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LAND USE CHANGE IN UPPER RIVER KIBWEZI RIPARIAN ECOSYSTEM FROM 1985 T0 2015

1.Kahi Henry.Chore. Principal Technologist.
2.Nyangito Moses.Moywaywa.Professor.
3.Gachene Charles.CK. Professor.

Wangari Mathai Institute for Peace and Environmental Studies , University of Nairobi, Kenya.

ABSTRACT

The Kibwezi river watershed and riparian areas is among the most important riparian ecosystem for the conservation of flora and fauna in the Southern Kenyan rangeland which is threatened by unsustainable anthropogenic activities. The study aim was to determine the land use change in the upper riparian and watershed of river Kibwezi from 1985 to 2015.

Image processing software; ERDAS IMAGINE 2015 (64 bit), ENVI Classic (64 bit), GIS software: ArcGIS 10.5 was used in addition to Thematic Mapper [TM] (operating on Landsat 4 and 5), Landsat 7 ETM and Landsat 8 OLI. The resolution (pixel size) of the imagery used was approximately 30m by 30m.

Cropland increased by 7-3% from the year1985 to 2000, but reduced by 29.82% from 2000 to 2015 In 1985 t0 2000 forest cover reduced by 16.67% but from the year 2000 the tree cover increased by 29.25%. Overall land under crops reduced by 28.82%, equivalent to loss of 7ha/ year and forest cover increased by 7.72% (1.19ha/year). The implication is that land under crop is reducing probably due to reduced water level in the river. Forest cover increase could be attributed to abandoned crop land and farmers impressing agroforestry practice as witnessed in most farm growing fruit and wood trees such as Mellia volkensii plantation and Mangifera indica. Land degradation in watershed is at the rate of 1.29% per annum, an indication that if *the status quo is allowed to continue more than 80ha of land will be degraded in the next 40 years.*

Farmers should be encouraged to use natural resources particularly indigenous woody vegetation cautiously. Further studies should be contacted to ascertain the extend of land degradation in the study area and how its impacting on riparian ecosystem.

Keywords: River Kibwezi, Land use change, forest, cropland, land degradation, agroforest

Introduction

Riparian woody vegetation includes plant communities in streams, on river banks and in floodplains which is an integral part of riverine ecosystems (Mligo, 2017). Ilhardt; *et al*., (2000) asserts that riparian zones are habitats that are adjacent on both sides of river extending to its catchments. Thus Riparian zones include the immediate upland habitats to a stream as well as areas that are hydrologically connected through groundwater flow that are adjacent to a stream (Richard and Haag, 2007, Marsh 2006). Naiman, Decamps, and McClain (2005) defined riparian zones as transitional semi-terrestrial areas regularly influenced by fresh water, normally extending from the edges of water bodies to edges of upland communities. These zones are the interface between land and rivers or streams, which include trees, usually accompanied by shrubs and other vegetation along a river, stream or shoreline.

The effects of human activities in riparian zones are poorly understood even though these habitats are important in providing ecosystem services and maintenance of biodiversity. This has resulted into the river ecosystems being neglected and over exploited in Kenya leading to decline in the goods and ecological services they provide and Kibwezi river riparian zone is not an exception. According to Cheruto *et al.*; (2017), a human-induced impact on the environment and their implications for climate change has evolved as a major cause of land use and land cover change especially in riparian habitats. The changes arise as a consequence of socioeconomic, political, cultural, climate change and forces related to high human populations.(Masek *et al*.; 2000)

The current state of the riparian habitats worldwide represents the outcome of more than a decade of water shed land use, often with little understanding of how various practices could affect these productive ecosystems (Burton, et al.,2005) in watershed areas climate change and the integrity of riparian habitats. Watersheds ecosystems are important in the management of water and related resources such as riparian habitats (NRC 1999). Thus for effective management of riparian habitats, there is need to understand linkage between land use change in adjacent watershed and the management of riparian ecosystem.

