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LAND USE AND COVER CHANGE IN PASTORAL SYSTEMS OF UGANDA: IMPLICATIONS ON LIVESTOCK MANAGEMENT UNDER DROUGHT INDUCED PASTURE

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ABSTRACT

The rangelands of Uganda used to be historically managed under traditional systems where grazers had open access with mobility as a main coping strategy to drought. Changes in land ownership, increased population and demand for food and fuel have led to changes in land use and cover types, affecting livestock management practices. This study assessed the extent of land use and cover change in Buliisa and Nakasongola Districts in the cattle corridor of Uganda over 27 years (1986 –2013), and their impacts on livestock management under drought induced pasture. Landsat TM (1986) and Landsat ETM+ (2000 and 2013) images were processed using a hybrid of supervised and unsupervised classification algorithm, using ENV1 software 4.7. Area under open water and grassland declined by 3.5 and 48.3%, while woodland, wetland, small scale farming and forest increased by 0.2, 62.2, 320.7 and 64.1%, respectively, in Buliisa. In Nakasongola, grassland, bushland and forest decreased by 96.1, 25.6 and 17.2%, respectively; while open water, bare ground, wetland, and small scale farming increased by 5.3, 210.9, 2.7 and 26.8%, respectively, between 1986 and 2013. Individualisation of land in Nakasongola led to settlement of cultivators and fencing of land leading to blockage of livestock migration routes. Reduced mobility of livestock during drought, increased stock densities resulting in land degradation exemplified by bare land in Nakasongola compared to Buliisa, where communal land ownership and limited cultivation enabled mobility. The current land use and cover changes have delineated mobility as a coping strategy to drought, contributed to degradation of rangelands, reduced the resilience of pastoral systems to drought and increased their vulnerability to climate change. Farm based water and forage conservation should be enhanced to sustain livestock production.

Key Words: Cattle corridor, coping strategy, forage, migration

RÉSUMÉ

Les pâturages de l' Ouganda étaient historiquement gérés sous système traditionnel où les éleveurs avaient un accès facile avec libre mouvement comme stratégie d'adaptation aux conditions de sécheresse. Les changements dans les systèmes de propriéte foncière , l'augmentation de la population et la demande accrue de la nourriture et produits de chauffe ont induit des changements dans l'utilisation des terres et types de couvert, affectant ainsi les pratiques de gestion de l'élevage. Cette étude a évalué l'ampleur du changement dans l'utilisation des terres et couvert végétal dans les districts de Buliisa et Nakasongola dans le corridor du bétail en Ouganda depuis 27 ans (1986 –2013), et leurs impacts sur la gestion de l'élevage en conditions de sécheresse. Les images Landsat TM (1986) et ETM+ (2000 et 2013) étaient exploitées par utilisation d'un mélange d'algorithme de classification supervisée ou non supervisée utilisant le logiciel 4.7 ENV1. Les surfaces d'eau et les pâturages ont diminué de 3.5 et 48.3%, pendant que les zonesz boisées , les marrais, les surfaces cultivées et les forets ont augmenté de 0.2, 62.2, 320.7 et 64.1%, respectivement, dans Buliisa. Dans la région de Nakasongola, les pâturages, les terres surbrulis et les forets ont diminué de 96.1, 25.6 et 17.2% respectivement; pendant que les surfaces d'eau, les

surfaces dénudées , les marrais et les surfaces cultivées ont augmenté de 5.3, 210.9, 2.7 et 26.8%, respectivement, entre 1986 et 2013. La privatisation des terres à Nakasongola a conduit à l'occupation des terres par les cultivateurs, restreignant ainsi les mouvement migratoire du bétail. Cette réduction de la mobilité du bétail durant la saison sèche a entrainé une augmentation de leur densité entrainant une dégradation avec dénudation des terres en comparaison avec Buliisa, où l'utilisation des terres communales et l'activité agricole limitée ont facilité la mobilité. L'utilisation actuelle des terres et les changements du couvert végétal ont renforcé la mobilité du bétail comme stratégie d'adaptation à la sécheresse, contribué à la dégradation des pâturages, réduit la résilience des systèmes pastoraux à la sécheresse et augmenté leur vulnérabilité au changement climatique. La conservation du fourrage et de l'eau au niveau des exploitations devrait être renforcée pour permettre un élevage durable.

Mots Clés: Corridor du bétail, stratégie d'adaptation, fourrage, migration

INTRODUCTION

Pastoral and agro-pastoral production systems are home to majority of ruminant livestock and supply more than 85% of milk and 95% of beef consumed in Uganda (King and Allan, 2002). Climatic variability is an intrinsic feature in pastoral areas with both seasonal and inter-annual variations in water and pasture availability. Historically, the rangelands of Uganda were managed under traditional systems, where grazers had open access to resources (Kisamba-Mugerwa, 1995) and largely depended on mobility to search for pasture and water. However, changes in land ownership, land uses and increased human population have compromised pastoral mobility as a coping strategy to drought induced water and pasture scarcity (Kisamba-Mugerwa, 1995). These changes have increased conflicts over resource use among different livelihood groups. Pasture scarcity, reduced water and resource degradation are on the increase due to deforestation, inappropriate land use practices and exceeding livestock carrying capacities. The rangelands are degraded with visibly compacted soils, open gullies, bare patches of soil, termite damage and woody encroachment affecting livestock production and threatening food security and livelihoods of rangeland communities (Mugerwa *et al*., 2008; Zziwa *et al*., 2008).

