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Research Application Summary

Land use/cover change in Aswa III sub-catchment, Northern Uganda

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Abstract

In post-conflict northern Uganda accelerated land use and land cover changes are observable but hardly quantified. This study used remote sensing technology to analyze land use/cover changes in Aswa III sub-catchment of Aswa catchment in northern Uganda over a period of thirteen years' time series (2006-2018), specifically for the years 2006 and 2018. Arc Map 10.1 software was used to analyze, model and map the land cover changes. Landsat imagery of 30 meter resolution were acquired from http://earthexplorer.usgs.gov/ and utilized with the application of unsupervised classification approach. Results showed that Grassland remained the dominant vegetation and that woodland decreased by ten folds, while small scale farming increased by six fold over the same period. This study has shown that subsistence cultivation is the major cause of land cover change in the sub-catchment arising from extensive production approach adopted by small scale farmers. It is recommended that agricultural intensification is adopted as a mechanism to reduce horizontal expansion of cultivated land that undermines tree cover. Further, a study on the effect of these changes on sub-catchment erosion and hydrology is recommended.

Key words: Agriculture, erosion, hydrology, intensification, transitions, Uganda

Résumé

Dans la région post-conflictuelle du Nord de l'Ouganda, l'utilisation accélérée des terres et les changements de la couverture terrestre sont observables mais à peine quantifiés. Cette étude a utilisé la technologie de télédétection pour analyser les changements d'utilisation des terres et de la couverture terrestre dans le sous-bassin versant Aswa III dans le nord de l'Ouganda sur une période de treize ans (2006-2018), spécifiquement pour les années 2006 à 2018. Le logiciel Arc Map 10.1 a été utilisé pour analyser, modéliser et cartographier les changements de la couverture terrestre. Des images Landsat d'une résolution de 30 mètres ont été acquises sur http://earthexplorer.usgs.gov/ et utilisées avec l'application d'une approche de classification non supervisée. Les résultats ont montré que les prairies demeurent une végétation dominante et que les boisés avaient diminué de dix fois, tandis que l'agriculture à petite échelle avait augmenté de six fois au cours de la même période. Les résultats ont montré que les prairies restaient la végétation dominante et que les boisés avaient diminué de dix fois, tandis que l'agriculture à petite échelle avait augmenté de six fois au cours de la même période. Cette étude a montré que la culture de subsistance est la cause majeure du changement de la couverture terrestre dans le sous-bassin versant résultant de l'approche de production extensive adoptée par les agriculteurs à petite échelle. Il est recommandé que l'intensification agricole soit adoptée comme mécanisme pour réduire l'expansion horizontale des terres cultivées qui mine le couvert arboré. De plus, une étude de l'effet de ces changements sur l'érosion et l'hydrologie du sous-bassin versant est recommandée.

Mots clés: Agriculture, érosion, hydrologie, intensification, transitions, Ouganda

Introduction

Globally, land use and land cover changes have been dramatic in the last two to three decades (Mugisha, 2002). This has been more pronounced in sub-Saharan Africa where agricultural production has been primarily driven by horizontal increase in cultivated areas (Ryan *et al.,* 2017). Uganda's annual population growth stands at 3.3% which is the second highest in Africa, only after Niger (Karamage *et al.,* 2017). With 80% of Uganda's population being farmers and 80% of the land being used for agriculture, the pressure on land and natural resources is high (Karamage *et al.,* 2017). As result, opening of new land to meet the growing food demand as well as commercialization of agriculture has become apparent. These patterns are further projected to continue as Uganda's population is expected to double by 2050.

The observed land use and cover changes in Uganda are having negative consequences on ecosystem function. For example, Karamage *et al.* (2017) indicated that in the last 23 years, Uganda has lost close to 17.56% of its land cover to degradation arising from dramatic land use and cover changes. It is such patterns that necessitate the estimation of the pattern and extent of new land use and cover changes (Nyeko, 2012). This is particularly important because land use and cover change is a local issue with a global importance (Foley *et al.,* 2005 in Peng *et al.,* 2008). As such, change detection is the baseline for environmental research for both present and future land management. According to Yuan *et al.* (2005), remote sensing data provide cheap and timely information about temporal distribution of land cover and make it possible for long term analysis and change detection. This has particularly been made possible through a series of satellite imagery such as Landsat, MODIS among others that support assessments at local to regional scale (Avitabile *et al.,* 2012; Sinya *et al.,* 2012).

