Vegetation Cover Changes in Selected Pastoral Villages in Mkata Plains, Kilosa District Eastern Tanzania

L. J. A. Kisoza
Open University of Tanzania
kisoza@yahoo.com

Abstract: *Arid and semi-arid savannah ecosystems of Tanzania are subjected to increasing pressure from pastoral land-use systems. A spatial temporal study involving analysis of satellite imageries and range surveys was carried out to determine the effects of high stocking levels on savannah vegetation cover types in Mkata plains. The GIS data sources include MSS satellite image of 1975, Landsat TM images of 1991 and 2000. Information obtained during community mapping and timeline trend analysis with local communities formed a local knowledge integrated into GIS analysis. Ground- truthing was based on 2000 satellite imagery sub-scenes. The main vegetation covert types in the study area include: wooded grassland (23.5%), bush grassland (20.12%), bush land (15.15%), woodland (11.65%), open grassland (5.2%), and cultivation area (18.64%). Net area cover changes between 1975 and 2000 include: 4 X increase in bush land, – 66.7% loss of open grassland and + 95.3% increase of wooded grass lands. Land cover change detection matrix indicates that the main land cover changes involved conversion to cultivation area (33.0%) and succession progression towards woody vegetation cover types (+ 33.4%). The rangelands were overstocked, in poor range condition and declining trend. There was a strong negative correlation (r = - o.87932) between stocking levels and size of open grassland and perfect correlation (r = 1) between stocking level and woody grassland cover types. It was concluded that increasing stocking levels has significantly contributed to conversion to woody cover types and loss of open grasslands. It was recommended to develop state-transit-models in order to predict the likely system response to policy interventions and to integrate control fire regimes and livestock mobility in range management strategy for the area.*

Key words: Savannas, pastoralism, herbivory, vegetation cover change, Mkata plains.

INTRODUCTION

Pastoral Sector of Tanzania

Pastoralism is a predominant land-use system in arid and semi-arid savannah areas of Tanzania. The pastoral sector account for over 95% of the national herd; approximated at 18.5 million cattle and 16.9 million sheep and goats (MoLDF, 2012). The sector account to about 18% of Gross National Product (30% of Agriculture Gross Domestic Product) and provide employment to approximately 3.8 million people (Kurwijira *et al*, 2002). To date, the pastoral areas in the country are experiencing environmental stress which emanate from increasing grazing intensities, environmental degradation, as well as demographic and policy changes.

These have culminated into increasing loss of grazing lands; prompting massive out-migration of pastoralists and their cattle to new areas (Brockington, 2000). Yet, little work has been done to assess the environmental impacts of grazing livestock in the pastoral areas of Tanzania. The objective of this paper is to examine the long term effects of high livestock grazing intensities on vegetation cover types in Mkata plains, eastern Tanzania.

Background of Mkata Plains

Mkata plains, eastern Tanzania have historically experienced a high influx of pastoralists starting from late1930s (Beidelman, 1960). This in turn led to high build up of livestock populations and varying levels of environmental changes. The area has since become a focus of resource-use conflicts involving farmers and herders competing for scarce resources (Shishira *et al*., 1997, Misana *et al*., 1997; Kisoza *et al.*, 2004). This had in mid 1960s prompted the Kilosa District Local Government to set aside eight villages in Mkata plains for the purpose of settling the pastoralists (KDC, 2000). This was in line with the village settlement schemes (TRSC, 1965; URT, 1965a), range development projects (URT, 1965b) and *Ujamaa villages* policies (Nyerere, 1968). These policies aimed at bringing about rural transformation and modernization through settling selected farmers or pastoralists in permanent villages. The pastoral villages were premised on "Western Ranching Model" which emphasized sedentarization, de-stocking and establishment of group ranches. The long-term environmental impacts of the interventions and its implication on pastoral livelihood can now be evaluated in Mkata plains. By employing time line analysis of livestock population changes and spatial-temporal vegetation cover change analysis, this paper examines the effect of increasing livestock stocking levels on distribution of vegetation communities in four study villages.

MATERIALS AND METHODS

Description of the Study Area

Mkata plains occupy part of Kilosa and Mvomero districts in eastern Tanzania. The plains are bounded between 5^0 4" to 7^0 15"S and 37^0 00 and 37^0 55"E, covering approximately 7,000 km2 (Figure 1).

The plains are bordered by Uluguru Mountains in NW and SE parts; Eastern Arc Mountans of Nguru, Ukaguru and Usagara in the NW, and Lubungo and Lukobe mountains in SE parts. These mountains to a large extent influences the climate experienced in the plains, whereby most parts are on the rain shadow and experience a semi-arid environmental regime. The mean annual rainfall ranges from 600 to 730 mm (Misana *et al*., 1997).

The study villages selected for this study were Twatwatwa, Mabwegere, Msowero and Mbwade, which forms a contiguous ecological unit in the northern parts of Mkata plains. The total land area in the study villages was 55,694.8 ha, with human population size of 12,308 people (KDC, 2002) and livestock herd size amounting to 103,948 cattle and 37,380 sheep and goats (Table, 1). The main land-uses in the area were pastoralism and smallholder subsistence farming (Kisoza *et al*, 2004)