Protection of pastoral and agro-pastoral grazing resources from degradation is a priority for sustainable livestock production and improved livelihood of pastoral communities. The objective of this study was to critically identify and map existing rangeland resources to guide the development of appropriate strategies and innovations for managing livestock especially during drought in the typical rangelands of Uganda.

MATERIALS AND METHODS

The study areas. This study was conducted in the rangelands of two districts, namely Buliisa and Nakasongola in Uganda. The two districts were identified and selected as study sites in a bigger regional project "Up-scaling feed packaging and feed conservation innovations to increase feeds availability and mitigate effects of drought crises in pastoral systems of ECA (ASARECA_RC12_LFP-01)".

Buliisa District. Buliisa District covers an area of 3,200 Km^2 and is located between latitude 1º 232 and 2º 212 N and longitude 31º 242 and 33º 242 E. Crop farming, livestock production and fishing are the main economic activities. Rainfall is bi-modal, occurring in March to May and August to November and ranging between 700 and 1,000 mm annually, with seasonal variations and prolonged droughts. The soils are ferralitic, ferrisol and hydromorphic (Harrop, 1960) and are yellowish-red clay loams. The vegetation is classified into forest, savannah, grassland and swamp. Forest vegetation includes Budongo high tropical forest; while savannah vegetation consists of perennial grasses, scattered trees and shrubs. The dry savannah lies contiguous to Lake Albert, turning into wet savannah grassland up to the escarpment. Swamp vegetation fills most of the water logged valleys (Langdale-Brown *et al.*, 1964).

Nakasongola District. Nakasongola District covers an area of 4,909 Km^2 located between latitudes 0º 57' 44.89" and 1º 40' 42.76" North and

between longitudes 31° 58' 03.77" and 32° 48' 00.29" E. The rainfall is about 1000 mm annually and bi-modal, falling between March and May and between August and November. Seasonal variations and prolonged droughts are common. The dominant vegetation is dry savanna dominated by *Hyparrhenia filipendula* and *Loudentia arundinacea* grasses and scattered fire-tolerant *Combretum terminalis* and *Acacia brevispica* trees (Radwanski, 1960; Langdale-Brown *et al*., 1964). Extensive bare ground and termite activity cause low organic matter in the topsoil. The soils classified under the Buruli catena (Radwanski, 1960) have inferior nutrient status with clay content of 12% in the upper layer, low organic carbon (1%), pH of below 5 and are deficient in phosphorus and exchangeable bases.

Developing a catalogue of resources. Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) were conducted to identify the existing natural resources, migratory patterns, livestock markets, perceptions and ideas on land use changes and causes. KIIs were conducted with officers in charge of key departments in local governments at District level. Key issues discussed were livestock production practices, challenges and opportunities, availability and accessibility to production resources such as pastures, water, health and markets, seasons of scarcity and the available coping and adaptation mechanisms. A list of geo-referenced resources was generated. FGD's were conducted in two sub-counties with high cattle populations and severe water and forage scarcity to elicit the coping strategies practiced by farmers, indigenous knowledge in livestock management and health, pasture and water management. FGDs of 8-12 persons were conducted in Nabiswera and Nakitoma Sub-counties of Nakasongola and Buliisa Town Council and Butiaba Sub-counties in Buliisa.

Resource mapping. Three sets of Ortho-rectified, cloud free multi-temporal Landsat TM/ETM+ images (30 m) for 1986, 2000 and 2013 were downloaded. The path and row were 172r58 and 172r59 for Nakasongola and 172r59 for Buliisa. The downloaded images were for the dry season months of the year. The multi-date images were subjected to atmospheric correction (Lu and Weng, 2007). The images were processed using a hybrid of supervised and unsupervised classification algorithm. An ISODATA clustering algorithm was adopted to merge spectral classes into meaningful classes; while the per pixel classification method was used to combine the spectra of all training set of pixels from a given feature of the images and classified using a maximum likelihood procedure using ENV1 Software Version 4.7. The Uganda Bureau of Statistics generated land use/cover map for 1986 and the land cover stratification maps from the National Biomass Study of 2003 were used as reference in the classification of the acquired images. The National Biomass Study (2003) classification scheme was adopted in the description of classified classes. Ground truthing and post-classification was carried out for the production of final land use/cover maps.

RESULTS

Land use and land cover types and changes. The extent of land use, land cover and their relative changes over a period of 27 years (1986 - 2013) for Buliisa and Nakasongola are presented in Tables 1 and 2, and Figures 1a-c and 2a-c. The land use types identified included grasslands, water bodies, forests, woodlands, bushes, wetlands, bare ground, livestock and livestock markets. Land use/cover changes for specific districts are presented in the following sections.

Land use/cover changes in Buliisa District. Land use/cover types in Buliisa for 1986, 2000 and 2013 are presented in Table 1 and Figure 1(a, b and c). In 1986, open water represented the highest land cover in the district, followed by grasslands; while small scale farming was the least covering only 2.2% of the area. Other land cover types were woodland, tropical forest and wetland. Buliisa District comprises of part of Lake Albert, which is associated with several small rivers and swamps, hence, the high water cover. The rivers include Sambiye, Waisoke, Bubwe and Sonso; and Kisiabi wetland (Fig. 3). Murchison Falls National Park and Bugungu game reserve contribute to grassland and woodland cover. In 2000, open water was still the most prevalent land

TABLE 1. Land use and land cover for Buliisa District in 1986, 2000 and 2013 in the rangelands of Uganda