In post-conflict northern Uganda, unprecedented changes in land cover and land use have been observed by Nyeko *et al.* (2014). These changes are particularly occurring in Aswa catchment, which is one of the most important catchments in the Upper Nile Water Management Zone (UNWMZ). According to Owona (2008), the Aswa catchment faces the challenges of vegetation degradation, unregulated charcoal production and wetland degradation, with over 90% of the population depending on land for their livelihoods. While this seems apparently clearer in the broader catchment level, the sub-catchment desegregation information relating to land cover changes is limited yet land cover change is a local issue with global effect dynamics. This study therefore analyzed land use/cover change in Aswa III sub-catchment – to inform sustainable watershed management.

Materials and Methods

Description of the study area. The Aswa iii sub catchment (Fig. 1) comprises six districts of Lamwo, Kitgum, Gulu, Omoro, Amuru and Pader, and covers approximately 2715.45 square kilometers. It is located between 3 40–3 53^0 N and 32 42^0–33^0 04 E. The altitude of the area ranges from 1100 to 2700 m A.S.L. The forests and woodlands mainly provide the local community with trees for building poles, honey, bush meat and medicinal plants. Northern Uganda experienced civil war between 1986 and 2006, which led to the establishment of internally displaced people's (IDP) camps in the region. The concentration of people in and around IDP camps created pressure on land resources, leading to negative ecological impacts, especially on forests, woodlands, wetlands and other fragile ecosystems.

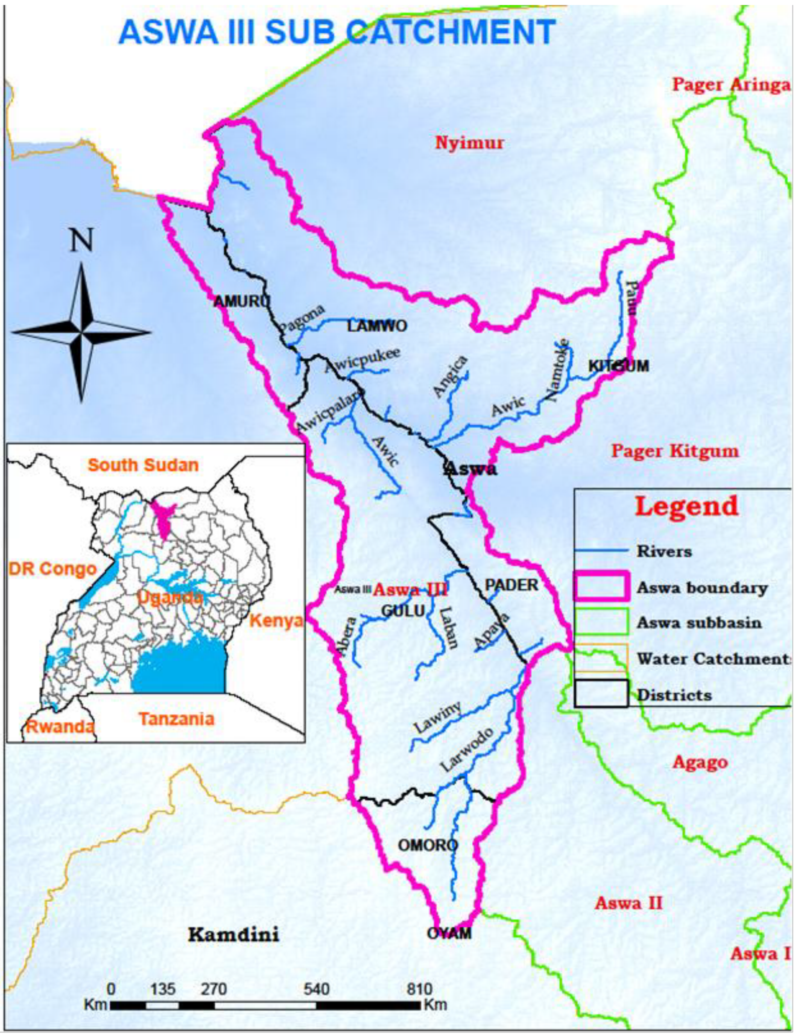

Figure 1. Map of the study area

Analysis of land use / cover changes. Satellite imageries were analyzed to determine land cover changes between 2006 (immediately after the civil war and closure of the IDP camps) and 2018, 13 years after the civil war. Arc Map 10.x software was used to analyze, model and map the land cover changes (Peng *et al.,* 2008). Landsat imagery of 30 meter resolution, because of their high resolution and availability, were acquired from http://earthexplorer.usgs.gov/ with path and rows for the study area as P 172 and R 58. For the year 2018, Bands 4, 3 and 2 were used, while 3, 2, and 1 were used for 2006 images.

