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Land use/cover change and perceived watershed status in Eastern Uganda

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This study assessed the current status of Awoja in Ngora district of Eastern Uganda. Remote sensing, household survey, In Pac S methodology and focus group discussions were used to acquire data from April to July, 2015. Landsat satellite imageries from 2007 and 2013 were acquired by USGS Earth Explorer to quantify land use/cover changes. Five land use/cover types were identified namely; (1) open water (2) wetland (3) tree cover (4) agriculture and (5) built up area. The findings indicate a fivefold increase in built up area by 154.27Km^2 and open water changed by 8.7 Km^2 and a reduction in wetland area by -1.0Km^2 tree cover by -48.07Km^2 and agriculture area by -11.4.0Km^2. The survey results indicated deforestation, wetland encroachment, poor attitude and over population as the main reasons for degradation. In Pac S methodology findings showed convergence in the perceived indicator of degraded watershed in terms of water and soil quality; vegetation type and species diversity among the lay people and technocrats. The focus group discussion findings indicated a negative trend in land use/cover change. There is need for a concerted effort to design an appropriate restoration strategy for Awoja.

Key words: Land use/cover, remote sensing, GIS and other methods.

INTRODUCTION

Whereas watersheds are recognised for their contribution to livelihoods, the main cause of degradation has been alternate human activities resulting into land cover change (Hari et al., 2015). A watershed is an area of land draining into a common body of water and is comprised of soil, trees, vegetation and water along with the people and animals that are the integral part of the system (Wani, 2008; Townsend et al., 2011). Land use/cover change is often used as a precautionary indicator of watershed status (Garroway et al., 2012; Filgueira et al., 2016). Watershed status refers to the position of affairs at a particular time, especially in terms of vegetation, water, soil and biota (Steven et al., 2012). Land use change is increasingly becoming a centre of debate in the current global change phenomena directly related to livelihoods (Víctor et al., 2013). This high rate of land use/cover

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change is escalating globally (Palmer, 2009; Townsend et al., 2011; Krumhansl et al., 2015). Additionally, population growth, increased conflict on resource use and limited alternatives are partly the reasons for this change (Turyahabwe et al., 2013; Qingqing, 2015; Junguo et al., 2016). The pressure on watershed resources has affected the original land use/cover. Land use/cover change is the intended employment of land management strategy placed on the land cover by human agents to exploit land cover and it reflects human activities like agriculture, mining among others (Zubair, 2006; Rawat et al., 2013; Bajocco et al., 2016). This change results into reduction in associated quality and availability of these resources (Tesfaye, 2011; Tsehaye, 2013). In India for instance, there has been an increase in land cover/use change specifically in built-up areas and sand bars by 88.8% (Rawat et al., 2013). On the other hand, in Egypt, land cover/use changes show significant decline in agricultural land among other land uses (Ibrahim and Mosben, 2015). Ideally, effective watershed management entails regulated off take of watershed resources to meet the socio-economic needs of the people without degradation and the interaction between water, biota and soil, stable in structure and functions (Qingqing, 2015). A healthy watershed must have clean air, water and biota for a well-balanced system that sustains many forms of life (Kevin et al., 2012).