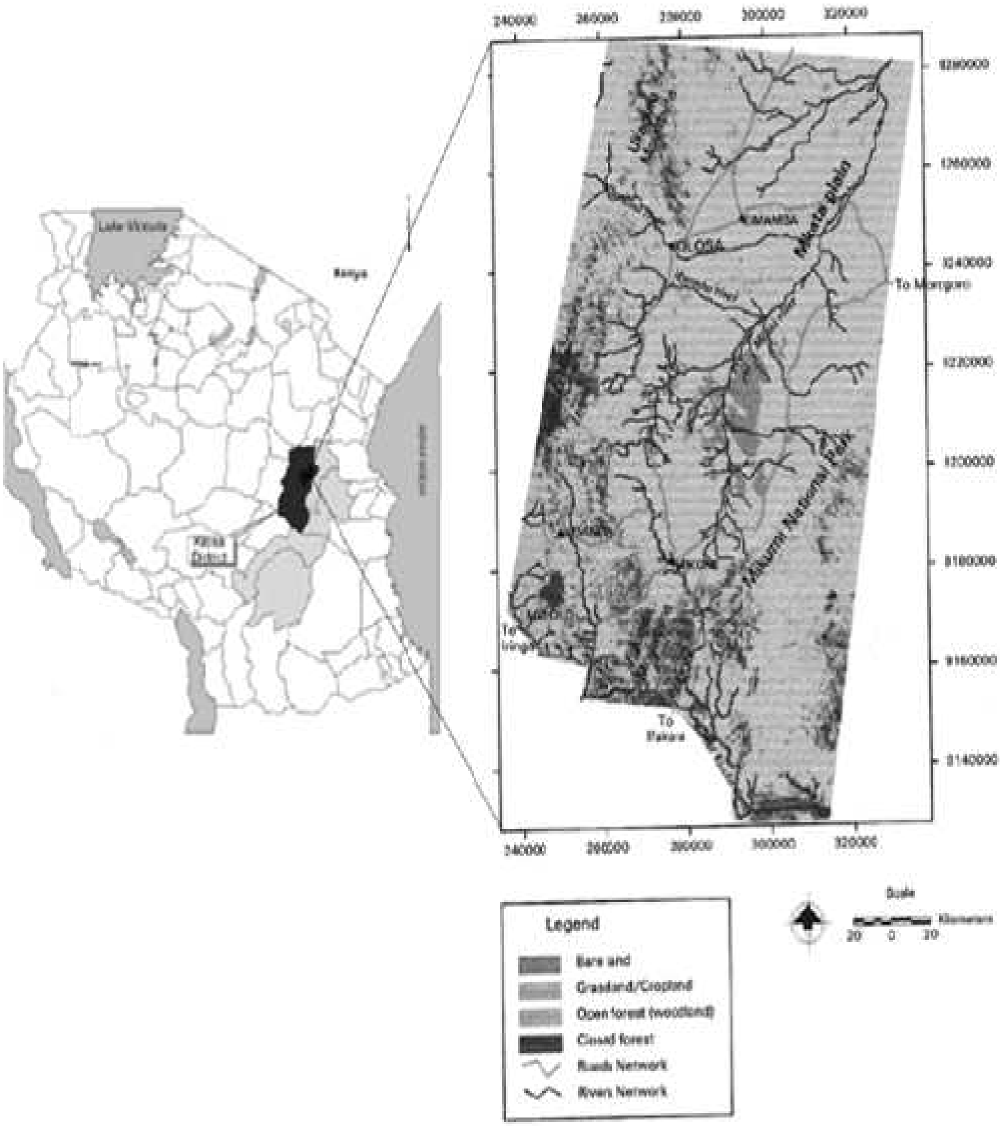


Figure 1: Location Map of Mkata Plains, Kilosa District Tanzania

Table 1: Socio-Economic Profile of Study Villages in 2002

Village	No. HH	Human population	Area village land (ha)	Herd Size	
				Cattle	Sheep +Goats
Msowero	1,700	5,725	7,200.0	1,107	1,710
Mbwade	146	2,325	7,412.8	6,700	2,402
Twatwatwa	250	2,112	30,850.0	60,320	12,555
Mabwegere	90	2,146	10,232.0	36,821	20,713
Total	**2,186**	**12,308**	**55,694.8**	**103,948**	**37,380**

***Source*: Kilosa District Council (KDC), 2002**

DATA COLLECTION METHODS

Socio-economic data

Participatory Rural Appraisal Approaches (transect walks, village resource mapping, village trend lines data, focused group discussions); informal interviews and documentary search were conducted to establish the socio-economic profiles of the four study villages.

Acquisition and Analysis of Remotely Sensed Satellite Imagery

Remote sensing techniques including Geographic Information System (GIS) were employed to determine land-use/land cover changes during the past 25 years (starting 1995). Data sources for GIS included Landsat Satellite Images (Landsat MSS of 1975, Landsat TM of 1991 and 2000). Local communities provided timeline data, which together with geo-referencing using the Global Positioning System (GPS) supplemented information generated during transect walks and ground-truthing. Map features and delineated classes were digitized using ArcView software and processed following the standard GIS procedures. Change detection analysis was conducted by using overlays generated from GIS land cover/land-use maps plus local perception information. The geo-referenced topographic maps were produced using ArcView, ARCInfo and Erdas Imagine software.

Change detection matrix tables were developed and used for quantification of land cover changes. Ground-truthing was conducted in October 2003 and based on the Landsat TM image of 2000. The enhanced colour composite image print-outs were used for training purposes in the field. The land cover classes were identified on the 4-5-3 colour composite image print-outs.

Range Inventory Surveys

A systematic sampling with a random start was adapted to sitting three transect lines in a representative range site selected in each study village. Sampling units were 0.5 x $1m^2$ quadrants set at 100m intervals on 1-km line transects set in each of range sites. Data on vegetation cover (herbaceous), forage yield, species composition were collected along the transect lines. Forage yields were determined by a dry and weigh method. Range condition and trend were estimated from the data. A rapid plot less survey method was employed to estimate the range trend (Improvement Task Force Handbook, 1985). A 3/4 cm diameter metal loop placed immediately in front of foot was used as sampling point. A total of 100 points were scored in each transect. "Hits" on vegetation, litter, rock and bare ground were recorded. The composition score was determined from a rating scale.
The range quality score was computed using a formula:

$$RQ = \sum_{i=1}^{n} (i\ Hi)$$

Where:

RQ = range quality
i = the score of range unit
Hi = proportion i^{th} range quality
n = number of range units

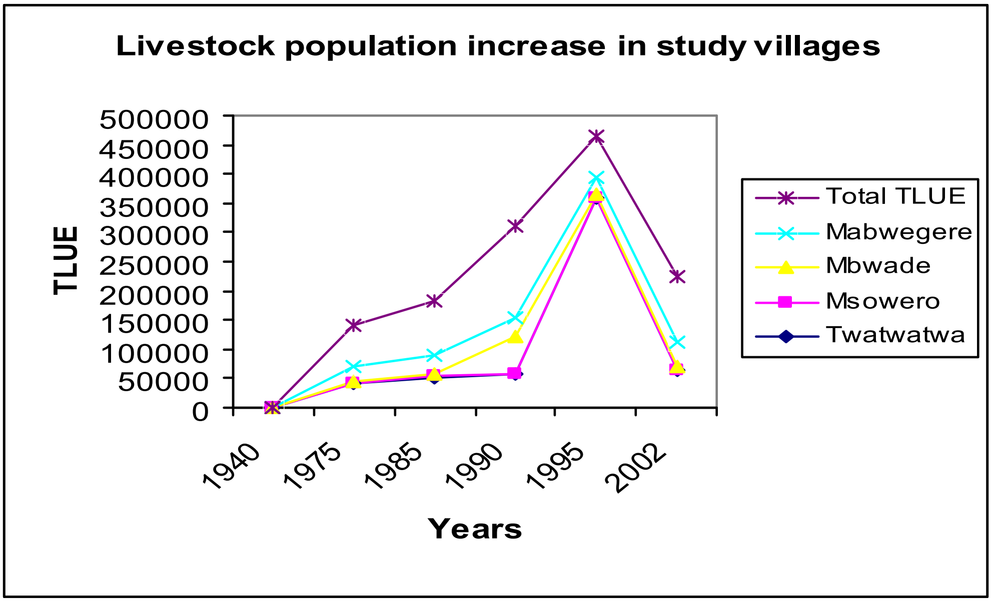
RESULTS

Livestock Population in the Study Area

Table 2 shows the stocking level in the study village. Twatwatwa village had the highest stocking level, with a herd of 62,861 Tropical Livestock Unit Equivalent (TLUE), followed by Mabwegere (40, 957 TLUE) and Mbwade (7,180 TLUE). Msowero village had the smallest herd amounting to 1,449 TLUE. The rangelands in the study villages, with exception of Msowero village, were generally overstocked. The total herd size in the study area was 112,447 TLUE, when this is compared to 27,838 TLUE the sustainable stocking level recommended for the area (KDC, 2002); there was an access of 84,609 TLUE. This is suggesting an excessive over stocking in the area.