Land use/ cover types	1986		2000		2013		Percent change in land use/cover		
	Area (km^2)	Percent Cover	Area (km^2)	Percent Cover	Area (km^2)	Percent Cover	1986 – 2000	2000 - 2013	1986- 2013
Open water	905.4	45.2	898.4	44.33	874.1	43.1	-0.77	-2.71	-3.5
Woodland	357.5	17.9	21.2	1.05	358.3	17.7	-94.1	1590.1	0.2
Grassland	475.1	23.7	698.3	34.46	245.7	12.1	47.0	-64.8	-48.3
Wetland	68.2	3.4	79.7	3.93	110.6	5.5	16.9	38.8	62.2
Small scale farming	44.9	2.2	213	10.51	188.9	9.3	374.4	-11.3	320.7
Tropical forest	151.9	7.6	116	5.72	249.2	12.3	-23.6	114.8	64.1

TABLE 2. Land use and land cover for Nakasongola District in 1986, 2000 and 2013 in the rangelands of Uganda

Land use/ cover types	1986		2000		2013		Percent change in land use/cover		
	Area (km^2)	Percent Cover	Area (km^2)	Percent Cover	Area (km^2)	Percent Cover	1986 – 2000	2000 - 2013	1986- 2013
Open water	247.6	7.1	263.1	7.5	260.8	7.4	6.3	-0.87	5.3
Bare ground	409.7	11.7	407.2	11.6	1273.7	36.2	-0.61	212.8	210.9
Grasslands	790.5	22.5	915.6	26.1	31.3	0.9	15.8	-96.6	-96.1
Bushland	1128.4	32.2	1123.1	32	839.7	23.9	-0.47	-25.2	-25.6
Wetland	285.6	8.1	248.2	7.1	293.4	8.3	-13.1	18.2	2.7
Small scale farming	635.1	18.1	542.5	15.5	805.3	22.9	-14.6	48.4	26.8
Forest	12.2	0.3	9	0.3	10.1	0.3	-26.2	12.2	-17.2

covers type; followed by grassland. However, small scale farming increased almost 5 times that of 1986 from 2.2% to 10.51%. Tropical forests and woodland as covers substantially reduced over the same period. In 2013, there was increase in woodland and tropical forest cover; while grassland cover reduced from 34.46 to only 12.1%. There were no major changes in open water, small scale farming and wetland.

The period 1986 to 2000 led to reduced open water, woodland and tropical forest by 0.77, 94.1 and 23.6% , respectively; while grasslands, wetland and small scale farming increased by 47, 16.9 and 374.4%, respectively. Between 2000 and 2013, the area under open water, grassland and small scale farming declined by 2.71, 64.8 and 11.3%, respectively; while woodland, wetland and tropical forest increased by 1590.1, 38.8 and 114.8%, respectively. Overall, between 1986 and 2013, there was a decline in open water and grassland of 3.5 and 48.3%, respectively; and increases in woodland, wetland, small scale farming and tropical forest of 0.2, 62.2, 320.7 and 64.1%, respectively.

Livestock types, numbers, and productivity in Buliisa District are given in Table 3. The number of households owning livestock (cattle and goats) and the total number of livestock were higher in Nakasongola than in Buliisa, although mean herd sizes per household were higher in Buliisa. Both districts kept mostly indigenous livestock. Although the number of cows milked was higher in Nakasongola, milk yield per cow did not differ significantly between the two districts.

Land use and land cover changes in Nakasongola District. Land use/cover types for Nakasongola

