefore recommended that, combination of manure and oversowing as well as manure, oversowing and furrowing can be used to improve pasture composition and productivity of the communal grazing land at Lubungo village.

DECLARATION

I, **Tito Eleutery Mdegela,** do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work done within period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

_____________________________ _____________________________

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(MSc. Candidate)

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Prof. Ephraim J. Mtengeti Date

(Supervisor)

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(Supervisor)

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DEDICATION

This work is dedicated to my father, the late Mr. Eleutery Mdegela and to my mother, the late Malegerita Mlasu, who sacrificed their time and the little resources they had on building the foundation of my education. May the almighty God rest them in peace, Amen!

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of variance
BD	Bulk density
DM	Dry Matter
GLM	General Linear Model
Ha	Hectare
Kg	Kilogram
Mg	Milligram
Ss	Number of sample
OC	Organic Carbon
PCQ	Point Centered Quarter
SAS	Statistical Analysis System
SE	Standard Error
SWh	Sward height

CHAPTER ONE

1.0 INTRODUCTION

Rangeland is defined as the land on which the native vegetation is predominately grasses, grass-like plants, forbs or shrub suitable for grazing or browsing use, or is all areas of the world that are not cultivated and will provide the necessities of the life for grazing and browsing animals (Blench and Sommer, 1999). They include tall grass and short grass prairies, desert grasslands and shrub lands, woodlands, savannas, steppes and tundra. These areas are characterized by low precipitation, shallow soils and slow nutrient cycling (Rinehart, 2006**)**.

Rangelands are home both to significant concentrations of large mammals and plants with a high value in both leisure and scientific terms and to human populations that have historically been excluded and marginalised, pastoralists and hunter-gatherers (Thornton *et al.*, 2003). The typical inhabitants of the rangelands are pastoralists, hunter-gatherers and increasingly subsistence farmers which depending on uncertain rainfed crops. Historically, when demographic pressure was substantially lower, these groups could interact with only limited conflict. Now, throughout the world's rangelands, these groups are competing for a shrinking land resource (Blench and Sommer, 1999; Sayre *et al.*, 2012).

Rangeland pasture is the backbone of livestock production in the world in general and Tanzania in particular. It supports life of some of the world's poorest people (Neely *et al.*, 2012) and livestock is growing as a sector, accounting for up to 50% of GDP in countries with significant areas of rangeland (World Bank, 2008). Due to increased land use pressures mainly overgrazing and shifting cultivation, these rangelands have been subjected to land degradation (Mohammed, 2013). This has reduced natural pasture productivity and the carrying capacity of the rangelands. The deterioration are not limited to grasses, but includes a decrease in the production of trees in form of pods and leaves which normally add over thirty percent to rangeland carrying capacity (Le Houerou, 2010). Normally, the degree of grazing strongly lead to deterioration of desirable plants and reduces its ability to compete with the undesirable plants for soil moisture, soil nutrients, space and light because following grazing their recovery are suppressed by the undesirable plants. Forinstance, Byenkya (2004) noted the differences within grasslands where intensities of grazing result to overgrazing of palatable plants and provide room for unpalatable plants to dominate. On the other hand, light to moderate level of grazing actually maximize both primary and secondary vegetation production and encourage perennial grass at the expense of the woody vegetation (Galt *et al*., 2000).

Shifting cultivation involves clearance of rangeland natural vegetation, burning, tilling and farming several years until the soil fertility decline and is inadequate for crop production, then the farmer shift to another fresh land with natural vegetation. Researchers have found that this type of cultivation is unsuitable land use contributing significantly to rangeland degradation (Luoga, 2000; Zahabu, 2008). It influences changes in grassland vegetation where by natural perennial grasses may be replaced by undesirable plants (Hiernaux *et al*., 2009). The degraded land may not be suitable for natural perennial grasses which dominated on the land before cultivation but conducive to invaders which may have adaptation suited to degraded soil (Drake *et al*., 1989). Rangeland improvement means all kind of land manipulation that increase pasture yield production and quality (nutritive value). It is done for the purpose of increasing pasture yield and thus the potential carrying capacity of the rangeland. The most employed rangelands improvement methods as stated by Tahir (2003) include:

i. Scratching the soil with chisel plough to destroy the hard pan
ii. Seeding and re-seeding/oversowing.
iii. Fertilizer application.
iv. Soil – water conservation through contour, terraces, water spreading and pitting
v. Bush clearing and weed control.
vi. Use of prescribed burning as a tool for rangeland improvement.
vii. Determination of the correct carrying capacity and stocking rate.
viii. Grazing management.

These rangeland improvement techniques should however not be introduced accidentally, the selection of one or the other depend on a number of parameters linked to climate, nature of the soil, management ability of the graziers and cost effectiveness of the technique selected under the particular circumstances (Tahir, 2003).

There is however, low adoption rate of these rangeland rehabilitation practices among pastoralists in Tanzania. This could be attributed by a number of barriers including culture, land tenure, lack of awareness, methods used to transfer proven rangeland rehabilitation technologies and practices, contradictory agricultural policies and unavailability of pasture seeds (Maleko *et al.,* 2015). More effort is required in Tanzania to foster the adoption of rangeland rehabilitation technologies by the targeted community in order to reduce the effect of soil erosion, increase soil fertility and soil moisture hence improving rangeland productivity.

1.1 Statement of the Problem and Study Justification

Most pastoral rangelands found in tropical countries particularly Tanzania are now facing a problem of low pasture production per hectare. This could have been caused by increased land use pressure (overgrazing and shifting cultivation) and lack of rangeland improvement programmes. Therefore, most rangelands have less water infiltration, increased soil erosion and bush encroachment. This have led to decreased pasture soil seed bank and increased bare soil patches. Instead of adapting proper range management measures in their grazing lands, pastoralists have been moving with their livestock all over the country to find pasture and water. This have led to conflicts between herders and farmers and even wildlife protected area authorities following crop damage and unpermitted grazing on reserved land.

There was a need, therefore, to conduct a study on response of communal grazing land to selected rangeland improvement practices (manure application, oversowing and furrowing as soil-water conservation techniques). These rangeland improvement methods could help to increase pasture productivity and carrying capacity of the degraded pastoral rangeland at Lubungo village and reduce some unnecessary mobility and land use conflicts. The pastoralists involved in this study from the beginning to the end were advised to adopt and apply these rangeland improvement practices at their own grazing sites.

1.2 Objectives

1.2.1 General objectives

To assess the response of communal grazing land to selected rangeland improvement practices (manure application, oversowing and furrowing as soil-water conservation techniques) at Lubungo village in Mvomero district.

1.2.2 Specific objectives

i. To conduct an inventory of the vegetation characteristics, pasture productivity and soil seed bank during dry season.
ii. To determine the effect of manure application on pasture composition and productivity.
iii. To assess the influence of soil - water conservation practices on pasture composition and productivity.
iv. To assess the effect of oversowing Rhodes grass on grazing land pasture dry matter yield.

1.3 Hypotheses

i. There is no significant different in pasture composition and productivity between the selected grazing areas.
ii. There is no influence of manure application on pasture composition and productivity.
iii. There is no effect of soil – water conservation on pasture composition and productivity.

iv. There is no significant difference between oversown and unoversown pasture plots in terms of pasture dry matter yield.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Rangeland Inventory

Rangeland inventory involves collection of information (vegetation types, range sites, range condition, carrying capacity, soil types, utilization patterns and topography) to document and describe the existing vegetation type and productivity of the rangeland. It is usually conducted to assess the response of vegetation to grazing management or to any improvement programme at the rangeland site. Such changes can be detected by series of measurements at the specific time (every season or year) (Gintzburger and Said, 2010). The detailed information obtained helps the range manager to plan and evaluate specific rangeland improvement project such as soil erosion control, oversowing, bush encroachments control, soil fertility and moisture improvement (Muir and McClaran, 1997).

Most pastoral rangelands have poor range condition due to overgrazing which lead to loss of desirable plant species and rise of undesirable plant species including bushes. These cause decrease of carrying capacity of the rangeland because of bush encroachments and marked soil bare patches. On the other hand, high bush/tree canopy cover hinders the establishment of understory grass species due to shade (Kapu, 2012). Oversowing is one of the rangeland improvement practices but is somehow expensive. One need therefore, to assess the soil seed bank density and characteristics in order to be sure if the grazing land is rested wouldn't come back with desirable vegetation.