Table 2: Livestock Herd Size and Stocking Levels in Study Villages

Village	Cattle	Sheep & Goats	Present stocking level (TLUE)	Recommended Sustainable Stocking level	Grazing Pressure Deficit/Excess (TLUE)
1. Msowero	1,107	1,710	1,449	3,600	- 2,151
2. Mbwade	6,700	2,402	7,180	3,707	+3,473
3. Twatwatwa	60,320	12,555	62,861	15,415	+47,446
4. Mabwegere	36,821	20,713	40,957	5,116	+ 35,841
Total	**103,948**	**37,380**	**112,447**	**27,838**	**+ 84,609**



Ke: TLUE = Tropical Livestock unit Equivalent

Figure 2: Time Line Data of Cumulative Livestock Population in the Study Villages (1940 To 2002)

Figure 2 shows the cumulative timeline data of livestock population in the study villages between 1940 and 2002. The results indicates that the area have experienced gradual livestock population increase, which started to peak as from mid 1980s to mid 1990s, followed by livestock population crash. The sudden increase of livestock herd in mid 1990s was associated to the increased in migration of pastoralists with their herds (KDC, 2002).

Table 3 shows the stocking rate in the study area. The cumulative stocking rate decreased from 2.42 ha/TLUE in 1940 to 0.60 ha/TLUE reaching the lowest level of 0.03 ha/TLUE in 1990; thereafter it increased slightly to 0.49 in 2002. This implies that between 1940 and 2002 the study area was subjected to high grazing intensities. Basing on a sustainable stocking rate of 2.5 ha/TLUE recommended for East African rangelands (Pratt and Gwyne, 1977), it could be concluded that the study area was severely overgrazed. This suggests alikelihood for wide scale range degradation in the area.

Table 3: Changes in Stocking Rate in the Study Area Between 1940 and 2002

Year	**Stocking rate ha/TLUE**
1940	2.42
1975	0.75
1985	0.60
1990	0.03
1995	0.76
2002	0.49

Key. TLUE = Tropical livestock unit equivalent (= 250 kg. Live weight)

Distribution of Main Land Cover Types in Mkata Plains

Table 4 shows areas and percentage coverage of the main cover types identified on the studied satellite image sub-scenes. The main land cover types in study area by August, 2000 were grasslands (48.8%) - consisting of open grassland (5.2%), bush grassland (20.12%) and wooded grassland (23.55%). Other main land cover types were cultivation area (18.6%), bush lands (15.15%), riverine vegetation (5.18%) and woodlands (11.6%) – these consisted of open woodland (5.33%) and closed woodland (6.32%).

Table 5 shows the net area change of main land cover types between 1975 and 2000 in the study area. The overall net changes include an increase of +12,624.0 ha (four-fold) of bush lands and a net loss of – 2,657.7 ha (– 6.7%) grasslands. The riverine vegetation experienced a net loss of – 3,065.7 ha (-60.2%). The results show a rapid increase of bush land at a rate 34.1% annually; followed by increase of wooded grasslands with annual increase of 7.9 %.

Table 4: Distribution of Land Cover Types in the Study Area in July 1975, July 1991 and August 2000

Cover type	July, 1975		July, 1991		August, 2000	
	Area cover (ha)	% Cover	Area cover (ha)	% Cover	Area cover (ha)	% Cover
Grasslands:						
• Grassland	16,055.4	15.5	4,233.2	4.10	5,380.3	5.2
• Bush grassland	25,754.9	24.84	19,416.4	18.73	20,856.8	20.12
• Wooded grassland	12,499.0	12.10	14,867.3	14.34	24,414.5	23.55
Sub-Total (Grasslands)	**54,309.3**	**52.38**	**38,516.90**	**37.15**	**50,651.6**	**48.85**
Bushlands:						
• Bush land	3,086.0	3.0	15,569.9	15.02	10,683.4	10.30
• Shrub land	-	-	-	-	5,026.6	5.02
Sub-Total (Bush lands)	**3,086.0**	**3.0**	**15,569.9**	**15.02**	**15,710.0**	**15.15**
Woodlands:						
• Closed woodland	7,246.1	5.6	6,961.8	6.31	5,529.5	6.32
• Open woodland	5,865.4	7.0	6,541.8	6.71	6,556.1	5.33
Sub-Total (Woodlands)	**13,111.5**	**12.65**	**13,503.6**	**13.02**	**12,085.6**	**11.65**
Cultivation area:						
• Small hold farms	6,859.2	6.62	13,985.6	13.5	18,584.9	17.93
• Sisal plantation	12,908.6	12.50	5,713.8	5.5	766.9	0.74
Sub-Total (cultivation area)	**19,767.8**	**19.07**	**19,699.4**	**19.0**	**19,351.8**	**18.64**
Fallow land	**-**	**-**	**-**	**-**	**551.9**	**0.53**
Riverine vegetation	**13,392.9**	**12.90**	**16387.8**	**15.8**	**5,327.2**	**5.18**
Total Area	**103,677.5**	**100.0**	**103,677.6**	**99.99**	**103,677.7**	**100.0**

Table 5: Net Area Change of Main Land Cover Types in Mkata Plains Between 1975 to 1991 and 1991 to 2000

Land cover	Net area change 1975 - 1991		Net area changes 1991- 2000		Overall net cover changes 1975 – 2000	
Type	Area (ha)	% cover change	Area (ha)	% cover change	Area (ha)	% coverage
Bush land	+12,483.9	+404.5(33.7)	+140.0	+0.9(0.08)	+12,624.0	+409.1(34.1)
Grasslands	-15,792.4	-40.8 (-2.5)	+ 12,134.2	+31.5(2.6)	-2,657.7	-6.7(0.6)
-Open grassland	-11,822.2	-73.6 (-4.5)	+1,147.1	+27.1(2.3)	-10,675.1	-66.5(-5.5)
-Bush grass land	-6,337.6	-24.5(-2.1)	-1,440.4	+7.2(0.6)	-4,898.1	-19.0(-1.3)
-Wooded grassland	+2,368.3	+18.9(1.6)	+9,547.2	+64.2(5.3)	+11,915.5	+95.3(7.9)
Woodlands	+ 392.1	-40.8(-0.25)	-1418.0	-10.5(-0.9)	-1,025.9	-7.8(-0.7)
Riverine vegetation	+2,994.9	+26.9(1.9)	-11,060.6	-67.0(-5.6)	-3065.7	-60.2(-5.0)
Cultivation area	-68.4	-8.16(-0.3)	-347.6	-1.8(-0.15)	-416.0	-2.1(-0.2)

- Numbers in brackets are annual percentage cover changes

The open grasslands lost at rate of – 5.5% annually. Whereas the riverine vegetation was lost at a rate of -5.0% annually, this was probably due to conversion to cultivated area. The results on land cover changes in Mkata plains suggest a progressive change from grasslands towards woody vegetation types (Figure 3).

Figure 3(a): Regeneration of Acacia Spp Woodland on a Grassland in Mkata Plains

Figure 3(b): A Secondary Acacia Spp Savanna Woodland in Mkata Plains

Land Cover Change Detection Matrix Between 1975 to 1991, and 1991 to 2000 in Mkata Plains

Land cover changes presented were computed by basing on subtracting areas; this might be inaccurate or misleading; therefore change detection matrices analysis were conducted in order to supplemented area net change results. Table 6 shows the land cover change detection matrix for 1975 and 1991, using 1975 as base year.