In Uganda, land use/cover change is an environmental challenge (Mbogga et al., 2014; USGS, 2015). The rate of land use/cover change was estimated at 7% in 1990 and now stands at 11% with eastern Uganda registering the highest rate of 20% (UBOS, 2011; Mary et al., 2014). Awoja watershed in Kyoga Water Management Zone of eastern Uganda with an area of 10 km^2 is a key watershed degradation hotspot with a perceived degradation rate of 76% as compared to 63% from Lake Victoria crescent and 41% in the south western farmlands of Uganda (NEMA, 2008; Nelson et al., 2013). In the last two decades, several strategies including sensitisation, training, tree planting, establishing soil and water conservation structures were put forward by both the government and development partners to protect and restore the degraded watersheds (Ministry of Water and Environment, 2013; World Bank, 2013;). Most of these strategies were geared towards improving the livelihoods of the communities living in the watersheds. In eastern Uganda, two such projects were implemented between 2007 and 2013. The projects implemented were Farm Income Enhancement and Forest Conservation (FIEFOC) and the Community Based Wetland and Biodiversity (COBWEB). The FIEFOC Project provided assistance to private forest owners to plan for and manage their forests, especially those located in watersheds. This was through restoration planting (MWE, 2009). The COBWEB aimed at restoring biodiversity (Crested crane, shoebills) in Lake Bisina, Awoja watershed area. This was through restoration planting including training on tree nurseries establishment, establishment of alternative sources of income for the community through ecotourism, initiation of a Savings and Credit Cooperative Organisation (SACCO). All these were aimed at restraining the community from over exploiting the watershed.

Awoja watershed supports over 1,700,000 individuals that derive their livelihood from it, with a contribution of over USD 200 as earnings from papyrus harvesting and mat making per household annually (IUCN, 2005; Richard et al., 2009). In spite of this, the watershed continues to face increasing degradation, even with government and development partner efforts to restore it. Although, studies conducted within Awoja watershed indicate failure in restoration efforts due to high population growth and increased demand for watershed resources, little is known about the magnitude of this change in terms of land use/cover (Mutekanga et al., 2013; Mbogga et al., 2014). Unless the extent of degradation in Awoja is known then will government and development partners devise appropriate approaches for restoration. This paper addresses this gap and avails empirical evidence on the status of Awoja watershed in Ngora district in Uganda and shows the extent to which it has changed. The findings contribute to the achievement of the Sustainable Development Goal 15 and its agenda that addresses degradation by ascertaining land use/cover change of Awoja for appropriate restoration.

MATERIALS AND METHODS

Description of the study area

This study was conducted in Awoja watershed of eastern Uganda basing on its high degradation rate in the last two decades of 20%, as compared to the national average of 11% (MWE, 2013). Additionally, it had the highest perceived degradation rate of 76% as compared to 63% from Lake Victoria crescent and 41% in the south western farmlands of Uganda (Nelson et al., 2013). Specifically, Ngora district was selected because it occupies a greater part of Awoja watershed. It also piloted the two restoration intervention projects by the Farm Income Enhancement and Forest Conservation (FIEFOC) and the Community Based Wetland and Biodiversity (COBWEB).

Ngora district is found in North Eastern Uganda which lies approximately between latitude 1°10' North and 1°35' North and longitudes 33°30' East and 34°20' East as shown in Figure 1. Ngora is bordered by the districts of Kumi in the east, Serere to the West, Soroti in the North West, Katakwi in the North and Pallisa district to the South. It covers a total area of 715.9 km^2, with 177 and 331 km^2 (19%) as land and open water bodies, respectively. The main water bodies include Lake Bisina, Lake Nyaguo, Lake Meito and Lake Nyasala. Over 93% of the households are engaged in agriculture with a population density of 267.5 persons/km^2, higher than the national average of 174 persons/km^2 (UBOS, 2015).

The sub counties of Mukura and Kapir were chosen because they were the implementing sub counties, besides having the