2.2 Influence of Oversowing, Manure Application and soil – Water Conservation on Pasture Productivity

2.2.1 Effect of oversowing on pasture production

Oversowing is the introduction of pasture species of grasses or legumes to a natural pasture stand. It is a method of improving productivity of the degraded grazing land with marked soil bare spots (Mwebaze, 2002). Not only had that but also used to improve quality of pasture by oversowing legume pasture species. Oversowing can be done by broadcasting seeds on scratched land or strip sowing with 50 cm inter-row spacing (Muraina *et al.*, 2017). However, low soil fertility and inadequate soil moisture can hinder the establishment of the oversown pasture. Oversowing increase the carrying capacity of rangeland through reduction of soil bare patches and increase in pasture yield per unit area. These have been observed by several researchers including Kusekwa *et al.* (1988) who recorded high annual dry matter yield of 15.6 tons of natural pastures oversown with *Desmodium intortum* compared to annual yield of 13.0 tons DM/ha from natural pastures alone. Also Atsbha *et al.* (2017) observed increase in dry matter yield that led to increase in stocking rate when natural pasture were over sown with *Vicia sativa.*

2.2.2 Influence of manure application on pasture production

Manure is the organic fertilizer which contains nitrogen, phosphorus, potassium and other nutrients. It adds organic matter to the soil which may improve soil structure, aeration and enhance soil moisture-holding capacity. Applications of manure fertilizers increase soil condition for vigorous crop growth. Fast growth gives quicker ground cover and higher yields (Sustainet EA, 2010). Manure has longer lasting effect than equivalent nutrient levels to chemical fertilizer. This is because a large proportion of the mineral nutrients are combined with organic substances which are released gradually as they decay. Hence, improved yield may continue years after addition of manure to the soil (Edmeades, 2003). Several studies have been conducted to investigate the influence of farmyard manure on the performance of pasture and crop production. Jusoh (2005) reported that, sheep manure alone or in combination with urea gave better growth performance of the Napier grass in terms of the tiller height, tiller number and leaf area index over the 6 cutting cycles of 6 weeks per cycle. The treatment with 200 kg Nha-1 of sheep manure gave highest dry matter yield (16 t/ha/yr) compared to control (10 t/ha/yr). When 12 t/ha of manure was applied, gave rise to 20.74 t/ha and 21.74 t/ha (Desalegn, 2017). Mosebi *et al.* (2015) examined the impact of manure application on growth characteristics of *Digitaria eriantha* where they observed the fast increase in plant height and leaves number in plots applied with manure compared to those which were not applied with manure.

2.2.3 Influence of soil and water conservation on pasture production

Soil - water conservation practices are done to maintain or improve capacity of the land productivity. They improve crop and pasture productivity through prevention of soil erosion, increase in water infiltration, retaining organic matter, improve soil fertility, soil water holding capacity and reduced soil compaction. These enhance enough moisture in the soil for germination and growth of crop and pasture plants in semi arid areas (Hatibu *et al.*,1999). Maleko *et al.* (2015) in their field experience work in central Tanzania found greater grass cover improvement in degraded land which were almost bare before establishment of furrows and pits as soil and water conservation techniques. Crop farmers in Ethiopia have appreciated increase in crop production per area since they adopted soil and water conservation methods which reduce soil erosion, water runoff and increase moisture in the soil (Nigatu *et al.*, 2017).

Among common methods used to conserve soil and water in the semi arid rangelands are contour farming practices, water retaining pits, broad bends and furrows and conservation tillage. Large structures such as terraces have seldom been considered practical on rangelands, mainly because of the high construction expenses (Branson *et al.*, 1966).

2.2.3.1 Contour farming practices

These involve ploughing, planting and weeding along the contour that is across the slope rather than up and down. Contour farming reduces soil erosion by as much as 50% on gentle slopes (Sustainet EA, 2010). Grass barrier strips of Napier or other fodder grasses are planted along the contour so as to increase the strength of the contour bands and reduce the speed of water runoff. Low crop or pasture production is caused by loss of soil fertility due to steep slope which enhance accelerated soil erosion. Angima (2000) found that contour hedges on 20% slope conserved more soil (168 Mg/ha) compared to the control plots. The yield of grasses per hectare increased due to reduced erosion and retained soil fertility.

2.2.3.2 Water retaining pits

Water retaining pits trap runoff and allow it to seep into soil. A series of pits are dug into the ground where the runoff occurs. The soil from the pits is used to make banks around the pits and furrows carry excess water from one pit to the next. The pit effectively serves as a basin to collect water and allow soil penetration. The value of pits in water retention depends on their density, size and depth and soil permeability. Normally they are dug 20 – 30 cm wide and 10 – 20 cm deep with the soil from the pit thrown downhill. The spacing of pits with a row as well as the spacing between rows of pits varies between 60 and 100 cm (Tim *et al*., 2013).

Pitting has been effective in increasing forage production by as much as 100 percent, primarily due to enhanced water infiltration (Simiyu *et al.*, 1992). The disturbance and better water retention increase productivity of the remaining vegetation through plant succession and make better plant communities (Schuster, 1996). Branson *et al.* (1962) in their experiment in Colorado found that there were high pasture composition, frequency of occurrence and dry mater yield in plots treated with pits than in control.

Pitting is best suited to medium textured soils with less than 8 percent slope, but the ideal slope is 3% to 5%. Steep slope result in swift moving water runoff that may cause soil erosion. On very flat land however runoff is so slow that much of water infiltrates without running into the micro catchments (Simiyu *et al.,* 1992). Its value is limited on sandy, rocky or brush covered soils.

2.2.3.3 Broadbends and furrows

In the broad bend and furrow system runoff water is diverted into field furrows (30 cm wide and 30 cm deep). The field furrows are blocked at the lower end. When one furrow is full, the water backs up into the head furrow and flows into the next field furrow between the field furrows are broad bends about 170 cm wide where crops are grown (Renner and Frasier, 1995). Contour furrowing of poor condition range has been shown to reduce runoff and conserve more than two centimeters of water annually in the Great Plains (Branson *et al.,* 1966). Increased herbage production follows improved water retention and storage and the transport of nutrients from surface layers to lower depths (Mugonola *et al.,* 2015). Furrowing treatment caused a decrease of salts of calcium, magnesium and sodium in the upper portion to the lower depth of the treated soils (Branson *et al.,* 1966). The removal of salts from the upper portions to lower depth of the soil resulted to greater availability of water for pasture growth (Branson *et al.,* 1966). Contour furrowing is applicable on gentle to moderate slope where the soil is productive enough to support the addition growth that the increased moisture encourages. They are not satisfactory on loose soil, rough broken land or on steep slope (Reese, 1966). Small furrows not exceeding one and a half meters apart are usually more effective than larger furrows or those more widely. The small furrows regrass more rapidly and hold the water where it is the most beneficial without causing an erosion problem (Hudson, 1987).

2.2.3.4 Conservation tillage

Is cultivation practice that include minimum tillage, no tillage, strip tillage, ridge tillage and mulching. Helps to reduce soil surface compaction, minimize soil disturbance that can lead to soil erosion, reduce subsurface soil compaction by tractor and improve water infiltration. Normally chisel plough is used to loosen the compacted soil degraded by grazing animals. The main function of this plough is to loosen and aerate the soil while leaving pasture crop residue at the top of the soil, unlike other many ploughs the chisel plough will not invert or turn the soil (Karlen and Rice, 2015).

Most of soils in sub-Saharan Africa suffer from poor physical and chemical properties, In addition to intensive rainfall events, make them sensitive to crust formation (Karuma *et al.,* 2014). Tillage systems affect soil properties which in turn impact root growth and distribution as well as crop yield (Basamba *et al.,* 2007). Sub-soiling with chisel plough improves soil bulk density and total porosity of degraded lands with had pans. These had significant moisture conservation and crop performance advantage over the control in the sand loam soil of semi arid area of Eastern Kenya (Miriti, 2010). It enhances water infiltration and root penetration into the soil of the left pasture crop and easy germination of newly sown seeds (Hoogmoeg, 1999; Aina *et al.,* 1991).