The major changes that occurred during the period under consideration were conversion of different land cover types to cultivation area totaling to 15,532.1ha (14.9%); and a total of 34,279.3 ha (32.9 %) progressed in a succession cycle towards woody vegetation climax. This includes conversion of 27,996 ha (26.7%) of grassland to shrub land.

Table 6: Land Cover Change Detection Matrix Between July 1975 and August 1991 in Mkata Plains

Land cover type	**Area Changes(ha)**	**% Change**
Bushed grassland to cultivated area	2,117.0	-2.0
Grassland to cultivated area	1,499.7	-1.4
Wooded grassland to cultivated area	508.9	-0.5
Riverine vegetation to cultivated area	4,095.0	-3.9
Sisal plantation to small hold farms	7,311.9	-7.00
Sub - Total	**15,532.5**	**-14.9**
Woodland to bush grassland	**141.9**	**-0.1**
Bush to thicket	2,316.0	+2.2
Open woodland to closed woodland	439.6	+0.4
Grassland to shrub land	27,996.7	+26.8
Open woodland to wooded thicket	3,375.8	+3.2
Sisal plantation to bush grassland	151.1	+0.1
Su-Total	**34,279.3**	**+32.9**
Unchanged Land cover	**54,457.9**	**52.1**
Total	**104,111.9**	**100.0**

Table7 shows the land cover change-matrix between 1991 and 2000. The main land cover changes that took place during this period involved conversion of different land cover types to cultivation area totaling up to 11,276.7 ha (10.8%); and 6,911.9 (6.7%) of dense woody cover types to more open woody cover types. Other changes involved conversion of 7,449.4 ha (7.2%) from more open woody cover to denser woody cover type.

The results suggest that changes occurring on different vegetation types were multi-directional and might be caused by a wide range of factors. Nonetheless, the change-detection matrix results supported the trend in vegetation changes established from net cover change analysis that indicates the main trend was conversion of grass cover types towards woody vegetation types.

Range Condition in the Study Villages

Figure 4 shows species composition, in the study villages. The rangeland at Mbwade village was dominated by annual grass species *Sporobolus cordotanus* (44%) and weeds including *Commelina benghalensis* (25%). The dominance of annual grass and weeds is an indication of severe overgrazing and deteriorating range condition. Again at Mabwegere village the dominant grass species was *Sporobolus cordotanus* and weeds – Cyperus rotundus (23%), Commelina. benghalensis (25%) and

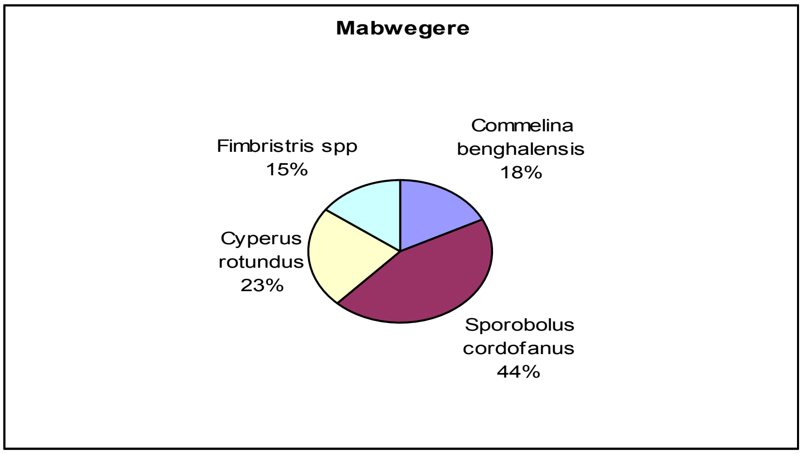
Fimbistylis spp (15%). At both Mabwegere and Mbwade villages there were a low diversity of herbaceous grass species. This could be attributed to high grazing pressure.

Table 7: Land Cover Change Detection Matrix Between 1991 and 2000 in Mkata Plains

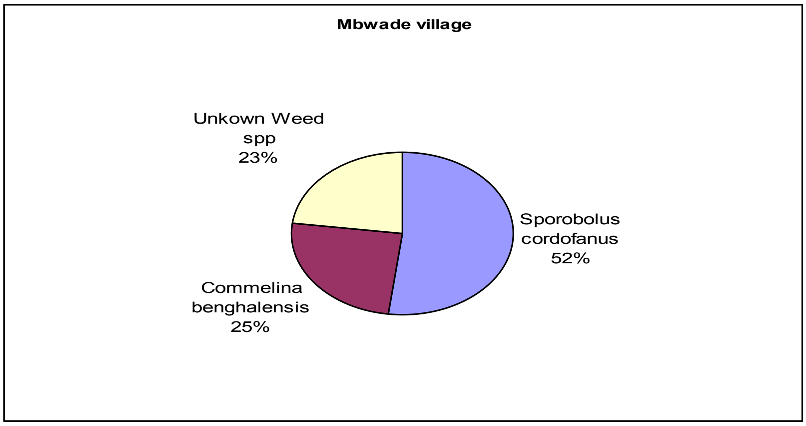
Land cover type	Area changes (ha)	% Change
Bush grassland to Cultivation area	1,096.8	-1.1
Closed woodland to Cultivation area	443.4	-0.4
Thicket to Cultivation area	1,979.0	-1.9
Wooded thicket to Cultivation area	565.3	-0.5
Riverine vegetation to Cultivation area	1,581.4	-1.5
Sisal plantation to small hold farming	5,630.8	-5.4
Sub -Total	**11,276.7**	**-10.8**
Closed woodland to Open woodland	1,163.7	-1.2
Wooded grassland to Shrub land	860.2	-0.8
Thicket to Shrub land	3,302.5	-3.2
Wooded thicket to Open woodland	1,595.5	-1.5
Sub- Total	**6,921.9**	**-6.7**
Bush grassland to Wooded grassland	6,022.3	+5.8
Grassland to Woody regeneration	665.2	+0.6
Open woodland to Closed woodland	382.7	+0.4
Wooded thicket to Closed woodland	379.2	+0.4
Sub-Total	**7,449.4**	**+7.2**
Land cover unchanged	**78,019.3**	**75.3**
Total	**103,677.3**	**100.0**

Both perennial and annual grass species were present at Twatwatwa village. The dominant species was a perennial grass *Urochloa pullatans.* This grass species is known to dominate on disturbed cites. Another perennial species was Dichanthium spp (5%) this tends to decrease with heavy grazing. The annual species present in the village include *Brachiaria deflexa* (29%), *Leptocholoa spp (5%),* and *Heteropogon conturtus* (2%). the high abundance of annual grass species in the village was an indication of declining range condition. A relatively high diversity of grass species and weeds was recorded at Msowero village. The dominant species were perennial grasses *Urochloa pullutans* (25%) and Leptochloa spp (16%). Others were *Dichanthium spp* (7%) and Sporobolus cordotanus (5%). The dominant annual species was *Brachiaria deflexa* (26%). The high proportion of perennial grass species present at Msowero was an indication of healthy range conditions.