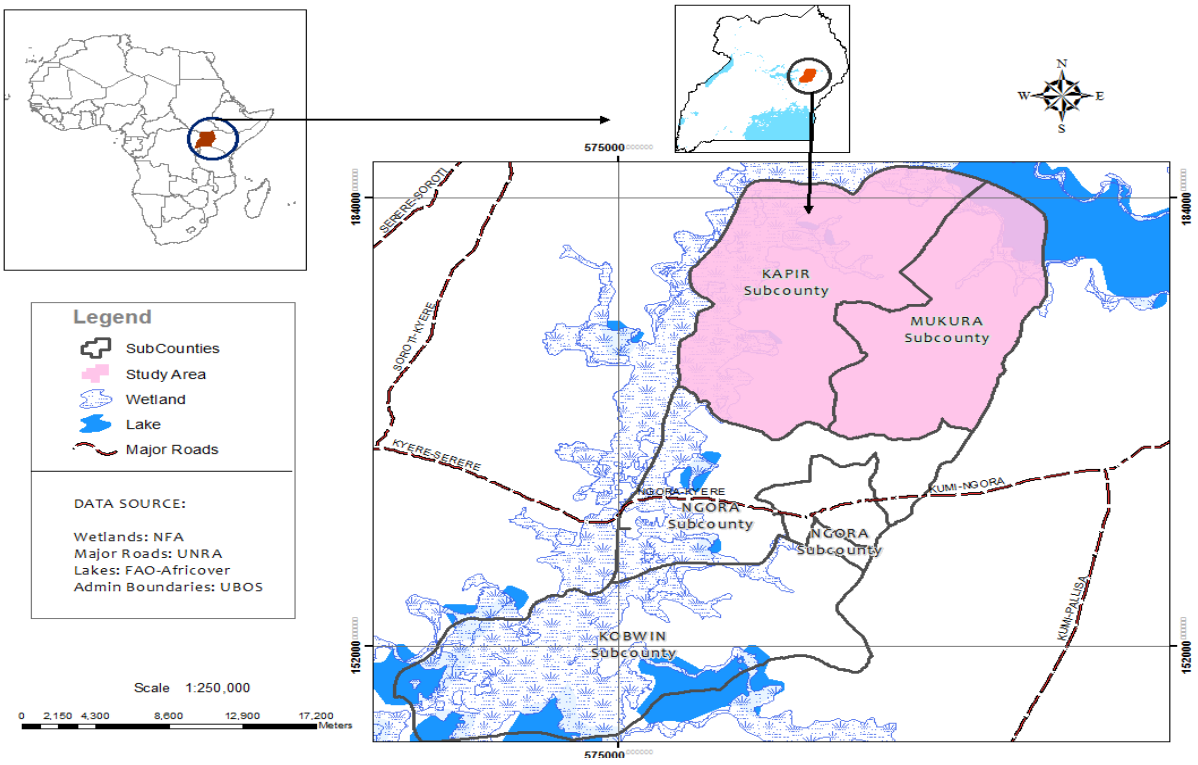

Figure 1. Map of the study area.

highest average household numbers of 5.3 and 5.2, respectively above the national average of 4.7 (UBOS, 2015). The parishes of Moru-Kakise and Mukura were chosen purposively because they were the implementing parishes for both COBWEB and FIEFOC interventions. The four villages of Kakor and Omitto in Omitto parish (Kapir) and Ariet and Puna of Moru- Kakise parish (Mukura) were chosen randomly out of the 8 implementing villages.

Data collection and analysis

Research design

This paper uses an ex post facto cross-sectional research design to acquire both quantitative and qualitative data used in the analysis. This research design best suits investigations where an intervention has taken place and data is collected at one point in time.

Quantification of watershed land use/cover changes

Remote sensing

Suitable processing of Land sat ETM Images covering the whole of Ngora district and part of Lake Kyoga (path 171, Row 59), of two time periods (May, 2007 and May, 2013) during the period of April – July 2015 was carried out. This was acquired from USGS Earth Explorer (Scaramuzza, 2011; USGS, 2015). The two time periods were considered before and after the two projects' implementation in order to establish the changes that may be attributed to these two projects. The change in land use/cover is shown in Figure 2. The down loaded images were processed and enhanced with ERDAS 2014 software to aid information extraction and analysis. Land cover change analysis, were performed on the processed images using ENVI 5.3 software (Rawat et al., 2013). The corrections made were meant to reduce inconsistencies in the satellite images which are inherent in the images because of differences in acquisition conditions including variation in sun zenith angles. Supervised classification method with maximum likelihood algorithm was performed to obtain land use/cover types. The classification was adopted from a similar study by Rawat et al. (2013). Five land use/cover types were identified and used in this study, namely; (1) Open Water (2) Wetland (3) Tree Cover (4) Agriculture and (5) Built up area. Post-classification detection method was employed to develop change detection matrix. Quantitative area data in square kilometers and their percentages, overall land use/cover change as well as gains and loss in each category between 2007 and 2013 were compiled as shown in Table 1.

