ANALYSIS OF LAND USE/COVER TRENDS IN KIRIMA SUB/COUNTY KANUNGU DISTRICT

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ABSTRACT
Like other countries in the Sub-Saharan Africa, Uganda is not an exception to the effects of land use/cover changes on the environment. This study aimed at analyzing land use/cover trends in Kirima Sub/County-Kanungu District. Specifically the study intended to; establish the main drivers of land use/cover change and determine their magnitude and trend for the last 35 years. In establishing the main drivers of land use/cover change the study utilized household questionnaires and a focus group discussion guide. A total of 65 respondents included in the study were randomly selected from the local council members list for questionnaire administration while 12 participants were included in the focus group discussions from eight randomly sampled villages in the sub-county. The data was analyzed using a Logistic Regression in SPSS Windows (10.0). A series of satellite imagery (1975, 1987 and 1999) were utilized to determine the magnitude of land use/cover change using unsupervised classification in Integrated Land and Water Information Systems (ILWIS 3.3) Academic software. Findings indicate that household size and the weak environmental laws were the main underlying drivers of land use/cover changes. Other drivers included; type of crops grown, extension agents' visits, and customary land tenure, all were statistically significant predictors of land use/cover change ($P<0.05$). The magnitude of small scale farming (non-uniform) largely increased by 5% from 1975 to 1999 while areas covered by Tropical high forest relatively decreased by 16% between 1975 and 1987 but slightly increased by 1% in 1999. The areas covered by wetlands comparatively increased by 4% from 1975 to 1987 and by 1999 they slightly decreased by 3% while the woodland areas also moderately decreased by 3% from 1975 to 1987 and to some extent increased by 2% in 1999 in Kirima sub-county. The time series regressions showed that small scale (non-uniform) farming (0.829) and Tropical High Forest (0.697) had relatively strong regression strength and good fit compared to wetlands (0.053) and woodlands (0.049) with very weak regression strength and a weak fit. This study has shown that it is possible to use GIS and Remote Sensing to quantify change patterns at micro scale to provide territorially differentiated statistics.

Key words: *Land use/cover change, Small Scale Farm lands, GIS and Remote Sensing*

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1.1 INTRODUCTION

Landuse/cover change affects environmental and social economic conditions (Krishna *et al.,* 2003; Mundia & Aniya, 2006) for instance; the expansion of grazing land for livestock is a key factor in deforestation, especially in Latin America: some 70 percent of previously forested land in the Amazon is used as pasture, and feed crops cover a larger part. About 70 percent of all grazing land in dry areas is considered degraded, mostly because of overgrazing, compaction and soil erosion attributable to livestock activities (FAO, 2006). The exponential population growth and shifting cultivation are causally linked to deforestation and environmental degradation (Jarosz, 1993). However, the recent research has shown that pastoralist's habits of burning grasslands, combined with the grazing and browsing of their livestock, have helped maintain savannas at their historically documented extent and succession stages (Gifford-Gonzalez, 2000) and most of Africa and Latin America have increased their food production through both agricultural intensification and extensification (Lambin *et al.,* 2003).

In Uganda, approximately 75 percent of the country's land is relatively fertile and receives sufficient rainfall for rainfed cropping or pasture. Only around 30 percent of the arable land is currently under cultivation (Zake *et al.,* 1999). The agricultural population is relatively concentrated in Eastern, Southern and Western Uganda, and zones within those areas have very high population densities. Indeed, food production has not kept up with the country's population growth increase despite an expansion of area under crops. Per capita food production hit a low in 1980, and even with recent increases it has not reached the levels of the 1970's (NEMA, 2001). Also it's generally estimated that 4% - 12% of GNP is lost from environmental degradation, 85% of this from soil erosion, nutrient loss and changes in crops. The worst affected areas include highland areas in the southwest and some dry-land districts. The combined effect of high economic growth and population growth has had and will continue to have a dramatic impact on the land cover (NBS, 2003). Currently Kirima Sub/county is still facing tremendous decline in land cover attributed to intensive agricultural activities primarily triggered by high population growth rates of about 3% per year and the weak land use/cover laws and policies. Unfortunately, the main drivers of land use/cover change, their magnitude and trend have received the least of attention. Therefore the study seeks to establish the main drivers of land use/cover change and determine their magnitude and trend for the last 35 years in Kirima sub-county.