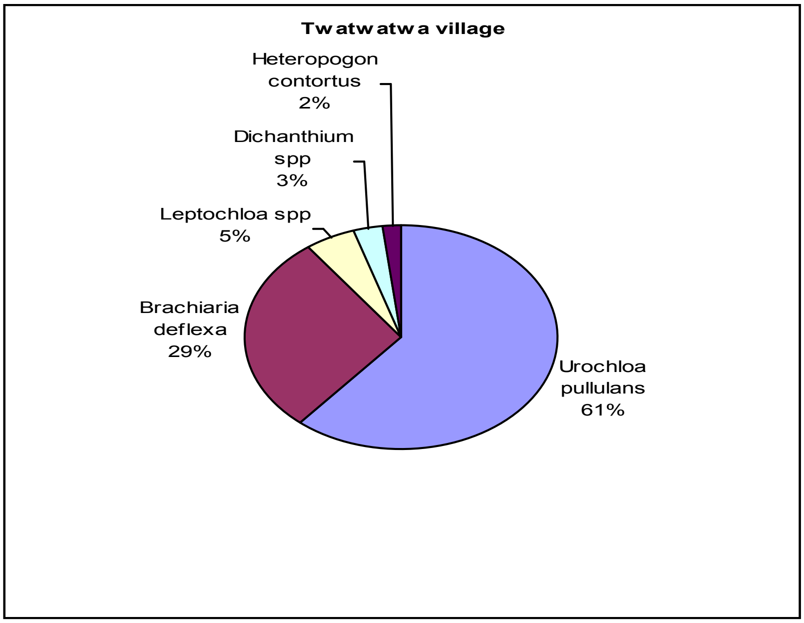
In general the dominant grass species in the study villages were “decreaser” annual grass species: *Brachiaria deflexa, Urochloa pullulans* and weeds *Commelina* spp. The area was also encroached by “increaser” species *Sporobolous cordotanus* and *Dichanthium* spp. Dominance of these species indicates that the range condition in the area was declining.


Mabwegere
Fimbristris spp
15%
Commelina
benghalensis
18%
Cyperus
rotundus
23%
Sporobolus
cordofanus
44%

a


Mbwade village
Unkown Weed
spp
23%
Sporobolus
cordofanus
52%
Commelina
benghalensis
25%

b


Twatwatwa village
Heteropogon
contortus
2%
Dichanthium
spp
3%
Leptochloa spp
5%
Brachiaria
deflexa
29%
Urochloa
pullulans
61%

c

d

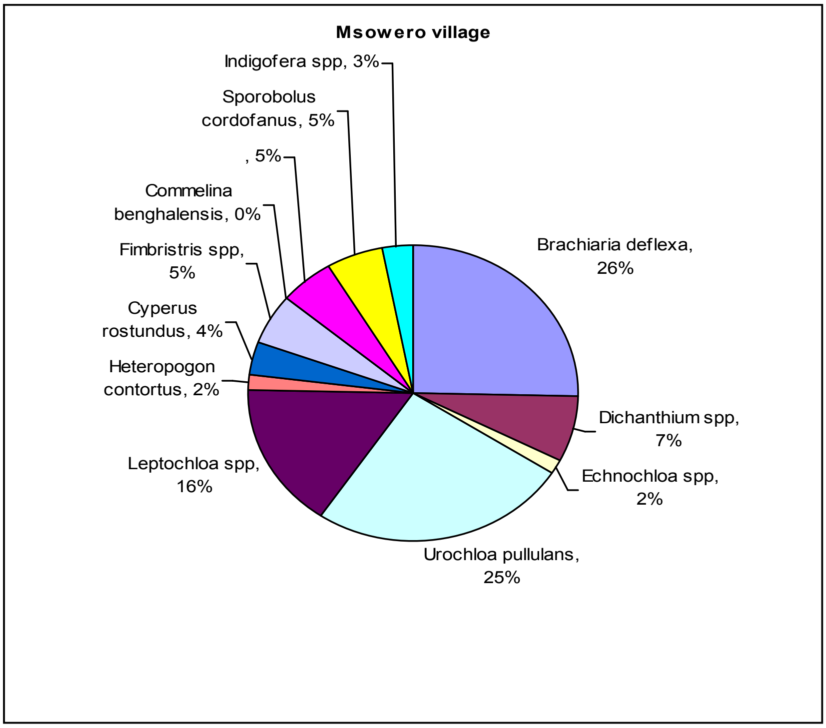


Figure 4: Herbacious Species Composition in the Study Villages
(a) Mbwade (b) Mabwegere (c) Twatwatwa and (d) Msowero

Table 8 shows forage yield and vegetation cover in the study villages. Basing on range inventory survey results forage yield varied from 3,200 kg DM/Ha at Msowero village; 2,170 kg DM/Ha at Twatwatwa; 1,807 kg DM/Ha at Mabwegere and 1,050 kg DM/Ha at Mbwade village.

Table 8: Vegetation Cover and Forage Yield in the Study Villages

Village	Vegetation cover (%)	Forage Yield Kg/Dm/Ha
Msowero	65.0	3,200.0
Mbwade	40.0	1,050.0
Twatwatwa	55.0	2,170.0
Mabwegere	50.0	1,807

Key: DM = dry matter

The results indicate that the forage yield in the villages under the study were moderately to low. The vegetation cover was 65% at Msowero, 55% at Twatwatwa, 50% at Mabwegere and 40% at Mbwade. The low vegetation cover (50% and below) indicates increasing risks for soil erosion.

Table 9 shows rating of range condition class on the villages under study. The results indicate that the range condition class at Twatwatwa and Mabwegere villages was *fair* with condition score of 54% and 50 % respectively, but with a declining trend. While the range condition class at Mbwade village was *poor* with a condition score of 24% with a declining trend.

Table 9: Range Condition Class in the Study Villages

Village	Condition score (%)	Class	Range Trend rating
Twatwatwa	54	Fair	Declining
Mabwegere	50	Fair	Declining
Msowero	60	Good	Stable
Mbwade	24	Poor	Declining

The range condition class at Msowero was rated *good* with a condition score of 60% and in a stable state. The range class gives an indication of the vegetation cover (thus site erosive capacity) as well as presence of palatable grass species for particular herbivores in this case livestock. A low range condition score and a declining trend indicate a deterioration process. The fair range condition at Mabwegere could partly be attributed to high mobility by herders from the village, suggesting that livestock mobility is an important management strategy which easy pressure on grazing lands. If well coordinated this strategy could enhance sustainability of rangelands.

Relationship between Stocking Level and Size of Grassland Vegetation Cover Types

Table 10 shows relationship between excessive stocking level and size of different grassland cover types. Excessive grazing was computed by subtracting the recommended sustainable stocking level from the actual stocking levels in 1975, 1990 and 2000 in the study area.

Table 10: Correlation Coefficient Between Stocking Level and Grassland Vegetation Cover Types in Study Area

Year	Excess stocking level	Open grass land coverage (ha)	Pearson's Correlation Coefficient (r)
1975	63467	16055	
1990	127548	4233	
2000	84765	5380	- 0.8793
Year	**Excess grazing**	**Wooded grassland coverage (ha)**	**Pearson's Correlation Coefficient (r)**
1975	63467	12499	
1990	127548	14867	
2000	84765	24414	1.0

Increase in stocking level during period under consideration shows a strong negative correlation with coverage area of open grassland (Pearson's correlation coefficient, r = - 0.87943). Whereas, there was a perfect correlation between increasing stocking levels and size of wooded grassland cover type (r = 1). These results suggests that herbivory is one of main factors driving conversion of grasslands towards woody vegetation formations in the study area.