Ground truthing using global positioning system (GPS)

The classified images were validated in a ground truthing exercise that involved the use of a GPS to collect geographic coordinates for each vegetation cover type. To improve the image classification accuracy, validation exercise was held.

Household survey

A household survey was carried out in the two restoration sites of

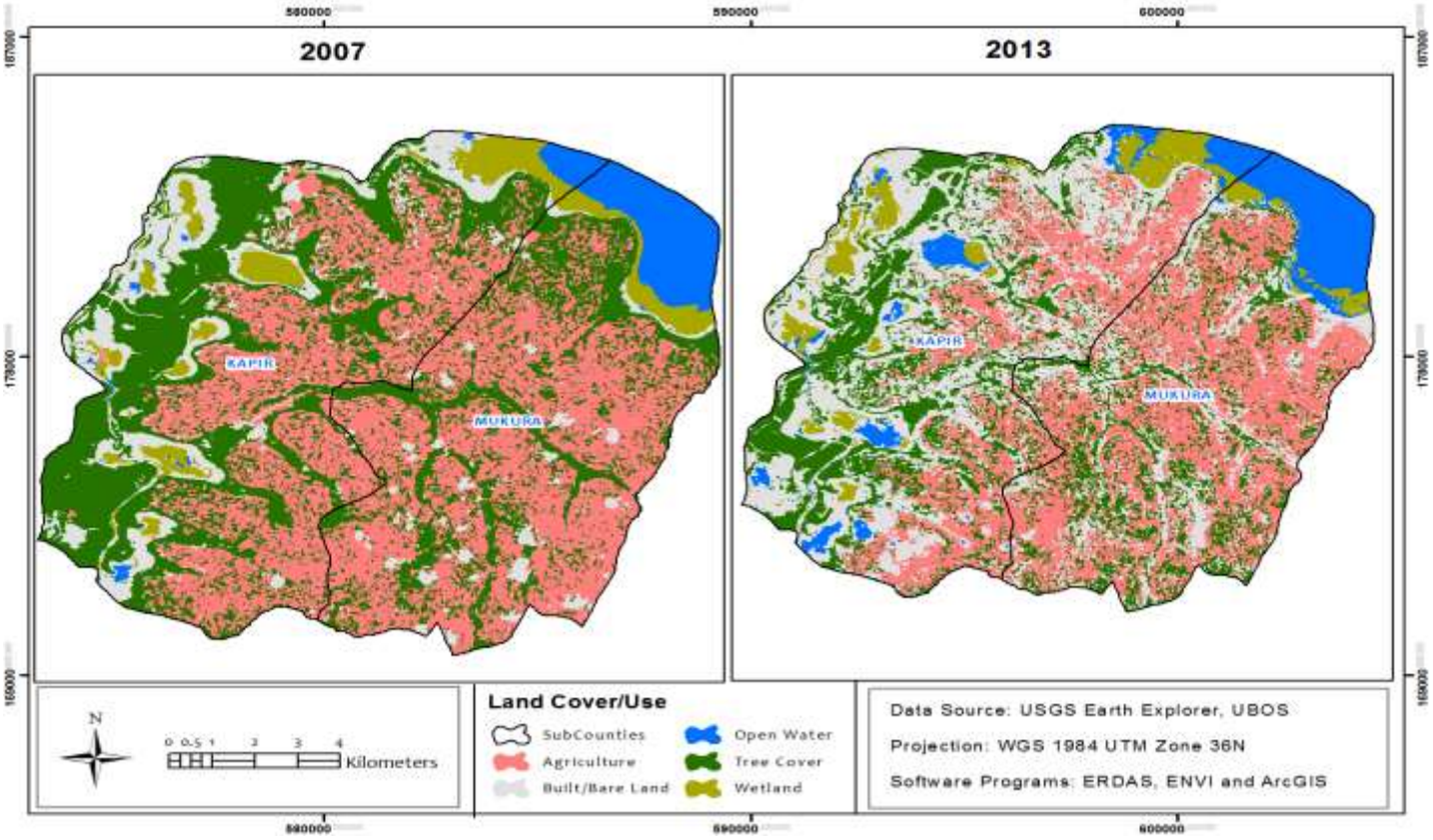

Figure 2. Land cover/use change from year 2007 to 2013.

Table 1. Area and percentage change in different land use/cover categories between the time periods of 2007-2013 in Awoja watershed.

Land use/cover categories	2007	2013	Change in land use/cover categories (2007-2013)	
	Area (km^2)	Area (km^2)	Area (km^2)	Change (%)
Open water	15.73	24.43	8.70	55.33
Wetland	16.24	15.24	-1.0	-5.1
Tree cover	139.63	91.56	-48.07	-34.46
Agriculture	223.35	109.35	-114.	-51.05
Built/bare area	41.1	195.39	154.27	375

FIEFOC (Mukura) and COBWEB (Kapir). This aimed at generating information from the household members that participated. The sample size was determined using Krejcie and Morgan (1970) formula, commonly used for determining sample sizes when the numbers of participating households are known.

$$s = X^2NP\,(1-P) \div d^2\,(N-1) + X^2P\,(1-P)$$

Where s = required sample size; X^2 = the table value of Chi-square for 1 degree of freedom at the desired C.L (3.841); N = the population size; P = the population proportion (of 0.50 since this would provide the max. sample size); d = the degree of accuracy expressed as a proportion (0.05)

Four villages of Ariet and Puna in Moru Kakise parish and Omitto & Kakor in Omitto parish were randomly selected out of the eight implementing villages, that is, two from each sub county. The household members interviewed were selected through simple random sampling so as to have equal chances of being chosen from the list provided by the chair persons of the groups. On average, each group had 65 and 75 households for FIEFOC and COBWEB Projects, respectively. A total sample size of 56 and 63 households for FIEFOC and COBWEB Projects were selected. In