2.3 Conclusion

The literature reviews have revealed that soil moisture and fertility are potential factors for seed germination, crop growth and yield. Rangeland management measures that conserve moisture and increase soil fertility are important for limiting the devastating consequences of drought to the crop yields in semi arid areas. The resulting effect however depends on the availability of soil seed banks of desirable pasture species that enables the range land to regenerate following degradation. Assessment of the soil seed bank density and characteristics prior to adoption of rangeland rehabilitation techniques is significant for attainment of better results. If the soil seed banks density of desirable pasture species is very low, regardless of the high cost of oversowing one need to involve oversowing when carrying out rangeland productivity improvement of these degraded rangeland.

Few studies have been conducted on the effect of soil - water conservation practices on pastoral rangelands productivity in Tanzania semi arid areas. As a result there are low adoption rate of these rangeland rehabilitation measures by pastoralist in Tanzania. Reasons might be several among which are unawareness, contradictory Agriculture policy and unsecured land ownership. Nyamekye *et al.* (2018) in Burkina Faso found that communal ownership of grazing land discourages adoption and investment in rangeland improvement among individual pastoralist. Therefore, the study involved pastoral community to assess the effect of oversowing, manure application and soil – water conservation practices on range land productivity.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

This study was conducted at Lubungo village in Mvomero, located at North East of Morogoro Region between 8° 00" and 10° 00" Latitudes south of equator and between Longitudes 37° 00" and 28° 22" East. This site is found at an elevation of between 300 to 400 m above the sea level.

The indigenous people of Mvomero district are mainly of Bantu origin. The tribes that dominate in Mvomero district include: Waluguru, Wakaguru and Wakwere. The main economic activities practiced at Mvomero district are crop production (food and cash crops) and livestock production. The area receives annual rainfall ranging between 580 mm and 1191 mm. Rainfall distribution is bimodal with the short rains in October to January and the long rains in March to May.

3.2 Research Methods

This research was conducted in two stages. The first stage was assessment of vegetation characteristics, pasture productivity and soil seed bank during dry season and the second stage was an experiment to study the response of the communal grazing land to the selected rangeland improvement practices (manure, oversowing and furrows as soil – water conservation practice) in terms of pasture composition and productivity during the rainy season. The aim of first stage of this research was to observe the current characteristic of continuously grazed area while the second stage aimed at visualizing the effects of imposing selected rangeland improvement practices on pasture composition and productivity.

3.2.1 Assessment of vegetation characteristics, pasture productivity and soil seed bank during the dry season in communal grazing land

These included evaluation of vegetation ground cover, dry matter yield, soil seed bank, tree density and canopy cover. Data were collected along three transect lines of 700 m each and 40 m apart established in the communal grazing land of 8.4 ha in October, 2018. In each transect line a sampling unit of 10 m was set after every 70 m using a tape measure. Each transect line had 8 sampling units making a total of 24 sampling units for the whole plot. In each sampling unit data on pasture species composition, dry matter yield, soil seed bank, tree/ shrub density and canopy cover were collected as explained below:

3.2.1.1 Pasture species composition, distribution and ground cover

The pasture species composition and distribution was determined by using a quadrant frame of 0.5 m×0.5 m which was randomly thrown towards the left at 5 m and towards the right at 10 m in each sampling unit. Pasture species inside each quadrant frame were identified and recorded in field note book. The frequency of occurrence of each pasture species was obtained by dividing the number of quadrats it was observed by total number of quadrant frames times hundred.

Vegetative ground cover was determined using a line interception method, where a 10 m tape measure was stretched out on the ground at each sampling unit. The distance of vertical projection of the edge of the crown or base of a plant and bare soils intercepting the tape was read and recorded. The percentage ground cover of pasture species was obtained by dividing the total linear distance along the tape intercepted by the crown or base of pasture species by the total stretched length of the tape times hundred.

3.2.1.2 Dry matter yield

Desirable pastures (edible to grazing animals) inside the quadrant frames in each sampling unit were harvested, sorted to remove undesirable materials and weighed to get the weight of fresh sample. These samples were packed into labeled paper bag and were then placed into plastic bucket that were used to transport them to SUA Animal Nutrition Laboratory for further analysis. In the laboratory the samples were oven dried to constant weight at temperature of 70^0C for 48 hours. The weight of dried sample was recorded and used for the determination of dry matter yield per quadrant and thereafter per hectare.

3.2.1.3 Tree density and canopy cover

Point Centered Quarter (PCQ) method was employed to assess tree density and tree canopy cover in the study plot. In every sampling unit 4 nearest trees were established by using a cross made of two sticks each 1m in length and put on the ground nearly at the centre of the 4 trees, in a way that each tree had to fall in each quarter. Measurement of distance of each tree from the central established point (quarter distance) in meters and canopy diameter of tree was recorded and used for an estimation of tree density and canopy cover of the communal grazing land.

3.2.1.4 Soil seed bank

In order to assess soil seed bank density and its plant species composition, soil samples were collected around each sampling unit. Therefore, a total of 24 samples were collected in the study site. Areas where soil sample for soil seed bank analysis was collected were first cleaned by removing plants and litter materials on the ground surface so as to avoid taking seed lodged in litters. Thereafter, soil sample were collected in an area measuring 30 cm x 30 cm wide and a depth of 5 cm by using a hand hoe and bush knife. The collected soil sample was packed into the labeled paper bag, put into plastic bucket and transported immediately to Sokoine University of Agriculture. Each soil sample was filled at plastic pot with a diameter of 22 cm and depth of 3.5 cm. The pots were then placed in transparent nylon greenhouse structure measuring 2 m x 2 m×2 m to prevent incoming seeds from the surroundings. The pots were covered by perforated nylon to minimize moisture loss and the cover was removed after seven days to allow the germinated seeds to access more light and remove impedance for growth. Moisture content of the soil was maintained all the time by regular watering with industrial bottled drinking water so as to prevent any foreign seed from direct river water. Data on seedlings emergence was recorded after every 7 days for 8 weeks starting from seventh day since incubation date. Each emerged seedling per pot was counted and the number of seedlings per hectare was calculated so as to obtain soil seed bank density. Identification of germinating plants of the soil seed bank started in 8^{th} week though some of the seedlings died before reaching the stage of being identified.

3.2.2 Effect of selected rangeland improvement practices on pasture composition and productivity during the rainy season

An experiment to study the effect of selected rangeland improvement practices on pasture composition and productivity during the rainy season was conducted in a plot of 3168 m^2 delineated within the 8.4 ha used for the first study of this report (section 3.2.1). The experiment was conducted during the rainy season from March to June 2019 and involved rangeland improvement practices namely manure application, oversowing with perennial grass species (Rhodes grass) and furrowing as rain water spreading structure.

3.2.2.1 Experimental design and layout

The experimental area was demarcated into 3 plots each 24 m × 44 m with spacing of 2 m. Each experimental plot was thereafter divided into 8 subplots each 10 m × 10 m with spacing between subplots of 1 m. A total of 8 treatments were adopted in this experiment (Table 1). The treatments were allocated at random in a completely randomized design experiment with 8 treatments (sub plots) and were replicated three times in the study area.

Table 1: Experimental lay out

REPLICATIONS (Plots)	**RANGELAND IMPROVEMENT PRACTICES (Sub plots)**							
Plot I	T_0	T_4	T_2	T_7	T_3	T_6	T_1	T_5
Plot II	T_5	T_3	T_4	T_6	T_0	T_2	T_7	T_1
Plot III	T_1	T_2	T_0	T_4	T_7	T_5	T_3	T_6

Key: Treatments
T_0 = Control (no rangeland improvement was applied)
T_1 = Furrowing
T_2 = Oversowing
T_3 = oversowing and Furrowing
T_4 = Manure application
T_5 = Furrowing and Manure application
T_7 = Manure application and oversowing
T_8 = Manure application, Oversowing and Furrowing

3.2.2.2 Experimental procedure

This involved preparation of land which included bush clearing, slope determination, soil and manure sampling, manure application at a rate of 10 ton/ha, establishment of furrows of 30 cm wide and 20 cm deep after every 150 cm spacing (as soil-water conservation practice) and soil disturbance using hand fork hoe after every 30 cm in which *Chloris gayana* seeds were oversown at rate of 2.5 kg/ha along a strip line of disturbed soil in the respective subplots. The standing natural grasses were slashed down up to height of 5 cm before oversowing so as to reduce the competitive effect with new emerging pasture seedlings. Data on number and height of tiller was collected after every 3 weeks for 3 months so as to study the growth rate of pastures in each treatment. Data on percentage ground cover, specie composition and dry matter yield of pastures in every sub-plot were collected at the end of experiment on 12th week of 24th June, 2019.