MATERIALS AND METHODS

Description of the study area

The study was carried out in Kirima sub-county located in Kanungu District which is in south western Uganda bordering the district of Rukungiri in the north and east, Kabale in south east, Kisoro in the south and Democratic Republic of Congo in the west (figure 1). The district has a total area of 1,228.28 sq km with a total population of 204,732. Its administrative headquarters are in Kanungu town about 450 km from Kampala the capital city of Uganda. Kirima sub-county comprises of fairly flat topped hills with gentle sloping sides and broad valleys. The hills gradually increase in height to the highlands of Rutenga with Burimbi peak of Mafuga being the highest at 822222 ft (2503 m) above sea level (SOER, 2004).

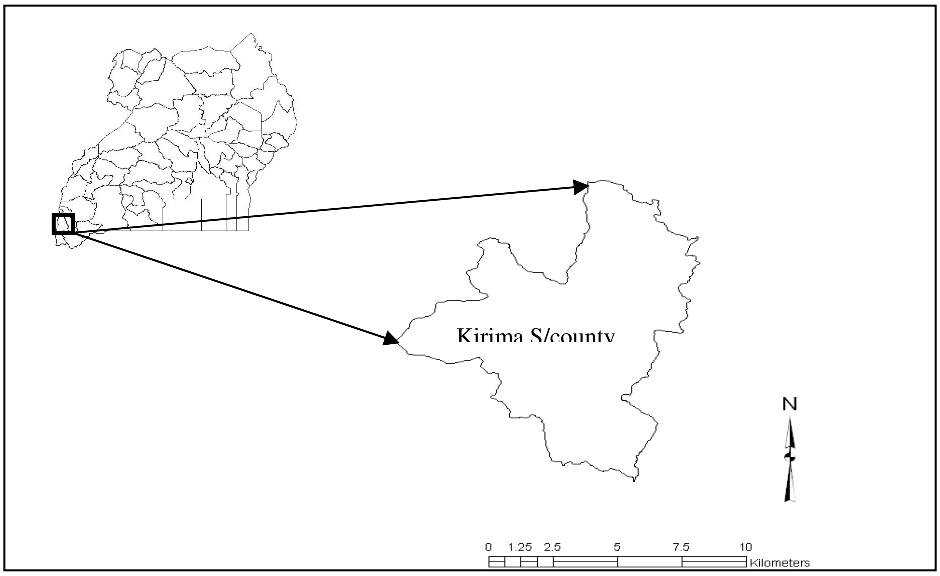

Figure 1: shows the location of area of study

Research Approach

Establishing the main drivers of land use/cover change in Kirima sub-county

To establish the main drivers of land use/cover in Kirima sub-county, the study utilized household questionnaires and a focus group discussion guide, which were prepared to address the driving forces of land use/cover change. The questionnaires were preferred in this study because they give an insight into the driving factors of land use/cover change (Jan *et al.,* 2005). The respondents included in the study were randomly selected from the local council members list for questionnaire administration and participation in focus group discussions from eight randomly sampled villages in the sub-county. This approach was utilized because it ensured that all members and villages were appropriately represented in the study whereas purposive sampling was conducted on only the key informants because of their knowledge on the catchment's natural resources usage. The main drivers of agricultural activities were examined through an administration of 60 personal questionnaire interviews to both the local residents and 5 key informants (District agricultural and commercial production officers, NAADS coordinator and Environment Officer) in the study. The questionnaire interviews were conducted on an individual basis to minimize the peer influence and improve the quality of data (Phillips & Gentry, 1993) while the focus group discussions were conducted at a village level comprising of 12 households. The socio-economic data from questionnaires was coded and entered in SPSS Windows Programme (10.0) and subjected to Logistic Regression to determine the main drivers of land use/cover change in Kirima S/county. The logistic model was used because land use/cover is normally expressed as a discrete variable (Jan *et al,* 2005).