Pre-processing, processing and classification of images. Some land cover change images were often marred by cloud contamination, and were therefore corrected by using an algorithm for masking clouds and its shadow as explained in (Huang *et al.,* 2010) or by replacing them with cloud free images. The Landsat TM/ETM+ images were interfaced to a common reference system (UTM WGS84, zone 36N). The resampled images (30m) were later atmospherically corrected using empirically image based Dark Object Subtraction (DOS) procedure to minimize the impact of atmosphere on the sensor. The images were classified using unsupervised classification algorithms in Arc-Map software version 10.1. The delineated classes of land use/cover in and around are; Grassland, Wetlands, Built-up areas, Woodland, and small scale farming.

Results

Land use/cover change during the period 2006 to 2018. During the thirteen years under study, very dramatic changes occurred in the land cover/land use in Aswa III sub catchment. The most notable changes occurred in the woodlands in the north western and middle part of the study area, where there was a tenfold decrease of woodland from 26.98% in 2006 to a mere 2.6% of the study area in 2018. The second notable change was the six fold increase in small scale farming from a mere 7.11% in 2006 to 44.87%. There was a marginal (less than 19%) decrease in wetland and grassland areas, as well as a marginal increase in built up areas. Overall, grassland remained the dominant vegetation type during the thirteen years, while small scale farming increased to be the second dominant by 2018. It is worth noting that in 2006, built up areas (settlements) were concentrated within specific places, and concomitantly, small scale farming followed the same trend. However, all these changed in 2018, where the two land uses were haphazardly distributed in the entire study area.

Discussion

It is clear from this study that land use/land cover has been changing at an increasing rate, from woodland to farmland. Most of the woodlands have been replaced by farmlands as reported in similar studies by Egeru *et al.* (2014) in north eastern Uganda where disappearance of woodlands and increase in small scale farming was observed. As observed by Nyeko (2012), the restoration of peace in 2006 led to a number of environmental challenges like deforestation, as crops seemed to have replaced woody savannah in the area. Owona (2008) observed that displacement of human beings accelerates environmental degradation through intensive use of land, resulting into loss of tree cover. Nampindo *et al.* (2005) also made a similar observation of an increase of woody biomass by about 20-39% in northern Uganda. Prior to 2006 (Fig.2) small scale farming was also observed to be taking place around IDP camps, confirming the observation by Owona (2008) that cultivation during the war was restricted to only about seven kilometers of IDP camps, where armed protection was provided by the Uganda People's Defense Forces (UPDF). Owona (2008) observed that the vegetation would recover as there was limited human activity owing to the curfews. However, when peace prevailed, there was increased indiscriminate cutting of trees for agriculture, settlement and charcoal (Fig.3). The horizontal increase in small scale farming could be attributed to the deliberate efforts by the Government of Uganda to support small scale farmers through various interventions like the National Agricultural Advisory Services (NAADS), Plan for Modernization of Agriculture (PMA) and Northern Uganda Social Action Fund (NUSAF) which were aimed at boosting agriculture through provision of inputs like improved seeds and seedlings, hoes, tractors and ox ploughs, among others.