DISCUSSION

The study area is a typical savannah ecosystem with a landscape characterized by co-existence of both grass and trees (van Langevelde, 2003). This reflects a peculiar balance of both biotic and abiotic conditions favouring the contrasting plant growth forms (Walker, 1985). The vegetation structure in savannas is determined primarily by a complex set of interacting factors (Archer, 1997). The important one being competition for soil moisture between grasses and trees (Sala *et al.,* (1989); which is subject to strong modification by grazing and fire disturbances (Walker and Noy-Meir, 1982; Savadogo, 2007; Asner *et al*., 2009, Staver *et al*., 2009). A balance between frequency of disturbances and competitive displacement; influence on species diversity and visual heterogeneity of the landscape (Sala *et al*., 1988;Scholes, 1990; van Langevelde *et al*., 2003, Archer and Fred, 2004).

Soil moisture availability is considered to be the main limiting factor in savannas. Here, there are considered two vegetation components: grasses and shrubs/trees - whereby grass roots are restricted to the surface soil, and are the strongest competitors. Thus, grasses are likely to out-compete woody species for water and restrict their growth and/or abundance (Noy-Meir, 1982; Walker and Noy-Meir, 1982; Archer, 1989).

Grazing by herbivores always act as a disturbance through removing living biomas (Norton-Griffiths, 1979; Senft *et al*., 1985). However, grazers tend to be selective of the species they consume resulting in a decrease in abundance of palatable species and increase in abundance of unpalatable species (Collins, 1987). This suggests that high livestock grazing pressure influenced on plants competitive patterns in the study area. So that the preferentially grazed grass species lost the competitive power to least grazed woody species. This led to changes from dominance of perennial palatable grasses to annuals and unpalatable woody species. The field evidence elsewhere shows that, if grasses are destroyed, e.g. by heavy grazing, results in increase in woody vegetation (Stuart-Hill and Tainton, 1989; Skarpe, 1990). The plausible explanation is that probably more water becomes available for trees and shrubs (Knoop and Walker, 1985), which in turn out compete and replace the grass species.

The savannahs were previously considered to be stable ecosystems, whose dynamics consist of fluctuations around one or more steady states or points of equilibrium (Noy-Meir, 1975; Walker and Noy-Meir, 1982; Lamprey, 1983; Dublin, Sinclair and McGlade, 1990), to which they return after disturbance. Although these equilibrium theories have contributed much to the understanding of savannah dynamics, the general value of these theories has been questioned (Caswell, 1978; Connell and Sousa, 1983; DeAngelis and Waterhouse, 1987). It has now been established that the savannas encompass elements of both equilibrium and non-equilibrium (Gillson, 2004) at different scales (Vetter, 2005).

The pattern of vegetation community structure changes in the study area could be explained by the "dynamic equilibrium theory" (White, 1979). This theory assumes that diversity as well as other community and ecosystem properties fluctuate in a range maintain by interaction of growth and competitive displacement, with disturbances. The dynamic equilibrium is therefore based on opposing forces of competitive interactions that lead to competitive exclusion; and mortality causing disturbances (mainly due to herbivory and or fire) that prevent competitive exclusion when the rate of competitive displacement is high, causing local decrease of slowly growing population.

Under this theory diversity can be reduced by either of the two processes. On one side of maximum diversity; it is reduced by competition. While on the other side, diversity is reduced by the inability of population to recover from disturbance. Thus, the theory is based on variation in the relative importance of different processes that influence species diversity. These include local processes such as competition, dominance and reduced diversity under conditions of high growth rate and low disturbance frequencies. Other local processes, such as mortality, reproductive failure and local extinction are important under conditions of low growth rates and high disturbance frequencies.

Variation in the pattern of grazing in terms of frequency and intensity, leads the disturbance to operates either as equilibrium or non-equilibrium processes. At high frequencies of herbivory, that is almost continuous, it can alter the strength and direction of competitive interaction, giving rise to coexistence of competing species under conditions equivalent to competitive equilibrium (Vanndermeer, 1980) leading to competitive exclusion of grass species. However, at lower herbivore frequencies; and acting as pulses of mortality, this interrupts the process of competitive exclusion allowing non-equilibrium coexistence and increase in species diversity. The role of herbivores in this case is to reduce population size of competitively dominant grass species.

Mortality that kills only the dominant competitive while not effecting other species is the most effective preventing competitive exclusion and allow high species diversity. Whereas, the highest levels of species diversity were maintained at some "intermediate" frequency or intensity of disturbance. At high rate of mortality/disturbance, diversity was reduced because some species failed to recover from the mortality. At low rates of mortality diversity was reduced by competitive exclusion as the dominant species eliminated poorer competitors (Vandermeer, 1980).

Fires on savannah also demonstrate outcomes of "dynamic equilibrium" model of species diversity across a range of disturbance regimes (Arora and Boer, 2005). Fires play a major role in maintaining most grassland, by eliminating trees and shrubs that would out compete and replace the grasses in absence of fire (Bragg and Hulbert, 1976). High densities of grazing ungulates consume a sufficient proportion of plant biomass thus reducing both frequency and intensity of fire (Martin, 1975). Cox and Dougill (1996) posit that high species diversity, particularly of grasses, forbs, and shrubs, is often found in vegetation that is regularly burned. Such findings have increased the reconsideration of the importance of fire in maintaining certain species and landscapes patterns, and in managing natural systems (Pyne, 1984).

The ultimate balance of trees and grasses in the study area, to a large extent, was determined by indirect interactive effects of herbivory and fire (van Langevelde *et al.,* 2003; Hoffmann, 2011; Collins *et al.,* 1987; Mott, 1985). These effects are based on the positive feedback between fuel load (grass biomass) and fire intensity. An increase in the level of grazing leads to reduced fuel load, which render fire less intense and, thus, less damaging to trees and, consequently, results in increase in woody vegetation (Savage and Swetnam, 1990; Kaufman *et al*., 1994). The balance between grasses and trees shifts when grazing, browsing and fire intensity changes. Fire is often important in controlling tree seedlings and young trees (Skarpe, 1991a). While, grazing reduces the standing crop of grasses, and thus fire frequency and or intensity (McNaughton, 1992). Thus, the encroachment by woody species in the study area could be attributed to the disruptions of balance between herbivory and fire regimes. Ecological studies elsewhere in Africa shows that; increase in livestock grazing intensities, in recent years, has led to increase in woody biomass productivity at expense of palatable grass species (Perkins, 1991; Bosch, 1989; van Vegten 1983). Similar encroachments of open rangeland by bushes have also been described from other continents, for example, Asia (Singh and Joshi, 1979); Australia (Walker and Gillison, 1982; Hacker, 1984); North and South America (Archer 1989; Adamoli *et al*. 1990).