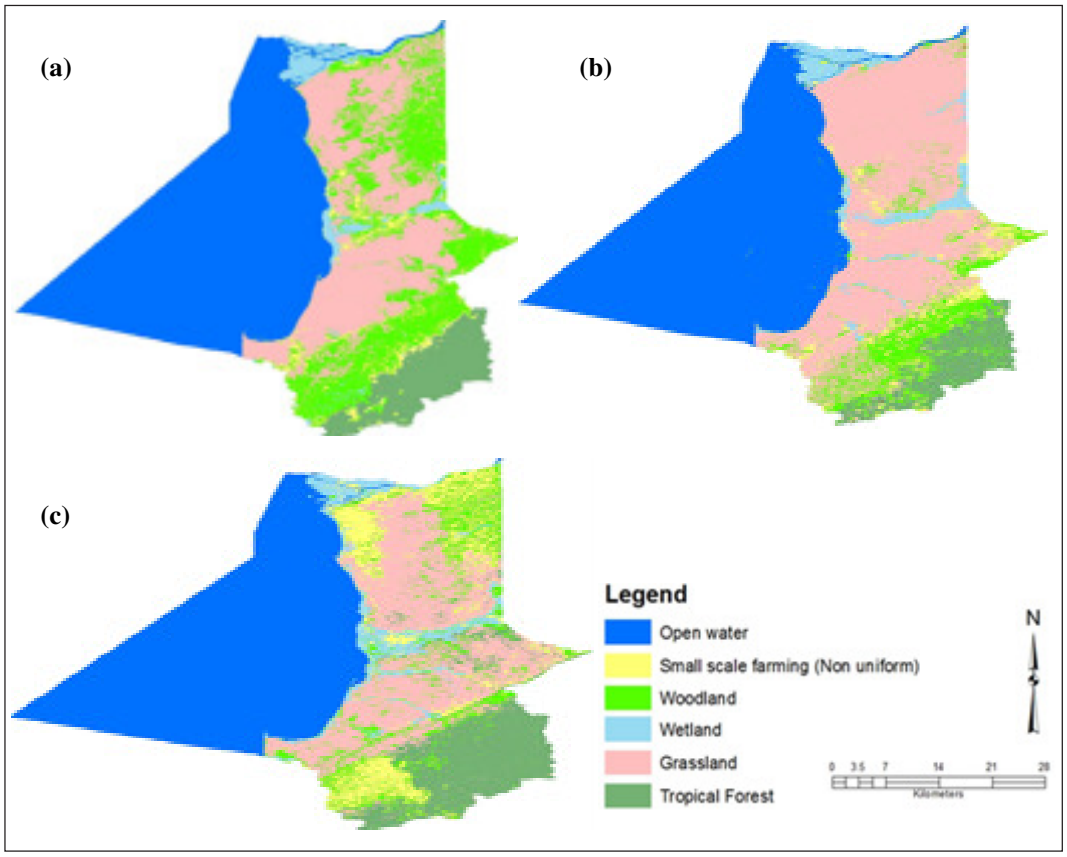

Figure 1 (a). Land use/cover map for Buliisa (1986), (b) Land use/cover map for Buliisa (2000, (c) Land use cover map for Buliisa (2013) in Uganda.

are presented in Table 2 and Figure 2 (a, b and c). In 1986, bushland was the highest land cover type, followed by grassland and small scale farming. The high prevalence of bare ground was also evident in Nakasongola. There was relatively less open water coverage compared with Buliisa District. In 2000, little difference was observed in land use in the district from that of 1986. In 2013, however, the bare ground (36.2%) dominated all the other land cover types, followed by bushland and small scale farming; but a significant decline in grassland was observed.

Between 1986 and 2000, bareground, bushland, wetland, small scale farming and forest declined by 0.61, 0.47, 13.1, 14.6 and 26.2%, respectively; while open water and grasslands increased by 6.3 and 15.8%, respectively. Between 2000 and 2013, open water, grassland, bushland decreased by 0.87, 96.6 and 25.2%; while bare ground, wetland, small scale farming and forests increased by 212.8, 18.2, 48.4 and 12.2%, respectively. Generally, there was a decline in grassland, bushland and forest by 96.1, 25.6 and 17.2%, respectively between 1986 and 2013; while open water, bare ground, wetland, and small scale farming increased by 5.3, 210.9, 2.7 and 26.8%, respectively. The water bodies in Nakasongola (Fig. 4) include Lake Kyoga; and Rivers Nile, Kafu, Lugogo, Mukote, Namwanga and Ndala. Livestock types, numbers, and productivity in Nakasongola District are represented in Table 3.

Water resources, livestock migration and cattle markets. Tables 4 and 5 show additional water sources in Buliisa and Nakasongola Districts. Nakasongola had more valley tanks and dams than Buliisa District. Also, Nakasongola had six

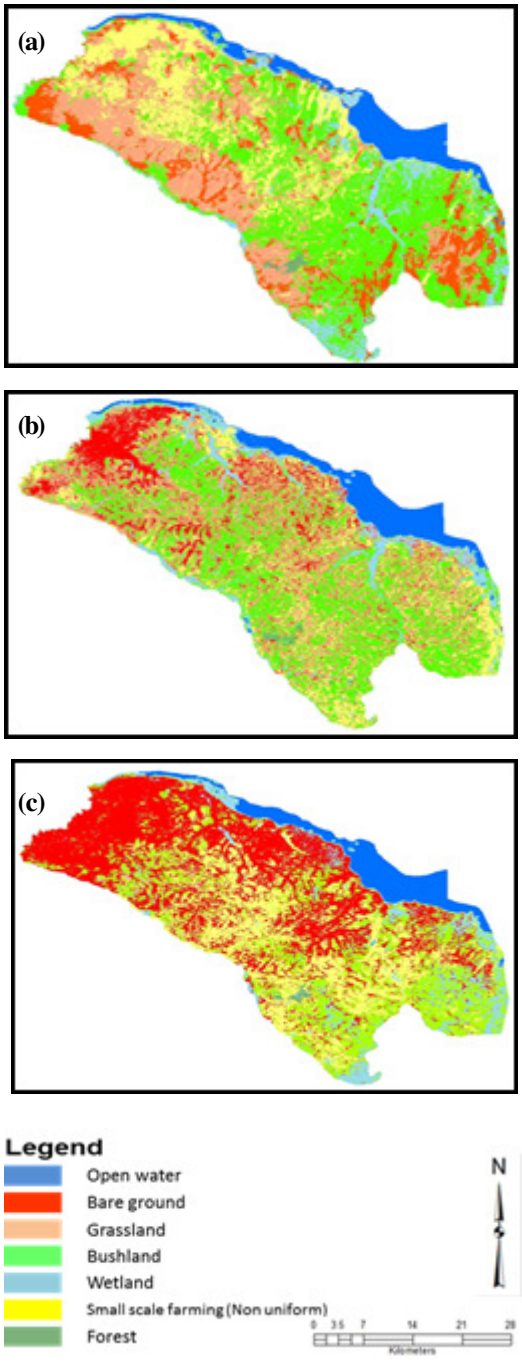

Figure 2 (a). Land use/cover map for Nakasongola (1986), (b) Land use/cover map for Nakasongola (2000), (c) Land use/cover map for Nakasongola (2013) in Uganda.

livestock markets while Buliisa had two. Buliisa had many operational livestock migration routes (Figs. 3 and 4), yet Nakasongola's were blocked and migration had virtually ceased. Contagious livestock diseases (Foot and Mouth Disease (FMD), Contagious Bovine Pleura Pneumonia (CBPP) and Brucellosis) were more prevalent in Buliisa than in Nakasongola, especially in areas where livestock converged during migration.

