

Dynamics of land use and land cover change in semi-arid Karamoja sub-region, Uganda

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Abstract

There is limited information on the patterns of land use and land cover changes taking place in the semi-arid ecosystem of Karamoja, a key livestock producing sub-region of Uganda. Thus, this study was designed to determine the pattern and rate of land use and land cover changes in Karamoja sub-region. The study was retrospective using Landsat imagery for 1986, 2000 and 2013. Imagery was obtained from the Global Observatory for Ecosystem Service and analysed using unsupervised classification in ERDAS IMAGINE 9.1 and ArcGIS 10.1. Satellite image overlays were conducted in order to determine the patterns of land use and land cover change. Results showed that grasslands remained the dominant land cover type, however, a declining trend from 75.8, 74.2 to 66% during 1986, 2000 and 2013 period, respectively, were observed. The decline in grasslands is orchestrated by an increase in bushland and croplands over the same period. Croplands increased ten-fold between 2000 and 2013 arising from increased promotional activities by government of Uganda and development actors in the sub-region. Land use and land cover change matrix revealed varied dynamics of change in different land use and land cover types. Between 1986 and 2013, 98.7% of woodlands converted to other land use/cover types. During the same period, 59.3% of grasslands converted to bushlands and 35.8% of croplands converted to thicket and shrublands. We have shown that bushland encroachment and cropland expansion present a real challenge to the continued existence of key grazing land covers in the rangelands of Karamoja.

Key words: Bushland, croplands, encroachment, grasslands

Résumé

Il existe peu d'informations sur les modes d'utilisation des terres et la couverture des changements terrestres qui ont lieu dans l'écosystème semi-aride de Karamoja, une sous région clé dans la production de bétail. Ainsi, cette étude visait à déterminer le motif et le taux d'utilisation des terres et les changements de la couverture terrestre de la sous-région de Karamoja. L'étude a rétrospectivement utilise des images Landsat de 1986, 2000 et 2013. Ces images ont été obtenues à partir de l'Observatoire Mondial pour les Services des

Ecosystèmes et ont été analysées en utilisant la classification non supervisée dans ERDAS IMAGINE 9.1 et ArcGIS 10.1. La superposition d'images de satellite a été menée afin de déterminer les modes d'utilisation des terres et les changements de la couverture terrestre. Les résultats ont montré que les prairies sont restées le type dominant de la couverture terrestre, cependant, une tendance à la baisse de 75,8, de 74,2 à 66% durant la période 1986, 2000 et 2013, respectivement, ont été observées. La baisse dans les prairies est orchestrée par une augmentation dans la brousse et les terres cultivées sur la même période. Les terres cultivées ont augmenté de dix fois entre 2000 et 2013 en provenant des activités accrues de la promotion du gouvernement de l'Ouganda et les acteurs du développement dans la sous-région. L'utilisation des terres et de la terre matrice de changement de la couverture de la terre ont révélé les dynamiques variées de changement dans l'utilisation des différentes terres et les types d'occupation du sol. Entre 1986 et 2013, 98,7% les régions boisées ont été converties en d'autres utilisations des terres /types de couverture. Durant la même période, 59,3% des prairies ont été converties en brousse et 35,8% des terres cultivées converties en taillis et arbustives. Nous avons montré que l'empiètement de la brousse et l'expansion des terres cultivées présentent un véritable défi pour le maintien de la clé de la terre qui couvre les pâturages dans les terres forestières de la région de Karamoja.

Mots clés: de brousse, les cultures, les empiètements, les prairies

Introduction

A growing concern among scientists (e.g. Lambin *et al.*, 2003; Oba, 2012; Nelson, 2012) focused on pastoral regions is how the current trends in land use and land cover are affecting the grazing resource base. These shifts in land use are largely externally driven and have set in motion a myriad of other challenges including restricted mobility of pastoral herds, reductions in grazing lands and increased conflicts, especially those between farming and pastoral communities (Campbell *et al.*, 2003; Nelson 2012; Oba 2012). In Uganda, livestock keepers in Kaliro district have experienced shortage in forage (Tabuti and Lye, 2009) due to conversion of communal grazing lands for agriculture. Such processes exacerbate the vulnerability of pastoral groups to the vagaries of nature leading to reduced livestock productivity (Nyariki *et al.*, 2009; Nelson, 2012). However, there is a dearth of information on the patterns of land use and land cover changes taking place in the semi-arid ecosystem of Karamoja, a key livestock producing sub-region of Uganda. Thus, this study was designed to determine the pattern and rate of land use and land cover changes in Karamoja sub-region.