total, 112 and 126 households in Mukura and Kapir, respectively, from the four villages chosen, were interviewed. Each household was represented by a respondent who was either the head of the household or any member of the household who was knowledgeable on the group activities. The unit of analysis was the household. Structured and semi structured questions were asked on the causes of degradation of Awoja.

Data analysis

The data collected from the survey was entered into SPSS version 21 in order to perform statistical analysis. Descriptive statistical techniques afforded the researcher the opportunity to generate frequencies in order to know the main causes of degradation from the multiple responses.

Qualitative data on perceived status of the watershed and historical trends

In Pac S methodology

This was employed to generate information on the perceived indicators of a degraded and a healthy watershed between the two categories of respondents, that is, the lay people and the scientists. The scientists were purposively selected based on their participation in the projects and technical knowledge of the watershed. These selected individuals were from Ngora District Local Government (NDLG) Environment and Natural Resources sector, Sub County Local Governments of Kapir and Mukura who participated in the projects. In addition, the lay people were purposively identified with the help of group leaders from the membership list presented by the chairpersons of the watershed user groups. This was done based on the knowledge of the watershed and time spent in the watershed area. A total of four FGDs were held, two in each sub county for each category. The number of participants was 6-12 per FGD who were asked semi structured and open ended questions on their perception on watershed status indicators. The variables assessed to ascertain the state of the watershed were: water smell, water colour, soil quality, species diversity and vegetation type. The responses were recorded using a voice recorder and later transcribed. The summary of their responses are shown in Table 3.