Determining the magnitude and trend of land use/cover changes for the last 35 years

The study utilized ortho-rectified and cloud free Landsat TM/ETM images. The twelve spaced years were selected (1975, 1987 and 1999) to determine the magnitude and trends of land use/cover changes. The spatial resolutions of the images are 30 meters. The Integrated Land and Water Information Systems (ILWIS 3.3) Academic software was used for initial image clustering. The ortho-rectified satellite images were subjected to unsupervised classification. The unsupervised classification was used because of more information present in unsupervised than in supervised classification (Jensen, 1986). The preliminary maps were validated and adjusted basing on ground truthed data. The time series regressions were used to determine the trend of all the land use/cover types.

Change Date Computation

The change rates of single land use/cover type were determined according to Peng *et al.,* (2008) procedures.

$$K_1 = \frac{(U_b - U_a) \times 100\%}{U_a \quad T}$$

Where K_1, is the land use/cover dynamics degree, measuring the change rate of the target land use/cover type, U_a and U_b are the area of the target land use/cover type at the beginning and the end of the study period respectively and T is the study period, which is usually measured with the unit of year.

Descriptions of four Land use/cover classes on the 1975, 1987 and 1999 images

The land use/cover type descriptions are according to the Uganda National Biomass Study Classification System (2003).

a) Woodlands; Areas where trees and shrubs were predominant. These were of wet type which occurred along the wetlands and the average height of the trees was exceeding 4m.
b) Tropical High Forest; was the natural forest (Bwindi Impenetrable forest) rich in species biodiversity and it is a normally stocked forest.
c) Small scale farmlands; these involved mixed farmlands, small holdings in use or recently used, with or without trees.
d) Wetlands; these had wetland vegetation with swamps and other sedges

RESULTS

The main drivers of land use/cover change

Table 1 shows the main drivers of land use/cover change

Predictor variables	*B*	*S.E.*	*Wald*	*Df*	*P*	*Odds Ratio*
Type of crops grown	.193	.058	10.907	1	.001	1.212
Education levels	-.288	.254	1.277	1	.258*n.s*[a]	.750
Livestock activities	.008	.027	.098	1	.755*n.s*[a]	1.008
Extension agents' visits	.743	.183	16.460	1	.000*	2.102
Customary land tenure	-.050	.014	13.816	1	.000*	.951
Weak land use laws	6.066	1.055	33.094	1	.000*	431.071
Household size	8.010	2.789	8.246	1	.004*	3011.048
Constant	-2.892	.724	15.935	1	.000	.055

**Significant at P<.05, [a]Not significant at P<.05*

Overall model evaluation

Test	X^2	*df*	*P*
Goodness of fit Hosmer & Lemeshow	53.322	8	.000

Cox and Snell R^2= .202, Nagelkerke R^2= .209, -2 Log likelihood =430.611

The Observed and Predicted frequencies with cut-off of 0.50

	Predicted		
Observed	**Yes**	**No**	**% correct**
Yes	306	14	95.6
No	90	36	28.6
Overall % correct			**76.7**

According to the model, the log of households clearing land for agricultural activities was negatively related to education levels and customary land tenure (*P<0.05*) whereas positively related to the household size, weak land use laws, type of crops grown, extension agents' visits, (*P<0.05*) (Table 1). In other words, household size, weak land use laws, type of crops grown, extension agents' visits, and customary land tenure were statistically significant predictors of land use/cover change (*P<0.05*) compared to increasing livestock activities and education levels which were non significant drivers of land use/cove change in Kirima S/county (*P<0.05*) (Table 1).

The inferential goodness of fit test is the Hosmer-Lemeshow (H-L) test that yielded a X^2 (8) of 53.322 and was significant (*P<.05*), suggesting that the model was not fit to the data well. The overall correction prediction is 76.7, an improvement over the chance level. Besides, the classification table is most appropriate when classification is a stated goal of the analysis, otherwise it should only supplement more rigorous methods of assessment of fit (Hosmer & Lemeshow, 2000).