The slope of the study area was determined by using sprit level, tape measure and sisal rope. Two poles were fixed 100 m apart and the sisal rope was fixed at bottom of one pole at the uphill. It was stretched strongly and leveled by a sprit level. The raised height of the downhill side (elevation) pole was measured by tape measure and the slope was calculated by the formula;

$$\text{Slope (\%)} = \frac{\text{Change in elevation (rise)}}{\text{Horizontal distance (100 m)}} \times 100$$

3.2.2.3 Data collection

Two soil samples were collected at a depth of 0 – 20 cm in every sub-plot before the application of rangeland improvement practice and thereafter it was mixed well to get one soil sample then put into a labeled plastic bag. A soil core sampler was also used to collect two undisturbed soil samples in every plot for soil bulk density determination. The undisturbed soil samples were collected by inserting the soil core sampler at the side of the hole at a depth of 20-40 cm and then was removed gently from the hole and parked in labeled paper bags and stored in a plastic bucket. The soil samples were taken to Soil

Laboratory at SUA for determination of bulk density, organic matter, particle size (soil texture), pH, total Nitrogen, extractable Phosphorus and exchangeable Potassium. Also four representative manure samples were collected from the manure that were used in this study as fertilizer and then taken to SUA Soil Laboratory for analysis of Nitrogen (N), Phosphorus (P) and Potassium (K).

In order to study the effect of each treatment on pasture growth two diagonal lines were established in each subplot and quadrant frame of 0.5 m×0.5 m was thrown randomly at either side at 5 m in each diagonal line. Five pasture plants were selected randomly inside the quadrant frame and the number of tillers per plant were counted and their height were measured by using a tape measure and recorded in note book. An estimation of percentage ground cover of each pasture species was conducted by stretching 10 m tape measure on the ground along the two diagonals of each sub plot and the distance of vertical projection of the edge of the crown or base of a plant intercepting the tape was read and recorded. The percentage ground cover was obtained by dividing the total linear distance along the tape intercepted by the crown or base of pasture species by the total stretched length of the tape times hundred.

Along the same established diagonal lines for estimation of percentage ground cover of pasture species, a quadrant frame of 0.5 m ×0.5 m was thrown randomly to either side at 5 m in each diagonal line. Pasture species appearing inside the quadrant frame was identified, counted and recorded in note book to observe the effect of each treatment on pasture species composition. All desirable pastures inside the quadrant frame was clipped at 5 cm above the ground, sorted to remove undesirable material, weighed, packed in well labeled paper bag and taken to SUA Animal Nutrition Laboratory for oven drying to constant weight at 70^0C for 48 hours so as to determine the effect of each treatment on pastures dry matter yield. The collected data was summarized and compiled by using excel computer program and posted to the statistical model.

3.2.3 Data analysis

The data for assessment of vegetation characteristics, productivity and soil seed bank which included vegetation ground cover, dry matter yield, soil seed bank characteristics, soil characteristics, tree density and canopy cover of the communal grazing area were analyzed by Microsoft Excel Spreadsheet computer program to generate descriptive statistics including mean, percentage and standard error. The data collected to assess the response of communal grazing land to selected rangeland improvement practices (manure application, oversowing and furrowing as rain water spreading structure) adopted completely randomized design. A General Linear Model (GML) procedure of Statistical Analysis system (SAS, 2013) was used to analyze the data.

Model; $Y_{ij} = \mu + T_i + \varepsilon_{ij}$, Where;

Y_{ij} = Pasture yield or Growth or Ground cover

μ = General mean

T_i = Effect of i^{th} selected rangeland improvement practice

ε_{ij} = Error term

CHAPTER FOUR

4.0 RESULTS

4.1 Vegetation Characteristics, Pasture Productivity and Soil Seed Bank During the dry Season in Communal Grazing Area

The communal grazing land which is continuously grazed had an average ground cover of desirable plants, undesirable plants species, litter and bare soil patches of 67.7±2.71%, 10.5±1.45%, 9.4±0.61% and 12.3±1.54% respectively (Table 2).

Transect line	Desirable (%)	Undesirable (%)	Litter (%)	Bare soil (%)
1	61.70	13.56	7.58	17.16
2	64.49	12.48	11.20	11.84
3	76.98	5.53	9.56	7.94
Mean	67.72	10.52	9.45	12.31
SE	±2.71	±1.45	±0.60	±1.54

Table 2: Percentage vegetation ground cover of pasture species in a communal grazing area

The average dry matter content of the desirable pastures was 76.6% and its dry matter yield ranged from 626.99 – 931.88 kg DM per hectare (Table 3).

Transect line	Dry matter content (%)	Dry matter yield (Kg/ha)
1	76.16	861.46
2	76.41	626.99
3	77.20	931.88
Mean	76.60	806.77
SE	±0.18	±29.9

Table 3: Dry matter content and the dry matter yield of the desirable pasture

The dominant desirable pasture species were *Bothriochloa intermedia*, *Enteropogon macrostachyus* and *Heteropogon contortus*. The undesirable plant species were *Aristida stipoides*, *Indigofera arrecta* and *Cida acuta* with frequency of occurrence of 18.75%, 22.92% and 16.67% respectively (Table 4).

Table 4: Frequency of occurrence and ground cover of different plant species in a communal grazing area of Lubungo village in October 2018

Plant specie	Plant type	Frequency of occurrence	Ground cover	Grazing Preference
Bothriocloa intermedia	Grass	29.17	15.42	Desirable
Enteropogon macrostachyus	Grass	33.33	30.17	Desirable
Heteropogon contortus	Grass	25.00	14.50	Desirable
Themeda triandra	Grass	12.50	4.17	Desirable
Bothriocloa petusa	Grass	12.50	1.39	Desirable
Brachiaria sp	Grass	6.25	0.65	Desirable
Pogonathria squarrosa	Grass	8.33	1.43	Desirable
Aristida stipoides	Grass	18.75	3.57	Undesirable
Indigofera arrecta	Forb	22.92	4.63	Undesirable
Cida acuta	Forb	16.67	2.32	Undesirable

The tree density was 1500 per hectare with the total canopy cover of 63.49%. The most dominant tree species were *Combretum collinum*, *Comiphora Africana* and *Piliostigma thonningii* with densities of 864, 163 and 97 trees/ha and canopy cover of 22.6%, 6.2% and 5.4%, respectively (Table 5).

Table 5: Frequency of occurrence, tree density, crown cover and canopy cover of each tree species per hectare

Tree name	Frequency of occurrence (%)	Tree density by specie/ha	Mean crown cover (m^2)	Tree canopy cover by each sp/ha	Canopy cover of each specie/ha (%)
Euclea divinorum	4.2	16.3	5.16	84.20	0.84
Combretum hereroense	4.2	16.3	3.78	61.66	0.61
Piliostigma thonningii	12.5	97.8	5.53	541.40	5.41
Dalbegia sp	4.2	48.9	0.95	46.49	0.46
Combretum collinum	87.5	864.1	2.62	2267.44	22.67
Commiphora africana	29.2	163	3.82	624.18	6.24
Acacia nilotica	16.7	81.5	8.69	708.62	7.08
Terminalia seriacea	4.2	32.6	4.43	144.75	1.44
Terminalia brownie	12.5	65.2	1.21	79.51	0.79
Brachystegia bussei	4.2	16.3	5.40	88.18	0.88
Sclerocarya birrea	4.2	32.6	44.17	1440.36	14.40
Combretum schumanii	4.2	16.3	5.95	97.13	0.97
Dicrostachys cinerea	4.2	16.3	4.61	75.26	0.75
Grawia bicolor	8.3	16.3	4.41	72.02	0.72
Rhus natalensis	4.2	16.3	1.11	18.12	0.18
Total		1499.9			63.49

A total of 9 monocotyledon seedlings species were recorded with a total seed density of 476851 seeds/ha. On the other hand, 11 dicotyledonous seedlings species with seed density of 138888 per hectare were recorded (Table 6).