Focus group discussion

The FGDs were held to generate information on the historical trends of Awoja watershed before independence to date. Participants were purposively selected from members of the projects based on their knowledge of the watershed land use/cover change, duration of residence in the watershed, sound memory of the key milestones in Awoja and utilisation of watershed products. The FGD comprised of mainly adult men and women between 60 - 85 years of age who were able to understand and vividly remember the dynamics of Awoja watershed. The members were identified with the help of group leaders from the membership list presented by the chairpersons of the watershed user groups (Golafshani, 2003). This choice was aimed at enriching the discussion with facts and memorable experiences as far as milestones in the management and status of Awoja are concerned. Four FGDs were held, one in each village. The villages were randomly sampled from the eight participating villages. The 6-12 participants per FGD were asked open ended questions on the status and trends of Awoja till the point of saturation was reached (Yin, 2006). The responses were recorded using a voice recorder and later transcribed.

Observation

During the field work, observations were also made to verify the information given by the respondents on the current state of Awoja watershed.

RESULTS

Spatial and temporal changes in watershed use/cover

For the period of 2007 to 2013, there were marked increase in change of built up areas and open waters in Awoja watershed as shown in Table 1 and Figure 2. The increase in the built up area was found to be fivefold the size it was in 2007. Built up area in 2007 covered 41.12 km^2 and by 2013 it had increased to 195.39 km^2. This change of 154.27 km^2 accounted for 375% rise in the built up area. The area of open water increased from 15.73 to 24.43 km^2, representing a 55.33% increase of 8.7 km^2. These changes are evidenced in the significant reduction in land under tree and vegetation cover.

Conversely, a reduction in land use/cover was registered mainly in the tree cover and agricultural land categories. The tree cover change reduced from 139.63 to 91.56 km^2 representing a 34.46% decrease. The agricultural land cover category reduced by 114 km^2 (from 223.35 to 109.35 km^2), a reduction of 51.05%. However, the least change of 5.1% (1 km^2) was noticed in wetland use/cover category which reduced from 16.24 to 15.24 km^2.

Household survey

From the 237 households interviewed, 85.2% indicated that the main cause of degradation in Awoja watershed was defforestation, 80.6% mentioned wetland encroachement as the cause, 63.7% reported it was poor attitude, 55.3% over population and the least mentioned was political interference standing at 2.5% of the responses as shown in Table 2.

Perceived indicators of a degraded and a healthy watershed

From the FGDs held, the perceived status of a watershed was: rich in witch weed (emoto), elapanit", "ikodokodo", "ijeelo", the presence of hard pans, stunted growth of plants, disappearance of some wetland species like water fowl, shoebills, the crested crane, scanty Acacia species, bare soils, un clear waters of lake Bisina, unappealing water smell, the highly eroded banks and low water level

Table 2. The number of respondents and the percentage case on the causes of degradation.

Causes of degradation	Responses		Percent of cases
	N	Percent	
Deforestation	202	21.3	85.2
Wetland encroachment	191	20.2	80.6
Poor attitude	151	15.9	63.7
Over population	131	13.8	55.3
Poor awareness	111	11.7	46.8
Poor water and soil conservation practices	96	10.1	40.5
Lack of enforcement	59	6.2	24.9
Politics	6	0.6	2.5
Total	947	100.0	399.6

all pointing to degradation.

Additionally, the abundance of mud fish, small sized tilapia and absence of Nile perch further confirms that the lake Bisina which is part of Awoja watershed is degraded (Filgueira et al., 2016). The presence of small fish, few, thin and miserable cows, poor quality pasture, scanty woodlots and slow regeneration of Acacia trees further confirmed the degraded status of Awoja as shown in Table 3.

Focus group discussion

The historical trend generated from the discussions held, is shown in Table 4. The status of Awoja watershed is worrying. At independence during Obote I and II regimes, its status was fairly good. Its management had been under colonialists much as it was given to the Uganda government. Additionally, both regimes of Obote exhibited improved management through popularized extension services. During the regime of Amin and Museveni, lawlessness set in and the presence of wars and cattle wrestling marked the beginning of total dependence on natural resources with limited alternative source of livelihood. This was coupled with high population, corruption, returning of war affected people from the internally displaced people's camps (IDPs) and inadequate law enforcement.