Natural water resources, and their ecosystems which are linked to watersheds, provide critical economic and social benefits to agro-pastoralist living in this arid and semi-arid lands (ASAL) of Kibwezi sub-county. Linda et al, (1996) observed that the riparian habitats which are bands of green vegetation along the river banks, serves pastoralists and their livestock as source of water and pasture in the dry season.

Sustainable management of this habitats requires a detailed understanding of how human activities affect such systems, and how they response to these effects. Specifically we need to know and understand the location and distribution of riperian vegetation and how they are influenced by human activities such as crop production. However, there is limited attention that has been given to research on ecology of riparian zones in arid and semi-arid areas of Kenya (Cheruto *et al*, 2016).

MATERIAL AND METHODS

STUDY SITE

This research was conducted in the year 2017 in the upper riparian water catchment of kibwezi river ecosystem which is a semi-arid area of Kibwezi sub-county, Kenya. Kibwezi sub-county lies between latitudes 2º 6′S and 3ºS and longitude 37º 36′E and 38º 30′E respectively and has a total area of 3400 km2 (Mwang'ombe *et al.*, 2011). The climate Kibwezi is typical semi-arid characterized by low and unreliable supply of enough moisture for plant growth (Mganga *et al.,* 2010). The average annual rainfall is 600 mm (Musimba et al., 2004). These areas receive a bi-modal rainfall pattern with the long rains expected between April-May and short rains between November-December.
Kambas are the largest community in the area who practice agro-pastoralism as their mainstream economic activity. Crops grown include a variety of drought tolerant grains like maize, sorghum, millet, beans and pigeon peas. Tomatoes, water melons, cabbages and kales are grown under irrigation using water from river kibwezi. Livestock kept consist of local breeds mainly the Small East African Shorthorn Zebu cattle, Red Maasai sheep and the Small East African Goat (Nyangito *et al.,* 2009).

Scope of study area

Upper riparian habitats on river Kibwezi is located in Makueni county eastern part of Kenya. It covers an area of 37.2 km^2 and extends from latitude 2°20'23.341"S to latitude 2°24'14.513"S and longitude 37°58'47.611"E to longitude 38°4'30.756"E and an average elevation of 810 meters (2657.48 feet's).

METHODOLOGY

The sensors used were Thematic Mapper [TM] (operating on Landsat 4 and 5), Landsat 7 ETM and Landsat 8 OLI. The resolution (pixel size) of the imagery used was approximately 30m by 30m. The Scene locations was identified by Path and Row and the area interest was P167R062

The USGS on-line archives provided images for all archived Landsat scenes. The browse 'quick-look' images on this system are a fixed colour display and limited in resolution. The archive also provided an estimated cloud cover percentage for each image. These archives were accessed at (http://glovis.usgs.gov/ or http://earthexplorer.usgs.gov/
The multi-spectral imagery was calibrated to surface reflectance and was supplied as 16-bit data. These data was supplied at 30m resolution on a standard UTM (WGS84) grid. Layer stacking was done using six bands excluding the thermal, panchromatic, cirrus and Coastal/aerosal bands. This was done in Envi 4.7 using bands 2-7 for Landsat 8 and bands 1, 2,3,4,5 & 7 for Landsat 7. The bands were ordered in ascending order i.e. from 2-7 and 1-7
All images were reprojected from UTM WGS 84 to UTM Arc1960 37 South.

Land Cover Classification

Classification method used in the study was random forests (RF), which is a supervised classification approach that begins with operators selecting training samples from the image and therefore implemented in a program script in the statistical language 'R' (https://www.r-project.org/).The land use classes used in the study includes, Forestland, cropland, grassland and other land

Images were 'clipped' 'in order to remove pixels noise at image edges, subset the image as per the area of interest and to ensure a common null value (DN zero or -9999) was set for all non-data areas. Clipping is a standard process in ENVI or ERDAS. Change detection in land use involved comparing satellite imagery of the area taken at different time ie 1985, 2000 and 2015. The GIS Spatial Analyst provided a rich set of spatial analysis and modeling tools for both raster (cell-based) and feature (vector) data. The Raster Calculator allowed the input of simple Map Algebra expressions that generated an output raster. In the study, this tool was used to execute the expression to determine the change between 1985 and 2000.