Table 6: Monocotyledon and dicotyledonous soil seed bank density characteristics

Monocotyledon	**Family name**	**No. Seedlings/ ha**	**Pasture type**	**Life form**
Brachiaria specie	Poacea	13888.9	Desirable	Perennial
Dactyloctenium aegyptium	Poacea	97222.2	Desirable	Annual
Echinochloa colona	Poacea	41666.7	Desirable	Annual
Aristida stipoides	Poacea	180555.6	Undesirable	Perennial
Bothriocloa petusa	Poacea	32407.4	Desirable	Perennial
Enteropogon macrostachyus	Poacea	60185.2	Desirable	Perennial
Panicum specie	Poacea	27777.8	Desirable	Perennial
Leptocarydion vulpiatrum	Poacea	18518.5	Undesirable	Annual
Digitaria velutina	Poacea	4629.6	Desirable	Annual
Total		**476851.9**		
Dicotyledon				
Commelina specie	Commelinaceae	9259.3	Desirable	Perennial
Mullugo nudicaulis	Commelinaceae	32407.4	Unedible	Annual
Tridax procumbens	Asteraceae	9259.3	Unedible	Annual
Indigofera arrecta	Fabacea	27777.8	Unedible	Annual
Portulaca oleracea	Portulacaceae	13888.9	Unedible	Annual
Abutilon indicum	Malvaceae	4629.6	Unedible	Annual
Borreria pusilla	Rubiaceae	9259.3	Unedible	Annual
Vernonia cinerea	Asteraceae	4629.6	Unedible	Annual
Solanum incunum	Solanaceae	4629.6	Unedible	Annual
Cassia tora	Fabaceae	13888.9	Unedible	Annual
Malcastrum coromandelianum	Malvaceae	9259.3	Unedible	Perennial
Total		**138888.9**		

The dominant seedlings in monocotyledon were *Aristida stipoides, Dactyloctenium aegyptium* and *Enteropogon specie* with seed density of 180555, 97222 and 60185/ha respectively. On the other hand, the dominant seed species in dicotyledonous were *Mullugo nudicaulis* and *Indigofera arrecta* with seed density of 27777 and 32407 per ha, respectively (Table 6). The seedlings emergence started on 5th day of the soil incubation and some seedlings started dying on 45th day onward before being identified due to shallow soil depth of 3.5 cm.

4.2 Effect of Selected Rangeland Improvement Practices on Pasture Composition and Productivity

The slope of the study area, soil and manure characteristics was determined before the introduction of the treatments into experimental plots. This helped in designing the rain water spreading structures (furrows) and to know the availability of plant nutrients in manure and nutrient deficit in soil that need to be supplemented.

The study area was found to have a slope of 4.3±0.07% which can be termed as gently slope. The analyzed soil prior to manure application indicated the dominant soil class was sand clay loam (33.22% clay, 2.82% silt and 62.96% sand). The soil was slightly acidic with pH raging 6.1 – 6.5, slightly high bulk density, low organic carbon and low Nitrogen (N), Phosphorus (P) and Potassium (K). Manure had high Nitrogen (N), Phosphorus (P) and Potassium (K) (Table 7).

Table 7: Selected physical and chemical characteristics of soil and manure

Soil manure	Ss	BD (g/cc)	OC (%)	pH	N (%)	P (mg/kg)	K (Cmolkg^{-1})
Soil	4	1.40	1.14	6.33	0.09	0.89	0.33
SE		±0.003	±0.026	±0.035	±0.004	±0.273	±0.02
Manure	4				0.78	0.29	3.83
SE					±0.02	±0.05	±0.34

Ss = Sample size, BD = Bulk density, OC = organic carbon, N = Nitrogen, P = Phosphorus, K = Potassium

4.2.1 Pasture growth

The data were collected for 12th week from 20th April to 24th June, 2019 and the result showed that, pasture had rapid growth in plots applied with manure followed by furrowing, oversowing and the last was the control. On the other hand, pasture growth were relatively similar in plots treated with two treatment combination of manure and furrowing and three treatments of manure, oversowing and furrowing (Table 8). Except for manure pasture growth was found to be slow in plots applied with single rangeland improvement practice of furrowing and oversowing and even combination of oversowing and furrowing (Table 8).

Table 8: Effect of rangeland improvement practices on pasture growth in terms of mean plant height (cm) from 3rd week to 12th week

Rangeland improvement practices	3rd Week	6th Week	9th Week	12th Week
Control (no rangeland improvement practice)	15.07^{a}	26.30^{c}	38.20^{cd}	42.87^{b}
Furrowing	12.70^{a}	27.20^{c}	40.43^{cd}	45.43^{b}
Manure	15.77^{a}	45.70^{a}	58.13^{ab}	66.27^{a}
Oversowing	9.07^{a}	26.67^{c}	37.47^{cd}	43.03^{b}
Manure + Furrowing	14.53^{a}	45.60^{a}	61.67^{a}	74.23^{a}
Manure + Oversowing	8.50^{a}	31.63^{bc}	42.70^{c}	67.43^{a}
Furrowing + Oversowing	9.10^{a}	25.43^{c}	33.97^{cd}	45.43^{b}
Manure + Oversowing + Furrowing	11.75^{a}	34.73^{b}	52.76^{b}	71.27^{a}
SE	±3.39	±2.31	±2.48	±2.62
P-value	0.6427	0.001	0.001	0.001

^{abcd}Means with different superscript letters within columns are significantly different according to Duncan's test ($P < 0.05$). SE is the standard error

4.2.2 Species composition and percentage ground cover of pasture

These were assessed by using line interception to determine which pasture specie was widely distributed along the ground in each sub-plot. The percentage ground cover of desirable pasture species was found to be high in sub-plots treated with manure and oversowing, followed by those with three treatments combined together i.e. manure, oversowing and furrowing as compared to other treatments (Table 9). Pasture species noted with high percentage ground cover in each treatment were *Enteropogon macrostachyus*, *Bothriochloa intermedia*, *Heteropogon contortus* and *Chloris gayana* (Table 9). Undesirable pasture species had high percentage ground cover in plots applied with single treatment of oversowing and two treatments of furrowing and oversowing. Undesirable pasture species with high percentage ground cover in each treatment were *Stachytarpeta indica* and *Aristida stipoides.* These species had high percentage ground cover in control and in plots treated with furrowing, manure and furrowing, oversowing and furrowing (Table 10). Soil bare patches were high in plots with furrows and control (Table 11).

There was significant effect of rangeland improvement practices on percentage ground cover of desirable and bare soil patches at $P < 0.05$. But no significant effect of rangeland improvement practices on percentage ground cover of undesirable pasture species at $P > 0.05$ (Table 10).