Materials and methods

Study area. This land and land cover change analysis was conducted over Karamoja sub-region located in northeastern Uganda. Karamoja is a semi-arid region characterised by variable, unpredictable, and often sparse rainfall (Quam, 1999). It is principally a savannah ecosystem punctuated by woodlands and thickets and shrublands dominated by indigenous tropical C4 grasses; that are grazed by pastoralists' herds.

Satellite data and image processing. The study utilised a 27 years' time-series multi-spectral and multi-temporal Landsat TM and ETM+ satellite imagery. The images obtained were generally cloud-free (less than 10% cloud cover) with a 30m resolution. Four scenes covering the sub-region were mosaiced in ERDAS IMAGINE 9.1 and later analysed in ArcGIS 10.1. Imagery was interpreted and classified using unsupervised classification. A hand held Global Positioning System (GPS) was used to record a total of 465 ground truthing points that were used to aid image classification and validation. In order to test the classification accuracy, we computed a confusion matrix/error matrix.

Data analysis. In determining both the rate of land use and land cover and change matrix, the study adopted Peng *et al.*'s (2008) computation and analysis approach.

Results

Pattern of land use/cover change in Karamoja (1986-2013). During the last twenty seven years, there have been significant changes in land use/cover of the grazing lands of Karamoja sub-region (Figs. 1a, 1b and 1c). The trend patterns are presented in Table 1. Results show that in 1986, grasslands (75%) dominated the region. Croplands only covered 0.3% of the land area. By 2000, bushlands had increased by 2.2 to 15%. Similarly, thickets and shrublands experienced a fivefold increase. On the other hand, grasslands experienced

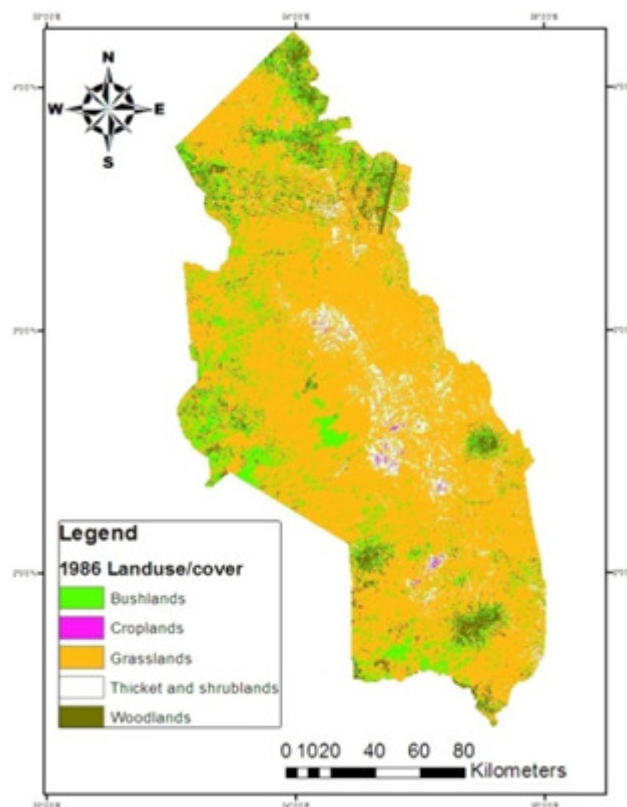


Figure 1a. Land use/land cover 1986.

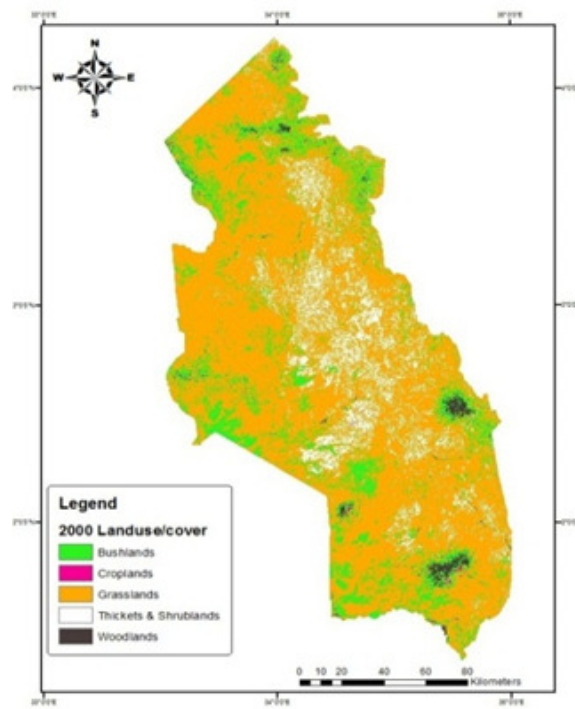


Figure 1b. Land use/land cover 2000.