In Buliisa, migration targeted rivers and Lake Albert, and sometimes towards the Park. In December to February and June to August dry seasons, herders followed normal migration in search of water and pasture. During drought, migrations followed water points (streams, rivers up to Lake Albert). Buliisa experienced more frequent prolonged droughts estimated at 3-4 years interval. Encroachment on restricted wild life conservation areas sometimes occurred resulting in conflicts. Movement during droughts sometimes caused conflicts between herders and cultivators.

In Nakasongola, migration only took place during prolonged droughts. Prolonged droughts had reduced to every 3-4 years as in Buliisa, from the original 8-12 years before 2000. Due to increased on-farm water resources, individual land ownership characterised by fencing and cultivation, there was limited migration in Nakasongola, occurring only in degraded areas with pasture scarcity.

DISCUSSION

Both temporal and spatial changes in land use/cover in the two districts were observed with spatial changes including expansion of cultivated lands into natural vegetation types (grasslands, bushland, wetland and forests), expansion of grasslands into bushland and woodlands, bush and woodlands encroachment in grasslands and increased bare ground (Figs. 1 and 2). Temporal changes included the regeneration of woodlands after clearance for wood and charcoal production and, thereafter, cultivation of the land. Bare ground prominently occurred in Nakasongola and

TABLE 3. Cattle and goat production status in Buliisa (B) and Nakasongola (N) Districts in the rangelands of Uganda

Livestock production parameter	Cattle		Goat	
	B	N	B	N
Number of household owning livestock	1,120	13,400	5,760	13,880
Percentage of livestock owning households in District	7.8	46.7	40	48.4
Total number of animals in district	34,800	222,190	43,326	87,823
Mean herd size per HH	31	16.6	7.5	6.3
Percentage of indigenous cattle in district	99.5	99.8	100	99.5
Percentage of Ankole breed in indigenous herd	28	45.6	-	-
Percentage of zebu and Nganda breed in herd	72	54.4	-	-
Percent of Mubende goat in herd	-	-	42.3	27.5
Percent of small East African goat in herd	-	-	56.6	72.4
Percent of Kigezi breed in herd	-	-	1.1	0.1
Number of cows milked	3,720	35,170	-	-
Average daily milk/cow (litres)	0.39	0.54	-	-
Percentage of milk sold	46	20.4	-	-

TABLE 4. Water reservoirs and livestock markets in Nakasongola District (2013) in the rangelands of Uganda

Sub-county	Communal valley tanks	Private valley tanks and ponds	Communal valley dams	Livestock markets
Nabiswera	10	94	3	2
Nakitoma	6	67	0	1
Kakooge	16	33	0	0
Wabinyonyi	13	43	0	1
Town council	2	4	1	1
Kalungi	5	20	0	0
Kalongo	9	47	0	1
Lwampanga	3	6	0	0
Lwabyat	5	27	0	0
Total	69	337	4	6

TABLE 5. Water reservoirs and livestock markets in Buliisa District (2013) in the rangelands of Uganda

Sub-county	Communal valley tanks	Private valley tanks and ponds	Communal valley dams	Livestock markets
Town council	0	3	0	1
Buliisa	2	7	0	0
Biiso	1	3	0	0
Ngwedo	1	4	0	0
Kigwera	2	4	1	1
Butiaba	1	2	0	0
Kihungya	1	4	0	0
Total	8	27	0	2