Table 9: Species composition of desirable pasture and its percentage ground cover across treatments

Plant species	Rangeland improvement practices							
	Control	**Manure**	**Oversowing**	**Furrowing**	**Manure and oversowing**	**Manure and Furrowing**	**Oversowing and furrowing**	**Manure, Oversowing and Furrowing**
Brachiaria specie						9		
Bothriochloa petusa		5	15	8.25		11.76	4	
Bothriochloa intermedia	23.7	19	6.3	12	14.8	13.1	19.5	20.2
Chloris roxaburgiana		4				1		8.5
Chloris gayana			19		13.5		13.1	20.8
Heteropogon contortus	12.6	10.8	9.2	7.5	4	5	17.3	12.8
Enteropogon macrostachyus	21.5	32.5	29.2	29.5	43.6	15	21.9	7.7
Hyperhenia specie	16.7	14.4	3.3	12.25	13.4	9.1		21
Dactyloctenium aegyptium							1	
Pogonathria squarrosa	3			5		14		
Total	77.5	86.7	82	76	92.3	80.22	76.8	90

Table 10: Species composition of undesirable pasture and its percentage ground cover across treatments

Plant species	Rangeland improvement practices							
	Control	**Manure**	**Oversowing**	**Furrowing**	**Manure and oversowing**	**Manure and Furrowing**	**Oversowing and furrowing**	**Manure, Oversowing and Furrowing**
Aristida stipoides	3	1.5	2	2.3	0.5	3	4	1.5
Cida acuta	1	1.5	2.2	1			1	
Indigofera specie			1			2	2	
Cyperus specie			1.2	1.8				
Ageratum specie			1					
Stachytarpeta specie	2		2.5	2.1	1	1.5	1.7	
Cassia tora	1			2	1	1		
Cassia absus		2.3				1.5	1	
Triumfeta specie			1	1				1.7
Dyschorite specie		1				0.3	2	
Leucas martinicensis	1.5	1		2				1.5
Achyranthas aspera							1	
Verbesina encelioid					0.8			1
Tephrosia specie	1			1				
Total	9.5	7.3	10.9	13.2	3.3	9.3	12.7	5.7

Table 11: Effect of selected rangeland improvement practices on percentage ground cover of desirable pasture species, undesirable herbaceous species and bare soil

Rangeland improvement practices	Desirables (%)	Undesirables (%)	Bare soil (%)
Control (no rangeland improvement practice)	77.50[ab]	9.60[a]	12.90[ab]
Furrowing	76.00[b]	9.17[a]	14.83[a]
Manure	86.67[ab]	8.00[a]	5.33[cd]
Oversowing	82.50[ab]	13.67[a]	3.83[cd]
Manure + Furrowing	80.17[ab]	12.66[a]	7.17[abc]
Manure + Oversowing	92.33[a]	6.67[a]	1.00[d]
Furrowing + Oversowing	76.83[b]	13.33[a]	9.84[abc]
Manure + Oversowing + Furrowing	90.00[ab]	7.67[a]	2.33[d]
SE	±4.54	±3.24	±2.15
P- value	0.1364	0.6373	0.0026

[abcd]Means with different superscript letters within columns are significantly different according to Duncan's test (*P* < 0.05). SE is the standard error

4.2.3 Dry matter yield

The dry matter yield data were collected at the end of experiment on 24th June, 2019. Plots treated with a combination of three treatment of manure, oversown and furrowed were found to have higher dry matter yield followed by those with two treatments of manure and oversowing, manure and furrowing and then manure alone. Dry matter yield was relatively low in plots treated with oversowing, furrows and control. The result showed that the selected rangeland improvement practices had significant effect on dry matter yield at $P < 0.05$ (Table 12).

Table 12: Effect of selected rangeland improvement practices on pasture dry matter yield

Rangeland improvement practices	Dry matter (Kg DM/ha)
Control (no rangeland improvement practice)	2615.33[e]
Furrowing	2770.33[e]
Manure	5134.33[d]
Oversowing	2641.00[e]
Manure + Furrowing	5834.00[c]

Manure + Oversowing	6412.00^{b}
Furrowing + Oversowing	3061.67^{e}
Manure + Oversowing + Furrowing	8355.00^{a}
SE	±190.25
P-value	0.001

[abcde] Means with different superscript letters within columns are significantly different according to Duncan's test (*P* < 0.05). SE is the standard error

CHAPTER FIVE

5.0 DISCUSION

5.1 Assessment of Vegetation Characteristics, Pasture Productivity and Soil Seed Bank During the dry Season in Communal Grazing Area

The results of the assessment of vegetation characteristics, pasture productivity and soil seed bank in communal grazing land during the dry season showed that there were high percentage ground cover of the desirable pasture species as compared to undesirable pasture species, litter material and bare soil patches. The dry matter yield was however, rather low (806.77±29 kg/ha) due to high tree density of about 1500 trees per hectare and continuous grazing. High canopy cover of trees may have prevented direct light falling to pasture growing under the tree that affected photosynthesis process, growth and dry matter yield during the previous growing season. Sangeda and Maleko (2018) observed low pasture yield production in areas with high woody plant cover compared to that with low woody cover in Simanjiro district northern Tanzania. This observation was in agreement with Kapu (2012) who noted that bush encroachment and marked bare spaces lead to low pasture yield per hectare and hence decrease in carrying capacity of the rangeland. Apart from that continuous grazing lead to decrease of herbaceous ground cover through deterioration of palatable pasture species (Kioko, 2012).

The soil sample taken from the bare soil patches showed relatively high germinable soil seed bank of monocotyledon and dicotyledon per hectare. Most seeds were annual grasses, undesirable and un-edible annual forbs with very few perennial grasses. This may have been attributed by anthropogenic activities such as overgrazing and shifting cultivation. Continuous grazing system which is practiced in the grazing land of Lubungo village seem, not to allow the desirable perennial grasses to reach seeding stage of growth. Lopez-Toledo and Martinez-Ramos (2011) found that shifting cultivation and heavy grazing introduces a disturbance to grasslands, which affect negatively the size and composition of grasses in the soil seed bank. Heavy grazing causes removal of immature reproductive plant parts leading to low soil seed bank and thus low recovery of the palatable vegetation and change in pasture species composition of the grazing land (Aboling *et al.,* 2008). Hiernaux *et al*. (2009) stated that shifting cultivation influence changes in grassland vegetation where by natural perennial grasses may be replaced by undesirable plants.

The seedlings characteristics of the soil seed bank indicated low grazing potential because of prevalence of many annual grasses, undesirable and unedible annual forbs, however, such a soil seed bank characteristic showed possibility of natural rehabilitation of this grazing land following enclosure and some restriction to grazing.

5.2 Effect of Selected Rangeland Improvement Practices on Pasture Composition and productivity

5.2.1 Grazing land slope, soil and manure characteristics

The performance of pasture in terms of growth and dry matter yield production are affected by several abiotic factors such as slope of the area, soil type, bulk density, organic carbon, pH and nutrient status of the soil. The study area had an average slope of 4.3% ranging from 2% to 6% that can be described as gentle slope with very stable soil that can contribute to good pasture growth (Ditsch *et al.*, 2006). Furrowing for rain water spreading as one of the soil-water conservation technique can be suitably applied in such a grazing land terrain so as to enhance moisture availability and pasture productivity. The results of soil analysis showed that the soil class of the study area was sand clay loam (33.22% clay, 2.82% silt and 62.96% sand). This soil had slightly high bulk density and low organic carbon due to continuous grazing. Yong-Zhong *et al.* (2005) stated that continuous grazing gives rise to a considerable decrease in ground cover, which accelerates soil erosion by wind, resulting in a further coarseness in surface soil, loss of soil organic carbon and nitrogen and depletion in soil biological properties. High grazing intensity increases soil compaction and bulk density (Zhou *et al.*, 2010).

The rangeland had critically low soil plant nutrient available for pasture growth, though the pH range was within 5.5-7.5 where various essential plant nutrients are available. This may be due to land degradation caused by continuous grazing that lead to reduction of ground cover and organic matter. This have reduced the ability of soil to bind cations and prevent them from leaching out of the soil profile. Yingzhi *et al*. (2004) in their study to assess the effects of grazing on grassland soils found low nutrient availability in soil with low organic carbon. Therefore, the rangeland need soil fertility improvement through Organic or Inorganic fertilizer application so as to increase pasture production per unit area.

The manure used in this study as fertilizer were analyzed and found that it contained adequate plant nutrients such as Nitrogen (N) phosphorus (P) and potassium (K) required for supplementation of nutrient deficit in the soil for pasture growth. According to Bayu *et al.* (2005), Manure have adequate plant nutrients and also have long lasting effect than equivalent nutrient levels to chemical fertilizer.

5.2.2 Effect of selected rangeland improvement practices on pasture growth

The results showed that there were rapid growth of pasture in plots applied with a combination of manure and furrowing, manure alone followed by a combination of the three rangeland improvement practices (manure, oversowing and furrowing).