Perkins, (1991) argues that if other factors remain relatively unchanged in their period, the observed vegetation changes can be explained by concomitant increase in grazing pressure. This implies that encroachment by woody species could be explained solely by the interactions between livestock pressure and fire regimes. The significance of applicability of the herbivory and fire explanation of encroachment by woody species, suggest that vegetation changes are reversible. Herbivory impact could therefore be adjusted through varying grazing management; whereby fire regimes may provide mechanisms that can cause bush die-back (Harrington and Henderson, 1986; Grandy and Hoffmann, 2012).

The study results refute a commonly held view, which associate traditional pastoral systems with desertification. The results further indicate that the savannah ecosystems are highly resilient to various disturbance regimes. This has an implication on management of savannah rangelands, whereby the different disturbance regimes could be encouraged in order to attain the desirable vegetation formations and range productivity. It can also aid rangeland managers to arrest the irreversible ecological changes from occurring.

CONCLUSION AND RECOMMEMNDATIONS

Conclusion

It can be concluded that the introduction of domestic livestock in the study area had been accompanied by significant vegetation cover changes; with an increased encroachment by bushes and woody species and loss of grasslands. The study results indicate that increasing grazing intensities in study area have tipped the grass-tree balance toward dominance of the tree species. The result demonstrates the dynamic nature of the savannah eco-systems in response to disturbances.

.

The results imply that the policy interventions that aimed at transforming the mobile pastoral production system resulted into a negative ecological consequences. The intervention was based on "equilibrium models" of range management that advocated introduction of formalized ranch system, and reduced herd mobility. This measure led into high and continuous grazing intensities in the study villages, which in turn disrupted the natural balances between grass and woody species characteristic to savannah systems. The interventions have triggered off range health degradation; thus engendering loss in livestock productivity.

RECOMMENDATIONS

In order to reverse the degradation processes in the study area it is recommended to:

- Develop "state and transit" model that will identify the key elements driving dynamics of bush encroachment. This will provide an understanding of the dynamics of the system in response to alternative management decisions.
- Introduce flexible sustainable grazing system in the area that will capture the opportunities that arise from climatic variability in the area. This system should include some levels of livestock mobility and introduction of controlled fire regimes to suppress bush encroachment
- Conduct further studies in order to establish the impacts of increasing stocking levels on soil structure, soil water and nutrients; in a view of developing a sustainable grazing management system in the study area.

ACKNOWLEDGEMENT

The authors extends sincere acknowledges to AFORNET for a research grant that supported field research phase of this study.

References

Archer, S. (1989). 'Have southern Texas savannas been converted to woodlands in recent history?' *Am. Nat*. 134: 545-561.

Archer, S. and F. E. Fred (2004). Rangeland Ecology. http/www.cnrit.tamu.edu. /rlem/textbook. Chapter 5. htm#index1. Visited on 5 December, 2004.

Arora, V. K. and Boer, G. J. (2005). 'Fire as an interactive component of dynamic vegetation models'. *J. Geophys. Res.-Biogeosci*., 110, DOI: 10.1029/2005JG000042.

Asner, G. P., Levick, S. R., Kennedy-Bowdoin, T., Knapp, D. E., Emerson, R., Jacobson, J.. (2009). 'Large-scale impacts of herbivores on the structural diversity of African savannas'. *Proc. Natl. Acad. Sci. USA*, 106: 4947–4952.

Beidelman, T. O. (1960). 'The Baraguyu'. *Tanzania Notes and Records* 35:245 - 278.

Brockington, D. (2000). 'Some consequences of the pastoral migration to southern Tanzania. *Tanzania Society of Animal Production Conference Series*. pp 30 - 37

Caswell, H. (1978). 'Predator-mediate co- existence: a non-equilibrium model'. *Am. Nat*. 112: 127-154.

Caswell, H. (1978). 'Predator mediated co-existance : anon-equilibrium model'. *American Naturalist*. 112: 127-154.

Connell, J. H. (1978). 'Diversity in tropical rain forests and coral reefs'. *Science* 199:1302-1310.

Connell, J. H. and Sousa, W. P. (1983). 'On the evidence needed to judge ecological stability or persistence'. *Am. Nat*. 121:789-824.

DeAngelis, D. L. and Waterhouse, J . C. (1987). 'Equilibrium and non-equilibrium concepts in ecological models'. *Ecol. Monogr*. 57: 1-21.

Dougill A. and Cox, J. (1996). 'Land degration and grazing In the Kalahari new analysis and alternative perspectives'. *Pastoral Development Network Service*, 30c: 16 pp

Dublin, H. T., Sinclair, A. R. E. and McGlade, J. (1990). 'Elephants and fire as causes of multiple stable states in the Serengeti-Mara woodlands'. *J . Anim. Ecol*. 59: 1147-1164.

Dyksterhuis, E. J. (1949). 'Condition and management of rangeland based on quantitative ecology'. *J. Range Management*. 2:104-115.

Gillson, L. (2004). 'Testing non-equilibrium theories in savannas: 1400 years of vegetation change in Tsavo National Park, Kenya'. *Ecological Complexity* 1:281–298.

Grady, J. M. and W, A. Hoffmann (2012). 'Caught in a fire trap: Recurring fire creates stable size equilibrium in woody resproutes'. *Ecology, 93(9),* pp. 2052–2060, by the Ecological Society of America

Grady, J. M. and Hoffmann, W. A. (2012). 'Caught in a fire trap: Recurring fire creates stable size equilibria in woody resprouters'. *Ecology, 93:2052-2060*.

Hacker, R. B. (1984). 'Vegetation dynamics in a grazed mulga shrubland community I. The mid-storey shrubs'. *Aust. J. Bot*. 32: 239-250.

Herlocker, S. (1999). *East African Rangeland Ecology and Management*. GTZ: Nairobi. 120 Pp.

Hoffmann, W. A., Jaconis, S. Y., McKinley, K. L., Geiger, E. L., Gotsch, S. G. and Franco, A. C. (2011). 'Fuels or microclimate? Understanding the drivers of fire feedbacks at savanna-forest boundaries'. *Austral. Ecol*., DOI: 10.1111/j.1442-9993.2011.02324.x.

KDC (Kilosa District Council) (2000). *Kilosa District Development Plan: 1998 To 2000. Final Draft*. 120 pp.

KDC (Kilosa District Council) (2002). *Kilosa District Development Plan*: *2002 To 20041. Final Draft*. 128 pp.

Kisoza, L. J. A., Kajembe G. C. and G. C. Monela (2004). Natural Resource Use Conflicts in Kilosa District, Morogoro Region, Tanzania. In: *Proceedings of the IFRI East African Regional Conference; Institutions*, *Incentives and Conflicts in Forest Management: A Perspective*. *(*Edited by Shemweta, D. T. K., Luoga, E. J., G. C. Kajembe and S. S. Madoffe). 12th –13th January 2004. Moshi, Tanzania. pp 108 – 123.

Knoop, W. T. and Walker, B. H. (1985). Interactions of woody and herbaceous vegetation in a Southern African savannah. *J. Ecol*. 73: 235-253.

Kurwijila, L.R.,Minga U. and Ashimogo, G.C.,(2002).. 'The Challenges of Research in Improving Livestock Productivity in Tanzania'. In: *Proceedings of the Second University wide Scientific Conference* held at the Institute of Continuing Education (ICE), SUA from 9th-10th May 2002, 29-63 pp.