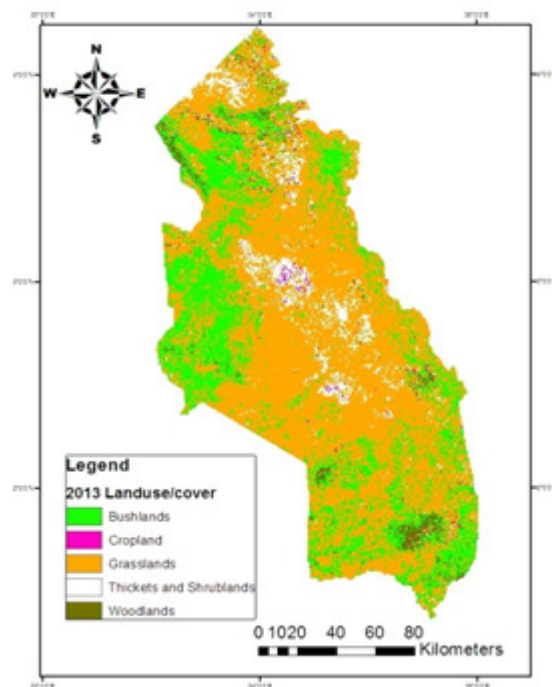


Figure 1c. Land use/land cover 2013.

a decline by 1.6 to 74.2% of the land area. This pattern was also observed in the woodlands and croplands. Woodlands coverage in 2000 decreased by 5.3% while croplands decreased by 0.24% of 1986 level. The period between 2000 and 2013 also recorded continued increase in the cover of bushland vegetation to 25% which represents a 10% increase in cover between 1986 and 2013. On the other hand, grasslands continued to experience a decline, falling to 66.0% which represents an 8.2% decrease. The confusion/error matrix results showed an overall land cover change classification accuracy of 82.6% (producer's accuracy) and 75.3% user's accuracy.

Land use/cover change matrix 1986-2013. Tables 2, 3 and 4 present the process of land use/cover change within the land covers in Karamoja sub-region from 1986 to 2013. Three change phases are presented, the first from 1986-2000, the second from 2000-2013 and the third from 1986-2013. Results in Table 2 (1986-2000) reveal that much of the woodlands changed to grasslands. Bushland to croplands experienced a marginal change. It was also observed that 36% of the grasslands converted to bushlands during the same period. Meanwhile, about half of the thickets and shrublands converted to grasslands and

Table 1. Land use/cover change in Karamoja sub-region.

Land use/cover types	1986		2000		2013	
	Area (ha)	% area	Area (ha)	% area	Area (ha)	% area
Bushlands	352948.3	12.8	415175.9	15	689614	25
Cropland	7520.7	0.3	1695.5	0.06	15686.4	0.6
Grasslands	2093308	75.8	2047648	74.2	1820489	66
Thickets and shrublands	123996.2	4.5	259863.8	9.4	159841.5	5.8
Woodlands	182576.8	6.6	35971.1	1.3	74730.8	2.7
Total	2760350	100		100		100

Table 2. Land use/cover change matrix (1986-2000).

Land use/cover types in 1986	Land use/cover types in 2000					
	Wood-lands	Bush-lands	Grass lands	Thickets and shrublands	Croplands	Total
Woodlands	0.2	11.9	78.5	9.4	0	100
Bushlands	2	30.2	66.2	1.5	0.1	100
Grasslands	14	36	48.1	1.5	0.4	100
Thickets and shrublands	0.1	3.4	52.6	43.7	0.2	100
Cropland	0	1.7	44	51.7	2.5	100

Note: The figures marked in bold indicate the unchanged percent area during the period.

Table 3. Land use/cover change matrix (2000-2013).