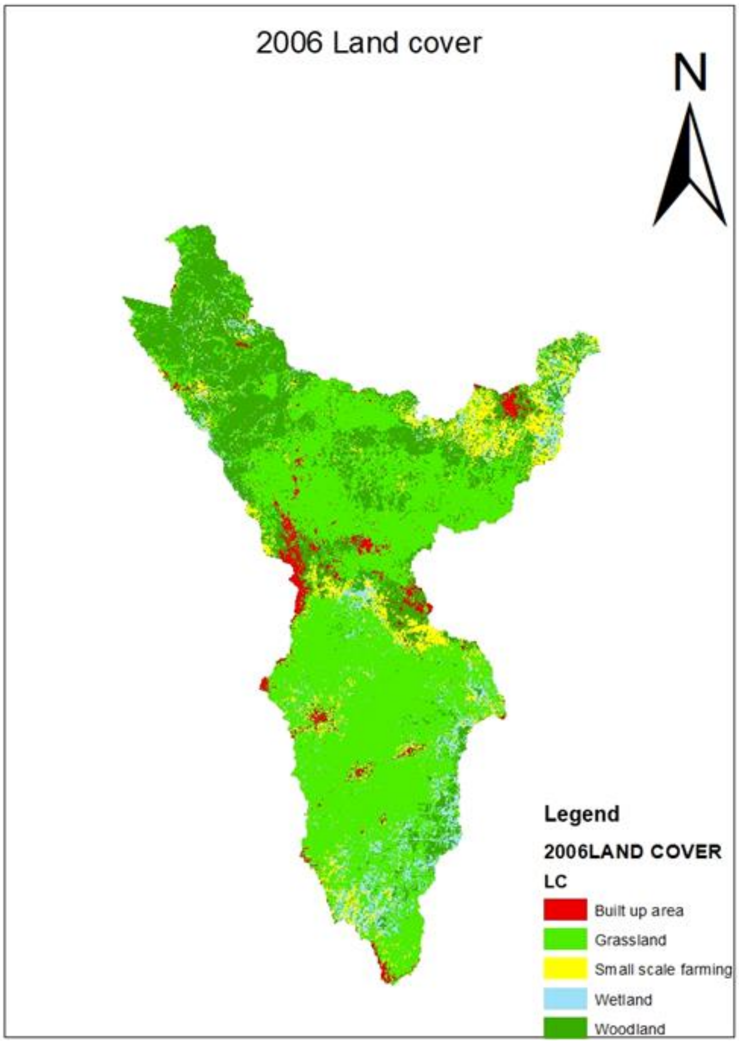

Figure 2. Land use/over 2006

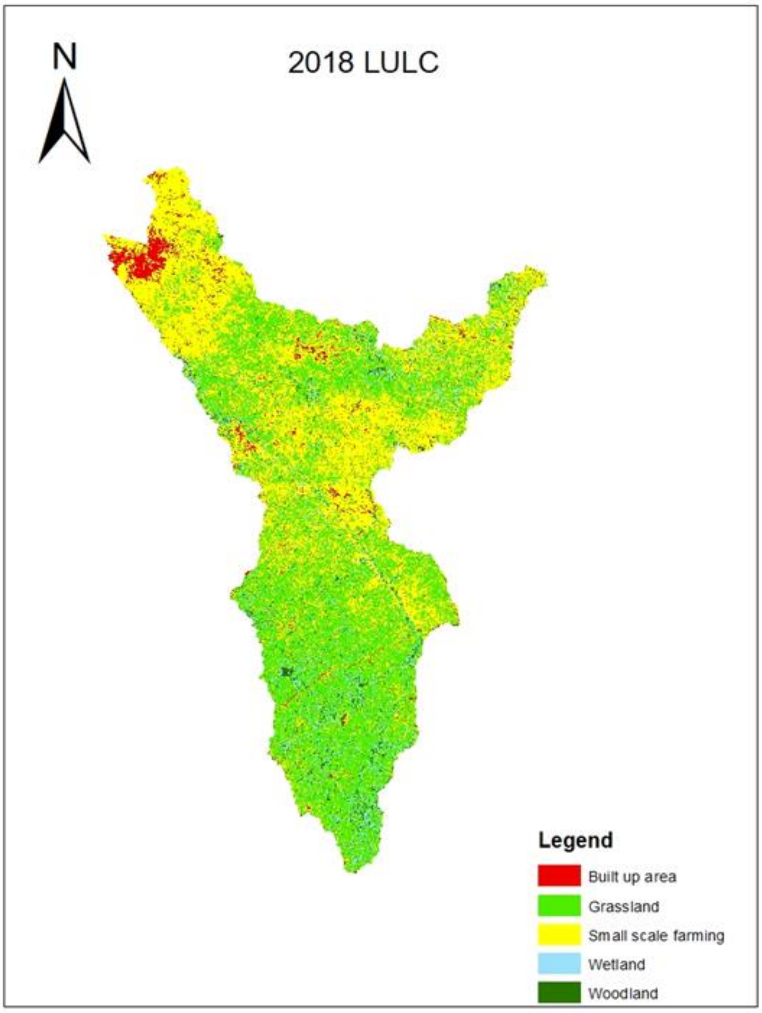

Figure 3. Land use land cover 2018

Table 1. Land use / Land cover change in Aswa III sub catchment

Land use/Cover	2006 Area (km)^2	2006 % area	2018 Area (km)^2	2018 % area	2018-2006 Change (km)	Rate of change
Built up area	80.63	2.97	103.42	3.81	22.79	1.28
Grassland	1,531.88	56.41	1247.10	45.93	-284.78	1.23
Small scale farming	193.03	7.11	1136.91	41.87	943.88	5.9
Wetland	177.19	6.53	157.42	5.80	-19.77	1.12
Woodland	732.73	26.98	70.62	2.60	-662.11	10.4
Total	**2715.46**	**100.00**	**271.46**	**100**		

Conclusions

This study has shown an expansion in smallholder farming in the sub catchment, which is happening at the expense of the grassland, woodlands and wetlands that are experiencing an overall decline (Table 1). In addition, built up areas are increasing in the sub catchment under study. This study recommends agricultural intensification in the catchment to increase agricultural production and at the same time contribute to the reduction of horizontal expansion of smallholder farms that are currently responsible for the land use and land cover changes in the catchment.

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