Lamprey, H. F. (1983). Pastoralism yesterday and today: the over-grazing problem. In: Bourliere, F. (ed.) *Ecosystems of the World 13 Tropical Savannas*, pp. 643-666. Elsevier, Amsterdam.

Makunda, J. J. (2005). 'Dynamics of livestock ownership and household food security in semi-arid Tanzania. The case of Dodoma Rural District'. M.Sc. Dissertation. Sokoine University of Agriculture. 120 pp.

McNaughton, S. J. (1992). The propagation of disturbance in savannas through food webs. *J. Veg. Sci.* 3: 301-314.

Ministry of Agriculture and Co-operatives (MoAC) (1998). 'Basic Data: Agriculture and Livestock sector 1991-1998'. Dar es Salaam, pp 50.

Ministry of Livestock dedevelopment and Fisheries (MoLDF) (2010). National sample census. National Report. www.himmotanners.com/index. Visited on 20 February 2013.

Misana, S. B., Sawiuo, C. J., Sechambo, F. and Mchome, S. (1997). *Strategies for village land management for resource conservation in selected villages in Tanzania. Final report*. University of Dar – Es- Salaam, Tanzania. 133 pp.

Mpiri, D. (1995). Pastoral production in Tanzania. *PINEP Regional Workshop*. Nairobi, 16 – 19. January 1995. 25 pp.

Norton-Griffiths, M. (1979). The influence of grazing, browsing, and fire on the vegetation dynamics of the Serengeti. Pages 310–352 *in* A. R. E. Sinclair and M. Norton-Griffiths, (eds) *Serengeti: Dynamics of anEecosystem*. University of Chicago Press: Chicago, Illinois, USA.

Noy-Meir, I. (1982). Stability of plant-herbivore models and possible applications to savanna. In: Huntley, B. J. and Noy-Meir, I. (1975). Stability of grazing systems: An application of predator-prey graphs. *J . Ecol*. 63: 459-481.

Noy-Meir, I., M. Gutman and Y. Kaplan (1989). 'Responses of Mediterranean grassland plants to grazing and protection'. *J. Ecol*. 77: 290-310.

Nyerere, J. K. (1968). The Arusha Declaration. In *Freedom and Socialism*. Chapt 5 pp 231-250. Oxford University Press.

Pratt, D. J. and M. D. Gwynne (1977). *Rangeland Management and Ecology in East Africa.* London: Hodder and Stoughton. 310 pp.

Range Improvement Task Force (1985). A guide to New Mexico Range Analysis. *Agriculture Experimental Station Bulletin* 2 (81): 302 – 401. New Mexico University Press.

Sala, E. O., R. A. Golluscio, W. K. Lauenroth, and A. Soriano (1989). Resource partitioning between shrubs and grasses in the Patagonian steppe. *Oecologia* 81:501–505.

Sala, O. E., W. J. Parton, L . A. Joyce, and W. K. Lauenroth.(1988). Primary production of the central grassland regions of the United States. *Ecology* 69:40-45.

Savadogo, P. (2007). Dynamics of Sudanian savanna-woodland ecosystem in response to disturbances. Diss. (sammanfattning/summary) Umeå : Sveriges lantbruksuniv., Acta Universitatis agriculturae Sueciae, 1652-6880; 2007:64 ISBN 978-91-576-7363-3 [Doctoral thesis] 320 pp

Scholes, R. J. (1990). The influence of soil fertility on the ecology of southern African dry savannas. *J. Biogeogr*. 17: 415-419.

Senft, R. L, Rittenhouse, L. R., and R. G. Woodmansee (1985). Factors influencing patterns of cattle grazing behaviour on short grass steppe. *Journal of Range Management*. 38: 82-87.

Shishira, E. K., Nyanda, P. Z., Sosovele, H. and J. G. Lyimo (1997*). Kilosa District: Land use and NaturalRresources Assessment*. *FinalRreport.* University of Dar-Es- Salaam, Tanzania. 85. pp

Singh, J. S. and Joshi, M. C. (1979). Primary production. In: Coupland, R. T. (ed.) *Grassland Ecosystems of the World. Analysis of Grasslands and their Uses,* pp. 197-218. Cambridge University Press: Cambridge

Skarpe, C. (1990). Shrub layer dynamics under different herbivore densities in an arid savannah, Botswana. *J. Appl. Ecol*. 27: 873-885.

Skarpe, C. (1991a). Spatial patterns and dynamics of woody vegetation in an arid savanna. *J. Veg. Sci*. 2: 565-572.

Skarpe, C. (1991b). Impact of grazing in savanna ecosystems. *Ambio* 20: 351-356.

Smeins, F. E. ,(1984). Origin of the brush problem-a geographical and ecological perspective of contemporary distributions. In: K W. McDaniel (eds), *Proc. Brush Manage. Symp. Texas* Tech Press, Lubbock. USA. pp. 5-16

Staver, A. C., W. J. Bond, W. D. Stock, S. J. Van Rensburg, and M. S. Waldram (2009). Browsing and fire interact to suppress tree density in an African savanna. *Ecological Applications*, 19(7), pp. 1909–1919p; by the Ecological Society of America

Stuart-Hill, G. C. and Tainton, N. M. (1989). The competitive interaction between Acacia karroo and the herbaceous layer and how this is influenced by defoliation. *J. Appl. Ecol*. 26: 285-298.

Tothill, J. C., and J. J. Mott (1985). Ecology and management of the world's savannahs. *Aust. Acad. Sci.*, Canberra. pp 98 – 105.

Trsc (1966). *Tanzania Rural Settlement Commission. A Report on Village Settlement Programmes From the Inception of RSC to 31st December, 1965*. Dar-Es-Salaam. Government Printer. 49 pp.

URT (1967). *Ujamaa Village Act 1967, No. 4. 1967*. Government Printers: Dar-Es-salaam. 126 pp.

URT (1965 a). *Land Tenure (Village Settlement) Act, 1965 N0.29*. Government Printers: Dar-Es-salaam. 132 pp.

URT, (1965b). Range development and management Act, 1965, No. 51. Government Printers. Dar-Es-Salaam. 161 pp.

van Langevelde, F., C. A. D. M. Van De Vijver, L. Kumar, J. Van De Koppel, N. De Ridder, J. Van Andel, A. K. Skidmore, J. W. Hearne, L. Troosnijder, W. J. Bond, H. H. T. Prins and M. Rietkerk (2003). Effects of fire and herbivory on the stability of savannah ecosystems. *Ecology,* 84(2): 337–350 : The Ecological Society Of America

Walker, B. H. (eds.) (1985). Ecology of tropical savannas, pp. 556-590. Springer-Verlag Berlin.

Walker, B. H. and Noy-Meir, I. (1982). Aspects of the stability and resilience of savanna ecosystems. In: Huntley, B. J. and Walker, B. H. (eds.), *Ecology of Tropical Savannas*, spp. 556-590. Springer-Verlag Berlin.

Walker, J. and Gillison, A. N. (1982). Australian savannas. In: Huntley, B. J. and Walker, B. H. (Eds.) *Ecology of Tropical Savannas*, Pp. 5-24. Springer-Verlag, Berlin.

White, P. S. (1979.) Pattern, process and natural disturbance in vegetation. *Botanical Review*. 45: 229- 299.