1985 2000 2015

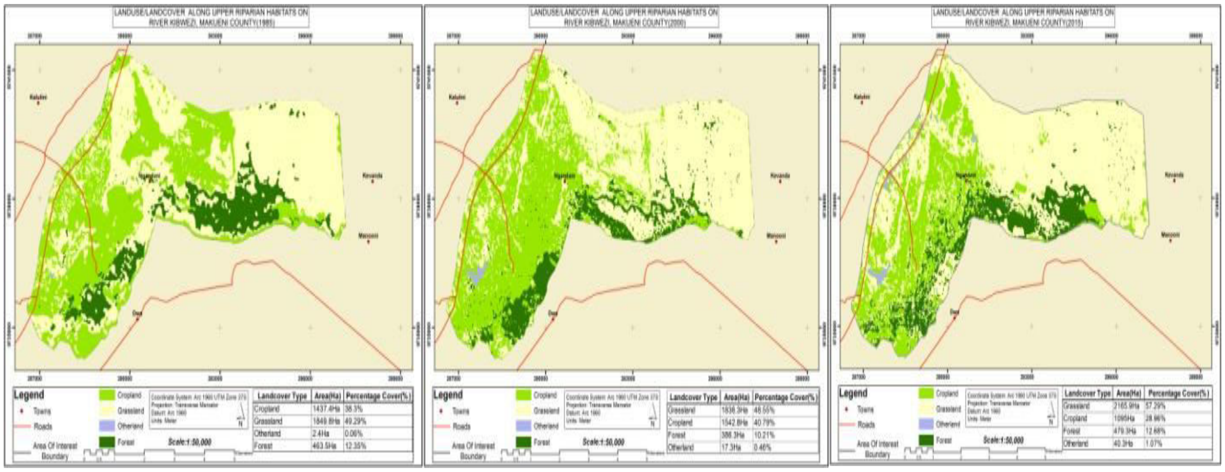

Figure. 1: Map of land use change in upper kibwezi river riparian ecosystem for the period 1985, 2000 and 2015 respectively

Figure one show map of land use changes based on crop land, grassland forestland and other lands (rocks, bare ground and eroded lands) from 1985 to 2015). Woody vegetation cover reduced from the year 1985 to 2000. From the 2000 the area covered by forest was improving (Table 2)

Table 1. landuse and total percentage coverage for the years 1985. 2000 and 2015

LANDUSE	1985		2000		2015		1985-2015	X^2 P<o.o5
	HA	Percent (%) total *coverage*	HA	Percent (%) *total coverage*	HA	*% total coverage*	*Ha*	
Cropland	1437.4	*38.3*	1542.8	*40.8*	1095	*29.0*	*-342.4*	
Grassland	1849.8	*49.3*	1836.3	*48.6*	2163.9	*57.3*	*+314.1*	
Forest/wood land	463.5	*12.4*	386.3	*10.2*	499.3	*12.7*	*+35.8*	
Otherland	2.4	*0.06*	17.4	*0.46*	40.7	*1.07*	*38.3*	
TOTAL	3753.1		3782.8		3798.9			

Data in Table 1 indicate that overall total area coverage by cropland increased by 7.3% from 1985 to 2000 and by 11.8% between 2000 and 2015. General trend of land under crop reduced by 342.4ha from the year 1985 to 2015. The reduction of land under crop could be attributed to reduced water level in the river during the same period. Most farmers who belong to river user association (RUA), use the water from the river to irrigate their crops (maize, tomatoes, capscum and kales mainly). In 1980s there was rapid expansion of farming along the river kibwezi as there was adequate water flowing in the river and availability of ready market in mombasa. The expansion may have led to cutting down of trees along the riparian ecosystem to open up more land for cultivation, which could be linked to low level of water in the river. Reduced water level probably could also be associated with a reduced land under crops coverage from the year 2000 to 2015 in the catchment and riparian ecosystem. During the same period grassland increased from 49.3%in 1985, to 57% in 2015 based on total land uses in the ecosystem. The increase of grassland areas (by 314.1ha) may be linked to reduced land that was under crops.