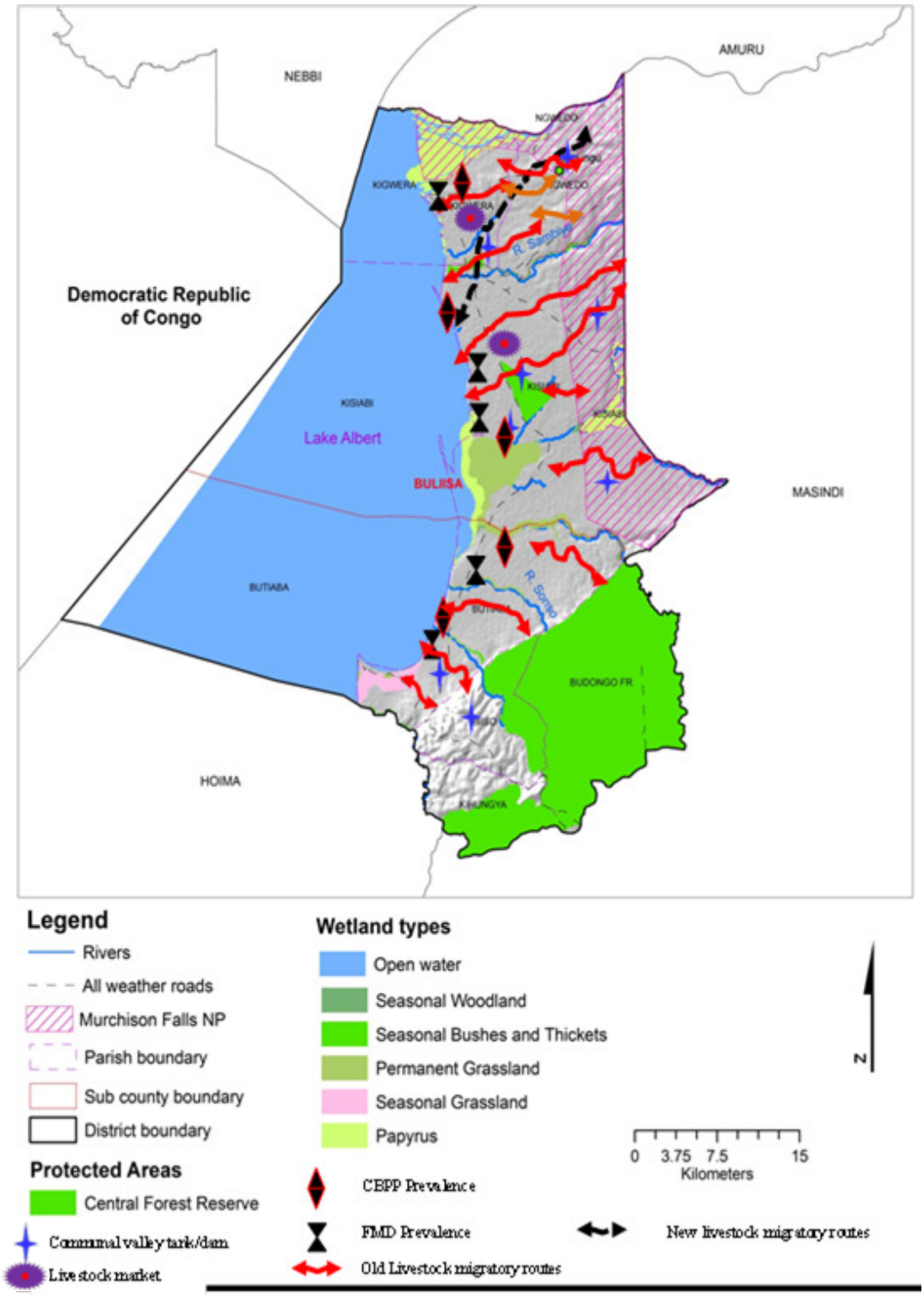

Figure 3. Livestock migration routes, markets and water resources in Buliisa District in Uganda.

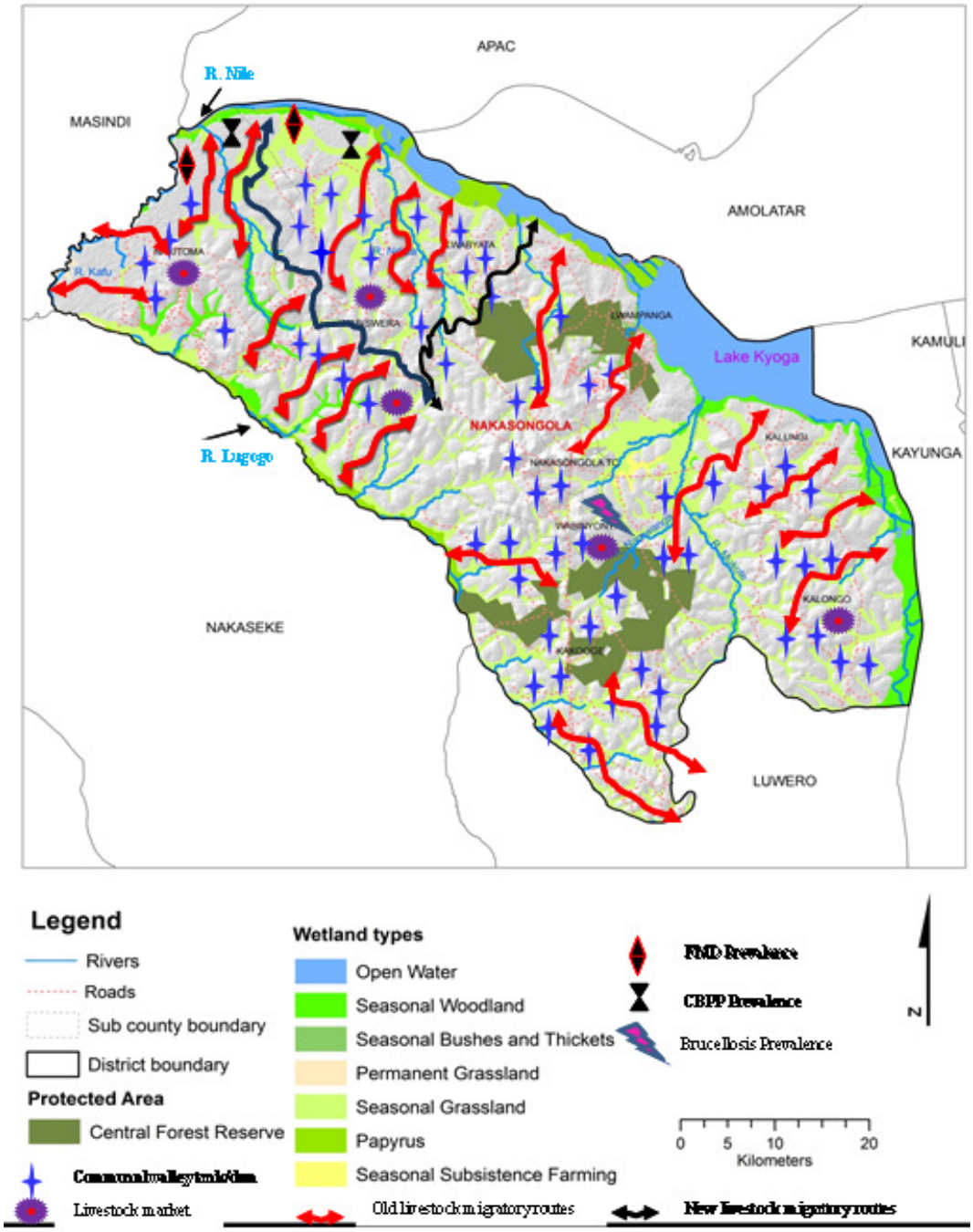

Figure 4. Migration routes, markets and water resources in Nakasongola District in Uganda.

was observed to increase at high rates. The role of human activities in the quest for food production, economic and social gains has been responsible for the observed spatial changes. Some of the changes observed are derived from non-supportive policies that encouraged investments and land use transformations that interfered with ecological and social dynamics of pastoralism. Multiple-uses of rangelands, droughts and climate change have interfered with the coping mechanisms of pastoral communities to changes (Galvin *et al*., 2004; Sidahmed, 2008).