DISCUSSION

The research findings show the land cover changes in Awoja watershed area in Ngora district, North Eastern Uganda for the period 2007 – 2013. The spatial and temporal changes presented are the basis for discussion. As earlier mentioned, the built up area increased fivefold by 154.27 km^2 signifying a 375% rise. This is explained by the high population increase of 12,119 and 13,312 for Kapir and Mukura sub counties from the period of 2002 and 2012 according to the national population and housing census. The number of individuals in the age bracket 18 years and above are highest in Kapir and Mukura, registered at 9,197 and 12,498, respectively (Ngora district development plan, 2015), implying the young couples will have to establish their homes hence the increase in the built up areas as they settle. Consequently, the need to establish trading or urban centers for provision of basic commodities such as sugar, salt in the watershed led to clearing land areas to build houses. Whereas, in Uganda, according to Kaggwa et al. (2009), agriculture is the principle cause of watershed degradation, this study differs from the watershed restoration sites in Kapir and Mukura sub counties in Ngora. The findings are also not in agreement with a study carried out by Tesfaye (2011) in Ethiopia, that asserted that agriculture is the main cause of watershed degradation. However, it concurs with Ibrahim and Mosben (2015) findings in Mansoura and Taikha watershed areas of Egypt that showed an eight fold increase in the built up areas from 28 to 255 km^2 from 1985 to 2010 that largely contributed to watershed deterioration The decline in land use/cover size in tree cover and agricultural land categories of 48.07 and 114 km^2 respectively was because agricultural land was taken over by settlement. Part of the area which was taken up for settlement and urbanisation was formerly for agriculture hence the decline in area under agriculture. Therefore, those involved in agriculture have abandoned it for petty trade like motorcycle riding (boda boda) and selling of basic household items like salt, match boxes, cloths while others are engaged in alternative sources of income such as baking chapatti and brewing (waragi), thereby diverting the youth who search for quick money.

This is further backed by responses from upto 85.2% interviewed individuals who stated that Awoja watershed had undergone degradation over the years due to deforestation, followed by wetland encroachemnt

Table 3. Perceptions on the status of Awoja watershed.

Variable	Degraded watershed (Lay persons)	Degraded watershed (Scientists)	Healthy watershed (Lay persons)	Healthy watershed (Scientists)
Water smell	Smelly	Poor water quality	Clear	Clean water, presence of water lilies, Nile perch, big sized tilapia, regeneration of papyrus
Soil quality	Very loose light soils easily blown by wind, very little harvest from such soils	Reduced yield, poor light soils	Dark sandy loamy soils , Earth worms are frequently found	Absence of species of animals like Antelopes, Rabbits, Foxes, Hyenas & Terrestrial tortoises, vegetation and trees like (Fagara: eusuk), Acacia species, Albizzia species, Grass (``ecici'',`` ekode'')
Water colour	Greenish in colour, brownish with dirt (silt)	De-oxygenated water rich in algae bloom	Whitish	Oxygenated and Colourless
Species diversity	Lung fish, crocodiles, frogs, leeches, snakes (puff udder), "Ailiilin"-(white festive ducks), pigs, big rat, ducks.	Destroyed vegetation, biota and water. Abundance of mud fish	Hippopotamus, sheep, goats, lizards, cows, squirrels, snakes (cobra), cat fish, Nile perch, tilapia, "abubusia", "adolia", "elibi", "ekolia",	Vegetation with vigorous growth, rich biota and clean water, abundance of Nile perch and Tilapia, shoebill and presence of created crane
Vegetation type	Abundance of Aleo vera species, star grass, witch weed (emoto), "ekeriau", "elapanit", "ikodokodo", "ijeelo", "ikarama'', "igirigiro''	Scanty Acacia trees, bare soils that cannot support large hard ,scanty vegetation, dry wetlands	Papyrus, water lily, spear grass, "ewaat", "lab lab", sedges, all crop types	Green vegetation rich in biodiversity, abundance of spear grass, nutritious and healthy pasture