Area occupied by tree species/forest, reduced in the period 1985 to 2000 but increased in the period 2000 to 2015. The reduction could be as a result of destruction of riparian woodland to open more land for cultivation. Barnes (2008) asserts that activities such as overgrazing, cultivation and wood exploitation for construction and fuel, may lead to loss of vegetation cover in any given ecosystem. This is supported by Agarwal., et al (2000) who observed that human induced land use change such as land clearing to plant crops and urbanization is currently among the significant drivers of global land use change. If such induced human activities are allowed to continue in Kibwezi river watershed, more land will be degraded. However, the result in Table 2 show that there is an increase in tree cover from 2000 to 2015 by 2.5% which could be linked to abandonment of cultivated land and probably farmers embracing agroforest practice on their farms. Reduction of cropland could be having a bearing in increased grassland by 8.7% in the period between 2000 to 2015 (Table 2)

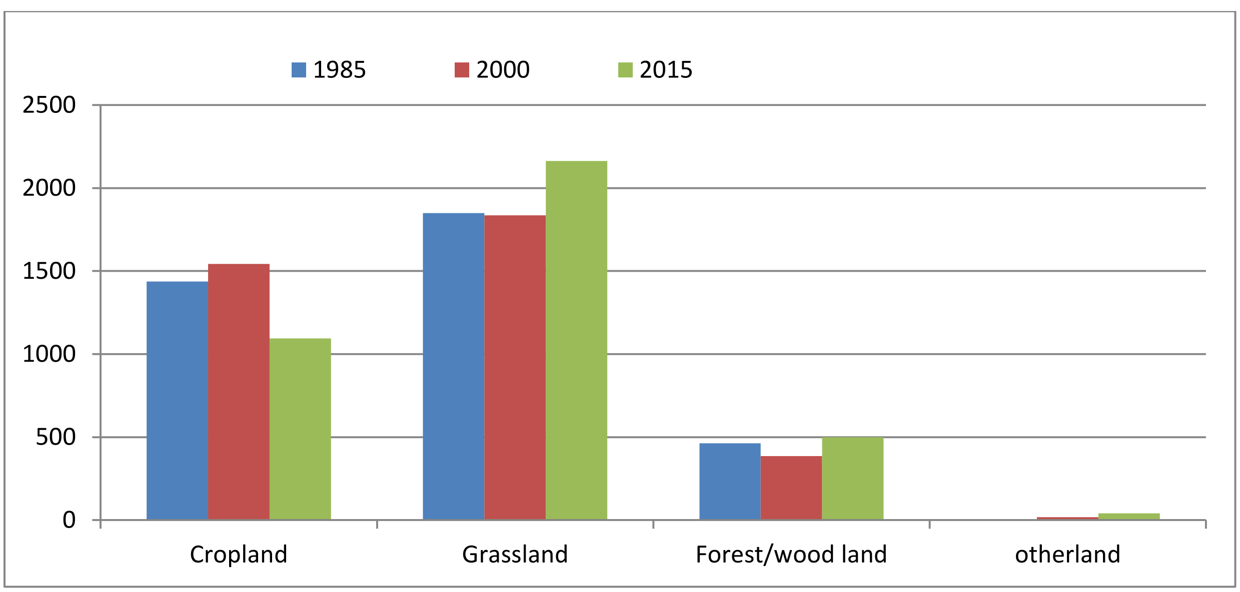

Figure 2: Land use change in upper river Kibwezi watershed from 1985 t0 2015. Grass land increased from 2000 to 2015 while land under crops reduced during same period