Changes in bare ground and bushland. Human settlements contributed to changes in bare ground between 1986 and 2000 in Nakasongola District (Fig. 2). Information gathered indicates that the stable political environment after 1986 led to movement of people into Nakasongola. These were returnees who had left the area due to civil war as well as new persons seeking new opportunities in the district. The sub-division and re-distribution of ranches in 1994 led to overstocking in several places, hence, limiting regeneration of pastures. Degradation will occur when natural forage productivity is reduced severely by soil erosion due to overgrazing (Jarvis, 1984). Termite activity and charcoal burning exacerbated land degradation; creating bare patches between 2000 and 2013. There was evidence of intensified termite damage and charcoal burning around 1996 and 1998 leading to creation of large patches of bare land, with undesirable consequences to the livestock industry (Mugerwa *et al*., 2008).

Increased human population, demand for food and increased cultivation in Nakasongola were partly responsible for the decline in the area covered by bushland. Generally, bush is a transitional succession stage to woodlands. Reduced livestock populations during and after instability, before and after 1986, resulted in reduced grazing pressure on the land leading to increased infestation by bushes. With the ensurance of political stability, there was increased settlement, bush clearing for cultivation, settlement and grazing, leading to the decline in area covered by bush between 2000 and 2013.

The decrease in forest cover between 1986 and 2000 in Buliisa District may be attributed to clearing land for sugar cane for the nearby factory, tobacco growing, subsistence farming due to population growth and settlements (Mwavu and Witkowski, 2008). Improved management of Budongo Forest through afforestation, gazetting and monitoring eventually contributed to increases in forest cover.

Changes in grassland and woodland. The decline in area covered by grasslands in Buliisa and Nakasongola deprived livestock of a basic grazing resource. The decline was attributed to increasing cultivation, bush and woody encroachment. In Nakasongola, the increase in bare areas contributed to declining grasslands. Increased conversion of grasslands into crop farming was driven by the increasing human population and demand for food, especially by immigrants from high potential areas who carried with them their former land use practices. Expansion of cropping systems and increase in domestic grazing put unnatural stress on native grassland species, pushing grazing pressure up on remaining rangelands (Brown and Archer, 1999). Overgrazing, climate change and increased carbon dioxide emission are partly responsible for increases in woody species in grass dominated savannas (Archer *et al*., 1995; van Auken, 2000; Asner *et al*., 2004; Zziwa *et al*., 2012), a possible cause of increased woodland between 2000 and 2013.

Anthropogenic activities that included tree cutting, establishment of plantation forestry, grassland and charcoal production were major drivers of changes in woodland and forest (Mwavu and Witkowski, 2008). Increased woodlands affected cattle grazing through reduction of grazable pasture and in extreme cases limiting cattle movement during grazing. The encroachment on woody species in grassland ecosystem is a complex process attributed to ecological events, including changes in management practices, climate and atmospheric composition (Archer *et al*., 1995; van Auken, 2000; Asner *et al*., 2004), acting singly or in combination with other factors such as overgrazing, suppression of fires, increased

termite activity, episodic rainfall and drought events, grazing and browsing pressures.

Increase in small scale farming. There is a strong relationship between human activity and the intensity of livestock production. The increase in small scale farming in both districts resulted in reduced area available to livestock grazing. Increased human population, especially with immigrants from a cultivation background, individualisation of land attracting fencing and cultivation, sedentarisation of pastoralists and their need to diversify the income base all contributed to increased small scale farming. In Nakasongola, the sub-division of ranches into small farms/patches unviable for livestock grazing, contributed to the adoption of crop production as the most appropriate land use for the small land holdings. However, because of the limited potential of soils in this area to support crop growth and the practice of low input agriculture, farmers often opened up new areas in search of fertility, in the process encroaching on woodland, bushland, grassland and wetland.

Livestock migration and changes in water resources. Both Buliisa and Nakasongola districts are water deficient just as in other rangelands of Uganda. Generally, water is a major constraint in livestock production in pastoral systems in Uganda's cattle corridor. Livestock movement is driven by pasture and water scarcity, with the latter having a strong bearing in migration than pasture scarcity (Zziwa *et al.*, 2008). Increased water harvesting capacity in Nakasongola reduced the need for seasonal migration, compared to Buliisa where few livestock water resources existed. Communal land ownership and free movement in Buliisa was a disincentive to private ownership of water sources, hence, the dependence on the few communal water resources, rivers and lakes.

Episodic changes in the area covered by water and wetlands were attributed to low rainfall received, droughts and encroachment of wetlands by cultivators. Increased rainfall amounts result in increased wetlands due to inundation of nearby areas. Conversely, long dry spells result in a reduction of area under water and wetland coverage.

Disappearance of livestock migration routes in Nakasongola was due to the individualisation of land, subdivision of ranches and fencing of land, increased cultivation and blockage of livestock migration routes that encouraged construction of private water sources (Tables 4 and 5). New but long routes were being created in areas prone to degradation and droughts (Nabiswera and Nakitoma sub-counties), where migration was still practiced. Mobility has been the cornerstone of dryland livestock cattle keeping (Peters, 1994).