The rapid growth of pastures was influenced by adequate nutrient availability, improved soil conditions and increased soil moisture. The plant nutrients were supplied by manure and increased soil moisture was enhanced by retained water in the furrows. Hati *et al.* (2006) reported that, application of animal manure improved physical properties of the soil, which promoted higher nutrient and water uptake by plant roots and increased plant growth. On the other hand, Salifu *et al*. (2019) found that soil- water conservation retain water and increase soil moisture content at maize root zone that influenced high crop growth rate compared to control.

The poor performance of pasture growth in plots with furrows alone and oversowing alone may have been caused by low soil moisture retention capacity of the soil and inadequate soil fertility. In this study, it was generally noted that; high growth of the pasture was well marked in the following practices combinations; manure and oversowing, manure and furrowing and three treatment combination of manure, oversowing and furrowing. This observation was in agreement with that of Sawadogo (2011) in his experiment of effect of zai pits on pasture productivity where it was found that soil-water conservation alone had no significant effect on pasture growth.

5.2.3 Effect of selected rangeland improvement practices on pasture composition and percentage ground cover

Plots treated with both manure and oversowing and those treated with manure, oversowing and furrowing had relatively high percentage ground cover of desirable pasture species of 92.3±4.54% and 90±4.54% respectively. The dominant pasture species in plots applied with two treatments of manure and oversowing and three treatments of manure, oversowing and furrows were *Enteropogon macrostachyus*, *Bothriochloa intermedia a*nd *Chloris gayana*. Except *Chloris gayana*, these pasture species had high percentage ground cover in both plots during wet season as compared to dry season. These observations complied with that of Bhalalahenda (2001) who found high ground cover of perennial grasses in wet season compared to dry season. The percentage ground cover of undesirable pasture species and bare ground patches in these plots was very low due to rapid growth of desirable pastures influenced by availability of soil moisture and nutrients supported by manure and rain water spread through furrowing.

There were relatively low percentage ground cover of desirable pasture species and high percentage ground cover of undesirable pasture species and bare soil in plots where each rangeland improvement practice was applied singly. This is due to either inadequate soil nutrient and moisture required for pasture growth and several bare soil patches without enough soil seed bank. These results comply with those of Ferreira *et al*. (2011) who found high percentage ground cover in fertilized and oversown plots. Likewise, Nnadi *et al.* (2015) found fast growth and quicker ground cover in plots with manure application compared to control.

5.2.4 Effect of selected rangeland improvement practices on pasture dry matter yield

The dry matter yield of pasture depends on several factors such as height of the sward, percentage ground cover and dry matter content of desirable pasture species. The results in this study showed higher pasture production in all sub-plots treated with manure. The highest dry matter yield was obtained in plots that were treated with all three rangeland improvement practices (8.36 t DM/ha) followed by those treated with both manure and oversowing (6.41 t DM/ha), manure and furrowing (5.83 t DM/ha) and there after manure alone (5.13 t DM/ha). The high dry matter yield in these experimental plots have been contributed by high growth performance of pasture and high percentage ground cover of desirable pasture species component. This have been influenced by oversowing leading to reduction of bare ground patches, increase in soil moisture by furrowing and increase in soil nutrient required by pasture for growth supplied by manure. Mestawet *et al.* (2005)

and Lissu (2016) found that oversowing increase carrying capacity of the land through reduction of bare ground patches and increase in pasture yield production per area. Ladha *et al.* (2002) also reported that wheat yields were consistently higher in the farmyard manure treatments than on the control.

This study found low dry matter yield production ranging from 2.6 to 3 t DM/ha in experimental plots with only oversowing or furrowing and were nearly similar to the control plots in terms of pasture productivity. This could be due to either failure of several soil seed banks to germinate, slow growth rate of pasture, frequent bare soil spots, low soil moisture retention and fertility. This means that oversowing and soil-water conservation technique like furrowing had positive effect on dry matter yields only when were combined with manure or supplementation of soil plant nutrients.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The result of this study showed that the communal grazing land of Lubungo village had high percentage ground cover of desirable pasture species compared to undesirables and bare ground patches during dry season. The bare ground patches had high soil seed bank densities which was mainly composed of annual grasses. Seeds of few perennial grasses and several undesirable and un-edible annual forbs were recorded in the grazing land soil seed bank during the dry season. The dry matter yield during the dry season was rather low due to high tree density and high tree canopy cover which normally affect the photosynthesis process, growth and dry matter production of the understory herbaceous vegetation.

The selected rangeland improvement practices under this study have shown fast pasture growth in plots applied with manure, manure and furrowing and a combination of manure, oversowing and furrowing. Plots treated with combinations of oversowing and furrowing and with either furrowing or oversowing alone had slow growth, relatively low percentage ground cover of desirable pasture species and dry matter yield. This implies that rapid growth, high percentage ground cover of desirable pasture species component and high dry matter yield production were achieved as a result of combined effect of the three rangeland improvement practices of manure, oversowing and furrowing.

6.2 Recommendations

Basing on the above conclusion it is recommended that;

i. The communal grazing land under continuous grazing system should have a regular bush clearing programme to reduce the tree density and canopy cover of the trees in order to allow pasture growing under the tree to access more light for growth and increase dry matter production. Few trees should however, be left during bush clearing so as to give resting places to the grazing animals in the afternoon. The left trees canopy should not exceed 20% per hectare so as to encourage perennial grasses to establish well.

ii. Oversowing should be applied in severely degraded areas with so many bare ground patches where desirable pasture species seeds in the soil seed bank are very rare.

iii. Furrowing as soil-water conservation technique should be applied in highly degraded gentle slope areas with high bulk density that exceed 1.4 g cm^{-3} so as to enhance moisture availability between field furrows for seed germination and pasture growth.

iv. Manure should be applied to improve soil condition and increase soil fertility and soil moisture holding capacity for pasture growth.

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APPENDICES

Appendix 1: Percentage ground cover of vegetation

A) Desirable pasture species

Pasture name	Cover (%)
Bothriochloa insculpta	15.42083333
Enteropogon macrostachyus	30.17083333
Heteropogon contortus	14.50416667
Themeda triandra	4.166666667
Bothriocloa petusa	1.3875
Brachiaria sp	0.645833333
Pogonathria squarrosa	1.425
Total	67.72083333

(B) Undesirable pasture species and forbs

Specie name	Cover (%)
Aristida stipoides	3.566666667
Indigofera specie	4.633333333
Cida acuta	2.320833333
Total	10.52083333

Appendix 2: Dry matter production of pasture per hectare

TRANSECT	WT FRESH SAMPLE/Q			WT DRY SAMPLE					
T1	**Q1 (gm)**	**Q2 (gm)**	**AV**	**Wt of bag (gm)**	**Wt of samp&bag (gm)**	**wt of samp (gm)**	**DM (%)**	**DM kg/quadr**	**DM Kg/Ha**
1	54	65	59.5	22.8	68.69	45.89	77.1	0.045895	1835.78
2	41	81	61	20.9	67.47	46.57	76.3	0.046565	1862.6
3	28	2	15	22.3	32.78	10.48	69.8	0.010475	419
4	22	8	15	21	32.45	11.45	76.3	0.011446	457.84
5	6	0	3	23.97	26.17	2.2	73.2	0.002195	87.8
6	18	12	15	22.09	34.58	12.49	83.2	0.012485	499.4
7	54	42	48	19.89	56.58	36.69	76.4	0.03669	1467.6
8	13	4	8.5	21.9	28.44	6.54	77	0.006542	261.696
Mean							76.1625		861.4645
T2									
1	5	28	16.5	22.3	34.82	12.52	75.9	0.012523	500.9
2	3	0	1.5	21	22.14	1.14	75.8	0.001138	45.5
3	26	28	27	23.97	44.62	20.65	76.5	0.020653	826.12
4	4	38	21	22.09	38.15	16.06	76.5	0.016064	642.56
5	26	0	13	19.89	29.93	10.04	77.2	0.010035	401.4
6	26	36	31	21.9	45.61	23.71	76.5	0.023705	948.2
7	36	48	42	22.8	54.91	32.11	76.5	0.03211	1284.4
8	8	16	12	20.9	30.07	9.17	76.4	0.00917	366.8
Mean							76.4125		626.985
T3									
1	93	106	99.5	22.3	98.52	76.22	76.6	0.076216	3048.62
2	42	63	52.5	21	63.15	42.15	80.3	0.042153	1686.1
3	24	12	18	23.97	37.7	13.73	76.3	0.01373	549.2
4	6	8	7	22.09	27.74	5.65	80.7	0.00565	226
5	10	24	17	20.1	33.1	13	76.5	0.013	520
6	6	37	21.5	22.04	38.48	16.44	76.5	0.016438	657.5
7	36	4	20	21.7	36.2	14.5	72.5	0.0145	580
8	12	0	6	20.8	25.49	4.69	78.2	0.00469	187.6
Mean							77.2		931.8775
SE							±0.11		±29.89448