Land use/cover types in 2000	Land use/cover types in 2013					
	Wood-lands	Bush-lands	Grass lands	Thickets and shrublands	Croplands	Total
Woodlands	46.6	39.5	11.3	1.6	1.1	100
Bushlands	6.6	60.1	31.1	1.7	0.5	100
Grasslands	1.4	47.5	45.9	4.8	0.4	100
Thickets and shrublands	0.5	9.6	66.7	21.4	1.8	100
Cropland	1.3	43.6	15.9	29.3	9.9	100

Table 4. Land use/cover change matrix (1986-2013).

Land use/cover types in 1986	Land use/cover types in 2013					
	Wood-lands	Bush-lands	Grass lands	Thickets and shrublands	Croplands	Total
Woodlands	1.3	44.1	49.1	5.3	0.3	100
Bushlands	5.3	60.6	31.4	2.1	0.6	100
Grasslands	16.1	59.3	21.1	2.4	1	100
Thickets and shrublands	0.3	12.6	53.2	30.3	3.6	100
Cropland	0.1	7.2	42.9	35.8	14	100

about half of cropland converted to thicket and shrubland. There was no transformation of croplands to woodlands during this period.

Table 3 presents the land use/cover change patterns for 2000-2013. During this period, a considerable proportion of woodlands (46.6%) remained unchanged. This could be attributed to the fact that most of the woodlands that are now in existence occur in the highlands and are, thus; relatively inaccessible to the local communities. However, most of the woodlands were converted to bushlands (39.5%). In the same period, 31.1% of the bushlands were converted to grasslands compared to 47.5% of the grasslands that converted to bushlands. This relatively greater increase of bushlands in grassland areas could be attributed to reduced grazing patterns in some locations.

Table 4 portrays the change in land use/cover between land cover units from 1986-2013. With only 1.3% of the woodlands remaining unchanged, the data show that over the last 27 years, 98.7% of the woodlands have undergone conversion to one or more land cover type. Thus, woodlands converted to bushlands, grasslands, thickets and shrublands and croplands, respectively (Table 4). This could be attributed to vegetation clearance for charcoal production

that is rapidly increasing in the sub-region. Grassland land cover experienced the greatest conversion to bushlands by almost six fold and woodlands by about two fold.

Discussion

Over the last 27 years, it is apparent that land use and land cover within the different land covers of Karamoja have been changing. The changes have been non-uniform in the three time steps (1986-2000; 2000-2013 and 1986-2013) observed in the sub-region. Notable in the process of change is the considerable disappearance of woodlands, the rapid rise in croplands between 2000 and 2013 and the increase in woody vegetation associated with bushlands in the sub-region. Although the woodlands appear to be recovering in 2013, they are nonetheless lower than the 1986 period and perhaps even the earlier periods. Majaliwa *et al.* (2009) indicated that over the last 30 years, deforestation has been rapid in the region. The land use/cover change matrices show a rapid increase in croplands in Karamoja sub-region. Other studies (e.g. Ekaya, 2005; Zziwa *et al.*, 2012; Tsegay, 2010) have shown increased crop cultivation in tropical semi-arid and pastoral areas in East Africa. Zziwa *et al.* (2012) observed an increase in croplands in Nakasongola, Uganda while Tsegay (2010) observed a similar trend in the Afar region of Ethiopia. In Karamoja, the increase in subsistence croplands can be explained by direct support for crop cultivation through provision of seeds and farm implements by the Government of Uganda and development actors operating in the region. It has been observed that bushland encroachment is progressively increasing in the sub-region leading to reductions in grassland land cover, a key grazing landscape. Bushland encroachment has been observed as a growing challenge in other semi-arid areas of Afar region of Ethiopia (Tsegay, 2010), and in Nakasongola (Zziwa *et al.*, 2012) and the Kagera basin (Tolo *et al.*, 2012) in Uganda. The reduction of fire use as a traditional management strategy and the absence of grazing have generally influenced increase in bushland encroachment (Gemedo, 2004; Oba *et al.*, 2000).

Conclusion

This study has shown that grasslands in Karamoja, the key grazing land cover types are under threat from bushland encroachment. The growth in croplands over the last thirteen years is unprecedented; it is, therefore, imperative that while supporting extensification and increase in crop cultivation, efforts are geared towards integrated livestock-crop production systems in the sub-region. Additionally, considerable efforts should be directed towards the control of woody expansion in the sub-region.

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