(80.6%), poor attitude (63.7%) and over population (55.3%). Political interference was rated least (2.5%) as one of the casues of degradation. The perceptions on the reason for degradation seem to be consistent with the trends recorded during this study for the spatial and temporal analyses of land use/cover change from satellite imagery. The gradual substitution of agriculture with urbinasation and settlement was reported during the FGDs to have intensified from the mid 1980s to date.

In Pac S methodology results showed convergence in perceived indicators of watersheds status among the lay people and the scientists. The current status of Awoja watershed depicts degradation from the perceived indicators. The responses on vegetation types indicated that, papyrus and spear grass were rarely seen and the species of organisms were not many like they existed half a century ago, hence a degraded Awoja. The focus group discussions equally showed a negative trend in the status of Awoja watershed despite several interventions by government and development partners (Mbogga et al., 2014). The degradation was mainly due to conflicts for watershed resources use, stemming from 3.1% population growth in the country (UBOS, 2015). Furthermore, the failure by the elders to perform rituals for rain making coupled with inadequate law enforcement are to be blame for this trend in the degradation of the watershed.

Conclusion

This study provides evidence on the state of land

Table 4. Historical trends of Awoja watershed.

1962 - 1970 Obote I	Colonialists transferred management to Uganda government, abundant tree (big) and vegetation cover with high biodiversity, low population, less pressure on natural resources , respect for the wetlands which were used as communal grazing lands and adequate professional extension services were provided
1971 – 1979 Amin's regime	Lawlessness sets in, deteriorating conditions of woodlands, vegetation, water, soil and fish catch, flood hit Lake Bisina and people could not cross to Katakwi on foot, abundance of lung fish and hunger was experienced with provision of relief food (yellow posho) by government and World Food Program, extension services on natural resources were paralysed, population increase, conflicts over land rose as the value of money began to depreciate
1980 - 1985 during Obote II	Improved extension services, increased tree cover and food production, rule of law resumed and beginning of conflict on watershed resources with increase in population.
1986 - 1992 Museveni regime	Genesis of civil war and cattle rustling, people resorted to use of hand hoes as opposed to ox ploughing and famine set in, most of the IDPs depended on watershed resources since the cattle were stolen (rustled)
1993- to date	Annual rate of degradation was increasing, there was typhoid outbreak, formulation of policies and laws on management of watershed like Environment Act, Forest Act, Water Act, emergence of many NGOs, beginning of corruption in the resource management, loss of respect for local leaders, lawlessness among the local people increased, increased number of offences related to watershed resource use, those from IDP came back home and began to encroach on wetlands, with massive tree cutting for brick making, charcoal burning and firewood for subsistence and commercial uses, population increase and increase in land conflicts. The rate of degradation is very high.

use/cover changes in Awoja watershed in Eastern Uganda from 2007 to 2013. The major causes of watershed degradation being deforestation, wetland encroachment, poor attitude and over population as the communities clear more land for settlement and utilise the watershed resources. This study thus deviates from a similar study by Kevin et al. (2012), who found out that 37% of the change in land use at Gaspereau watershed was as a result of agriculture and not urbanisation. Unless, appropriate watershed restoration strategies are designed through afforestation, law enforcement on culprits and continuous sensitisation of the watershed community on the causes of degradation, all individuals whose livelihoods depend on Awoja will continue to suffer effects of degradation. There is need to advocate for non-consumptive projects as alternative sources of income order to reduce on the pressure.

Conflict of Interests

The corresponding author indicates that she was a service provider for FIEFOC project but never worked in the study area hence did not influence the quality of this research.

The co-authors have not declared any conflict of interest either.

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