Trend of land use in river kibwezi watershed ecosystem

Table 2 further indicates that cropland reduced by 28.82% while grassland, forest and bare ground increased by16.98%, 7.72% and 1579.17% respectively. Rate of change per year is cropland -ve 23.8%/year, grassland, forestland and bare ground gain per year is +16.98%, 7.72% and 53.17% respectively. If the trend is allowed to continue for the next thirty years, we are likely to loose 210ha of cropland to other land uses. About 38.7ha in river Kibwezi watershed will turn into a barren/degraded land. This means the area is likely to become food insecure in the next 30 years if more trees in riparian habitats will be destroyed in attempt to open more wetland to produce more food. Olson and Matina (2006) asserts that most of the changes in riparian and watershed areas are mainly associated with intensification of mixed crop and livestock production into former grazing land and other natural areas.These could turn into vicious cycle between poverty and environmental degradation where the river may become a seasonal. This results agrees with GoK, (2009); and Mati et al., (2008). Who argued separately that watershed degradation in the developing countries due to anthropogenic activities is a threat to the natural water resources

Mburu, (2015) argued that ecosystem attributes such as biodiversity and the provision of ecosystem goods and services are affected negatively by land use change. This implies destruction of riparian trees to open up land for agricultural activities compromise the role they play in provision of ecological services such as protecting the area under it from excessive heat and erosion from heavy rain. The leaves and bark of a tree retain a huge amount of water, allowing some of it to evaporate (transpiration) and some of it to reach the ground more slowly. When surface water is slowed down, the soil is able to absorb more water and naturally filter it before entering the groundwater system. Slowing down surface water flow also reduces the threat of downstream flooding after heavy rain.

Table 2: Kibwezi river riparian zone Land use in 1985, 2000 and 2015

Landuse	1985 to2000		2000 to 2015		1985 to 2015	1985 t0 2015
	Ha	Percent (%) change	Ha	Percent % (%) change	Overall percent %Change	Rate of change (% loss/gain per year)
Cropland	105.4 (+ve)	7.3 (increase)	447.8 (-ve)	29.03 (decrease)	Decrease -28.82% (342.4Ha)	-23.8% (Loss 7.ha/year)
Grassland	13.5 (-ve)	0.73 (decrease)	329.6 (+ve)	18.95 (increase)	Increase 15.52% (314.1 Ha)	+16.98% (Gain 10.47Ha/year)

Forest/woodland	77.2 (-ve)	16.67 (decrease)	113.0 (+ve)	29.25 ((increase)	Increase7.72 (35.8Ha)	+7.72% (1.19Ha/year)
Otherland (Bare land, rocks etc)	14.9 (+ve)	620.8 (increase)	23(+ ve)	132.95 (increase)	Increase 1579.17% (38.3Ha)	+53.19% (1.29Ha/year)

CONCLUSION AND RECOMMONDATION

Result of the study indicate that:

- Although cropland increased in the 1980s to 2000, generally it reduced from 1985 to 2015 probably due reduced water level in the river that is used for irrigation.
- Forest or land under woody vegetation reduced in the 1980s to 2000 probably due to expansion of farming
- In the period 2000 to 2015 areas under trees is increasing probably because the land that was under crop is left furrow and farmers embracing the culture of agroforestry on their land, Thus in terms of forest cover, the present situation is better than the past and future state will improve upon the present practices of land use
- Land use type is linked to other land use within the water shade. Thus what changes takes place in one land use it affects other land use type.
- Finally the integrity of river Kibwezi riparian ecosystem and other rivers is linked to activities that take place in its water shade pointing at land degradation and if intervention measures are not taken with the aim of reversing the trend, river Kibwezi might turn to be seasonal in the next third years.

Thus riperian ecosystem along river kibwezi should be used in a way that is efficient, ecologically and economically sustainable and compatible with the social set up of the local communities, so that it can serve the interest of the current and the generation to come.

Increased agricultural, residential and farming has led to reduced riperian area occupied by woody species , which impede the effectiveness of these habitat to provide ecosystem service. Individual ownership of parcel of land in the study area could be exacerbating the effect land fragmentation which could be having a direct link in the destruction of riparian ecosystem.

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