In Buliisa, most livestock migration routes still existed with new but longer routes observed in Ngwedo and Kigwera sub-counties where crop cultivation was practiced. Land was communally owned with free movement of animals in search of water and pastures. In cultivated areas, conflicts were common between crop and livestock farmers during migration.

Changes in livestock markets and prevalence of livestock diseases. The high number of livestock markets in Nakasongola may be attributed to relatively larger number of animals (Table 3) and settled herders. Presence of many animals in an area attracts creation of markets to easily satisfy the animal requirements of traders. Being sedentary also meant a predictable supply of animals for the market. On the other hand, in Buliisa, there were few markets because cattle were concentrated in a small area easily accessed by traders. The availability of more livestock and markets in Nakasongola had potential to attract more cattle traders with likelihood of offering better prices.

CONCLUSION

Land use and cover changes in the pastoral systems of Buliisa and Nakasongola Districts have negatively impacted livestock management under drought induced pasture. Blockage of migratory routes and decline in grazing lands have resulted into concentration of animals in specific areas leading to overgrazing and bare areas, long migration routes and increased prevalence of contagious diseases during migration. Construction of individual water resources (ponds and valley tanks), reduction in

livestock numbers and taking long migration routes are the adaptive and coping strategies used by pastoralists in response to drought amidst changes in land use. The resilience of pastoral systems to drought has reduced and their vulnerability to impacts of climate change increased. Given the current trends in land use and cover change, pastoral communities are advised to harness feed conservation technologies and use of crop residues as dry season feeding resources to avoid long migration routes, conflicts with cultivators and contagious diseases in migratory sites.

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REFERENCES

Archer, S., Schimel, D.S. and Holland, E.A. 1995. Mechanisms of shrubland expansion: Land use, climate or Carbon dioxide. *Climate Change* 29: 91-99.

Asner, G.P., Elmore, A.J.and Olander, L.P. 2004. Grazing systems, ecosystem responses and global change. *Annual Review, Environmental Resources* 29:261-299

Brown, J.H. and Archer, S. 1999. Shrub invasion of grassland: Recruitment is continuous and not regulated by herbaceous biomass or density. *Ecology* 80:2385-2396.

Galvin, P., Hill, C. and Jones, G. 2004. Strategic Management: An Integrated Approach, Textbook, Wiley & Sons: Brisbane, Australia.

Harrop, J.F. 1960. Reconnaissance survey of soils of western Uganda. Department of Agriculture, Government of Uganda. Kawanda Research Memoirs.

Jarvis, L. 1984. Overgrazing and range degradation. The need for and scope of Government policies to control livestock numbers. Paper presented at a conference on livestock policy issues in Africa. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

King, M. and Allan, M. 2002. Joint donor agencies study on the performance and growth prospects for strategic exports in Uganda. Annex to case study on livestock and livestock products. Kampala: Delegation of the European Commission, Uganda.

Kisamba-Mugerwa, W. 1995. The impact of individualization on common grazing land resources in Uganda. Ph.D Thesis, Makerere University, Kampala, Uganda.

Langdale-Brown, I., Osmaston, H.A. and Wilson, J.G. 1964. The vegetation of Uganda and its bearing on land-use. CABI Direct. pp. 147.

Lu, D. and Weng, Q. 2007. A survey of image classification methods and techniques for improving classification performance. *International Journal of Remote Sensing* 28(5): 823-870.

Mugerwa, S., Mpairwe, D., Sabiiti, E. N., Mutetika, D., Kiwuwa, G., Zziwa, E. and Peden, D. 2008. Effect of cattle manure and reseeding on pasture productivity. Proceeding of second International Forum on Water and Food. 10th – 16th November 2008, Addis Ababa, Ethiopia. Volume II – IFWF2 Science Session papers. pp. 65 - 68.

Mwavu, E.N. and Witkowski, E.T.F. 2008. Land-use and cover changes (1988-2002) around Budongo forest reserve, N.W. Uganda: Implications for forest and woodland sustainability. *Journal of Land Degradation and Development* 9: 606-622.

National Biomass Study, 2003. Uganda Government Technical Report. ISBN: 9970 863 00 2

Peters, P. 1994. Dividing the commons: Politics, policy and culture in Botswana. University of Virginia. Virginia, USA.

Radwanski, S.A. 1960. The soils and land use of Buganda. A reconnaissance survey. In the Memoirs of the research division, series 1 – Soils, Number 4. 631.44 (676.1) UGA. pp. 1 - 133.

Sidahmed, A. 2008. Livestock and climate change: Coping and risk management strategies for a sustainable future. In: Livestock and Global Climate Change Conference Proceeding, May 2008, Tunisia.

van Auken, O.W. 2000. Shrub invasions of North American semiarid grasslands. *Annual*

Review of Ecology and Systematics 31:197-215.

Zziwa, E., Mpairwe, D., Kyambande, J., Iwadra, M., Mutetika, D., Kiwuwa, G., Mugerwa, S. and

Peden, D. 2008. Effects of upper catchments management and water cover plants on the quality and quantity of water in surface reservoir. Proceedings of second International Forum on Water and Food. 10-16th November 2008, Addis Ababa, Ethiopia. Volume II – IFWF2 Science Session papers. pp. 71-74.

Zziwa, E., Kironchi, G., Gachene, C., Mugerwa, S. and Mpairwe, D. 2012. The dynamics of land use and land cover change in Nakasongola district. *Journal of Biodiversity and Environmental Sciences* 2 (5): 61-73.