Appendix 3: Total distance quarter and tree crown area

TRANS	DQ (m)	CROWN AREA (m^2)	No. trees	Mean distance (m)	Absolute tree density
T1	84.92	154.095186	32	Mean D=Total Qd/No. trees in 24 sampling unit	ABS TREE D= AREA/D^2
T2	84.38	144.0952329	32		
T3	68.25	100.3222346	28	2.582065217	1499.911328
Total	237.55	398.5126535	92		≈ 1500 trees/Ha
Mean	2.582065				
SDE	9.472393				
SE	0.102961				

Appendix 4: Frequency of occurrence, tree density, crown cover and canopy cover of each tree species/hectare

TREE NAME Indigenous name	Sp name	No. of observation of trees in 24 SU	Frequncy of Occurrence (%)	TREE DENSITY BY SPECIE/Ha	MEAN CROWN COVER (m^2)	TREE CANOPY COVER BY EACH SP/Ha (m^2/Ha)	%COVER OF EACH SPECIE/Ha
Msungura	Euclea divinorum	1	4.2	16.3	5.1647	84.2020	0.8420

Mgonanyee	*Combretum hereroense*	1	4.2	16.3	3.7821	61.6618	0.6166
Mbalawala	*Piliostigma thonningii*	3	12.5	97.8	5.5347	541.4030	5.4140
Mpingo	*Dalbegia sp*	1	4.2	48.9	0.9505	46.4909	0.4649
Mlama	*Combretum collinum*	21	87.5	864.1	2.6241	2267.4465	22.6745
Mkambala	*Commiphora africana*	7	29.2	163.0	3.8286	624.1834	6.2418
Mgunga	*Acacia nilotica*	4	16.7	81.5	8.6929	708.6202	7.0862
Mpululu	*Terminalia seriacea*	1	4.2	32.6	4.4395	144.7574	1.4476
Mvumba	*Terminalia brownie*	3	12.5	65.2	1.2192	79.5105	0.7951
Mhangala	*Brachystegia bussei*	1	4.2	16.3	5.4091	88.1873	0.8819
Mng'ongo	*Sclerocarya birrea*	1	4.2	32.6	44.1739	1440.3685	14.4037
Mngoji	*Combretum schumanii*	1	4.2	16.3	5.9582	97.1383	0.9714
Mtunduru	*Dicrostachys cinerea*	1	4.2	16.3	4.6163	75.2612	0.7526
Grawia	*Grawia bicolor*	2	8.3	16.3	4.4180	72.0282	0.7203
Simanjiro	*Rhus natalensis*	1	4.2	16.3	1.1116	18.1235	0.1812
TOTAL				1499.9			63.4938

Appendix 5: Monocotyledon and dicotyledon soil seed bank density

MONOCOTYLEDON	No. SEEDLINGS IN 24 PORTS	No. SEEDLINGS (0.09M^2)	No. SEEDLINGS/Ha
Dactyloctenium aegyptium	21	0.875	97222.22222
Echinochloa colona	9	0.375	41666.66667
Aristida stipoides	39	1.625	180555.5556
Bothriocloa petusa	7	0.291666667	32407.40741
Enteropogon macrostachyus	13	0.541666667	60185.18519
Panicum specie	6	0.25	27777.77778
Leptocarydion vulpiatrum	4	0.166666667	18518.51852
Digitria perottetii	1	0.041666667	4629.62963
Total			476851.8519
DICOTYLEDON			
Commelina specie	2	0.083333333	9259.259259
Mullugo nudicaulis	7	0.291666667	32407.40741
Parthenium hysterophorus	2	0.083333333	9259.259259
Indigofera arrecta	6	0.25	27777.77778
Portulaca oleracea	3	0.125	13888.88889
Abutilon indicum	1	0.041666667	4629.62963
Borreria pusilla	2	0.083333333	9259.259259
Vernonia grabla	1	0.041666667	4629.62963
Solanum incunum	1	0.041666667	4629.62963
Cassia tora	3	0.125	13888.88889
Malcastrum coromandelianum	2	0.083333333	9259.259259
Total			138888.8889

Appendix 6: Analysis of variance table for Sward growth on 3rd week

Source	DF	Type III SS	Mean Square	F Value	Pr ˃ F
Treatment	7	179.425	25.6321	0.74	0.6427
Error	16	554.5333	34.6583		
Corrected Total	23	733.9583			
	R-Square	Coeff Var	Root MSE	SWh Mean	
	0.244462	48.82211	5.887133	12.058	

Appendix 7: Analysis of variance table for Sward growth on 6th week

Source	DF	Type III SS	Mean Square	F Value	Pr ˃ F
Treatment	7	1502.25166	214.6073	13.36	˂ .0001
Error	16	256.98667	16.06166		

Corrected Total	23	1759.23833			
	R-Square	Coeff Var	Root MSE	SWh Mean	
	0.853922	12.17838	4.007701	32.90833	

Appendix 8: Analysis of variance table for Sward growth on 9th week

Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Treatment	7	2273.6933	324.81333	17.53	< .0001
Error	16	296.44	18.5275		
corrected Total	23	2570.1333			
	R-Square	Coeff Var	Root MSE	SWh Mean	
	0.88466	9.425602	4.304358		

Appendix 9: Analysis of variance table for Sward growth on 12th week

Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Treatment	7	4072.93625	581.848	28.3	< .0001
Error	16	328.97333	20.56083		
corrected Total	23	4401.90958			
	R-Square	Coeff Var	Root MSE	SWh Mean	
	0.925266	7.955679	4.534406	56.99583	

Appendix 10: Analysis of variance table for Percentage ground cover of desirables

Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Treatment	7	823.833333	117.6904762	1.9	0.1364
Error	16	991.66667	61.979167		
corrected Total	23	1815.5			
	R-Square	Coeff Var	Root MSE	Desir Mean	
	0.453778	9.513819	7.872685	82.75	

Appendix 11: Analysis of variance table for Percentage ground cover of undesirables

Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**

Treatment	7	158.8229167	22.6889881	0.72	0.6572
Error	16	504.16667	31.5104167		
Corrected Total	23	662.989583			

	R-Square	Coeff Var	Root MSE	Undesir Mean

Appendix 12: Analysis of variance table for Percentage ground cover of bare soil patches

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treatment	7	521.5729167	74.5104167	5.37	0.0026
Error	16	222.166667	13.8854167		
corrected Total	23	743.7395833			

	R-Square	Coeff Var	Root MSE	Bare Mean
	0.701284	52.14667	3.726314	7.14

Appendix 13: Analysis of variance table for pasture Dry matter in kilogram/Ha

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treatment	7	98046898.29	14006699.76	128.99	< .0001
Error	16	1737452.67	108590.79		
corrected Total	23	99784350.96			

	R-Square	Coeff Var	Root MSE	DM Mean
	0.982588	7.159117	329.5312	4602.958

Appendix 14: Pictures showing different events taking place in the research site

PICTURE 1: Showing bush encroachment and bare soil patches at the study site




PICTURE No. 2: Showing soil seedbank experiment

Experiment for determination of soil seedbank density and characteristics

PICTURE No. 3: Showing land preparation prior to set up of rangeland improvement experiment

PICTURE No. 4: Showing slope determination in the study area

PICTURE No. 5: Showing preparation of furrows and strip cultivation

Furrows for soil water conservation

Strip cultivated plot for oversowing Rhodes grass seeds

PICTURE No. 6: Showing pasture growth pattern in sixth week across experimental plots

Control

Plot applied with oversowing only

Plot applied with manure only

Plot applied with manure and furrows

Plot applied with manure and oversowing

Plot applied with manure, oversowing and furrows