The magnitude and trend of land use/cover changes in Kirima Sub-county

For the last 35 years small scale (non-uniform) farming enormously increased from 60% in 1975 to 75% in both 1987 and 1999 while areas covered by Tropical High Forest and woodlands decreased from 32%, 7% in 1975 to 16%, 4% in 1987 but gradually increased to 17% and 6% in 1999 respectively (Table 2). However, areas covered by wetlands comparatively gained more land in 1987 (5%) compared to 1999 (2%) and 1975 (1%) (Table 2 and Figure 1). In period of 1975 and 1987, the highest annual land use change rate was experienced in wetlands (44%) compared to tropical high forest (5%), woodlands (5%) and small scale farmlands (2%) and while between 1987 and 1999 the highest annual land use change rate was experienced in woodlands (7%) followed by wetlands (6%), tropical high forest (1%) and small scale (non-uniform) farmlands (0.1%) (Table 2).

Table 2, shows the magnitude of land use/cover changes in Kirima Sub/county

Period	**1975**		**1987**		**1999**		**Change Date Computation (%)**	
Land use types	**(ha)**	**%**	**(ha)**	**%**	**(ha)**	**%**	**1975-1987**	**1987-1999**
Small scale farmlands	4757.8	60	6006.8	75	5963.9	75	2	0.1
Tropical High Forest	2522.8	32	1235.5	16	1319.7	17	5	1
Wetlands	74.4	1	432.9	5	157.6	2	44	6
Woodlands	593.6	7	284.9	4	518.9	6	5	7

Trend analysis

The time series regressions showed that small scale (Non-uniform) farming (0.829) and Tropical High Forest (0.697) had relatively strong regression strength and good fit compared to wetlands (0.053) and woodlands (0.049) with very weak regression strength and a weak fit (Figure 1 and 2). The forecasts show that small scale farming and wetlands are likely to gain more land in 2011 (6773 ha), (305 ha) and in 2023 (7376 ha), (346 ha) respectively while in 2011 the areas covered with tropical high forest and woodlands will reduce from 490 ha, 391 ha to 112 ha and 354 ha in 2023 correspondingly.

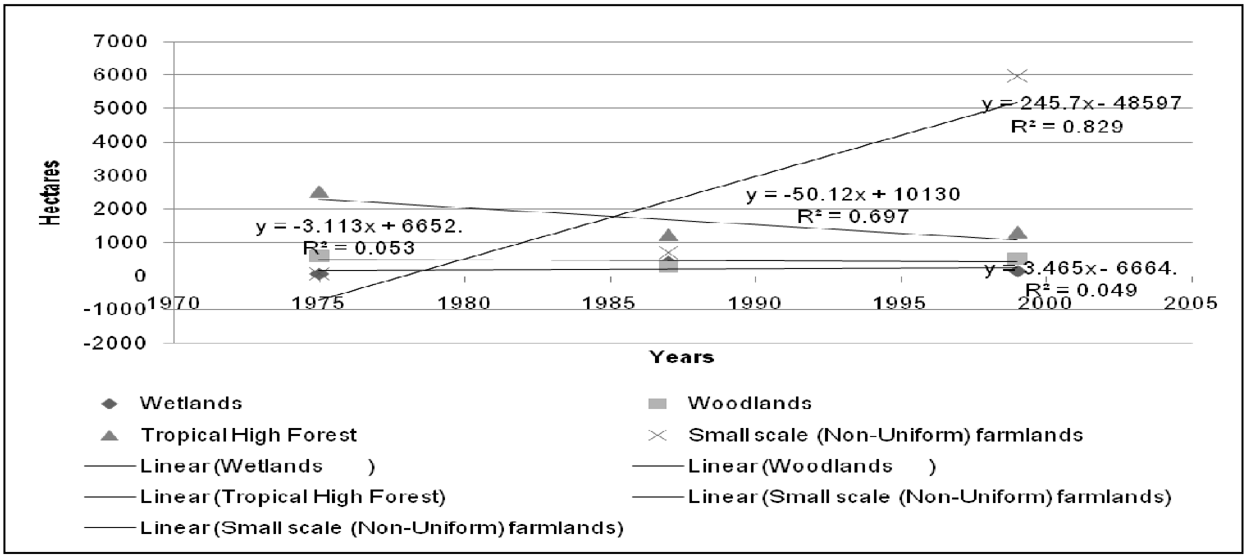

Figure 1 shows the trends of land use changes in Kirima S/county

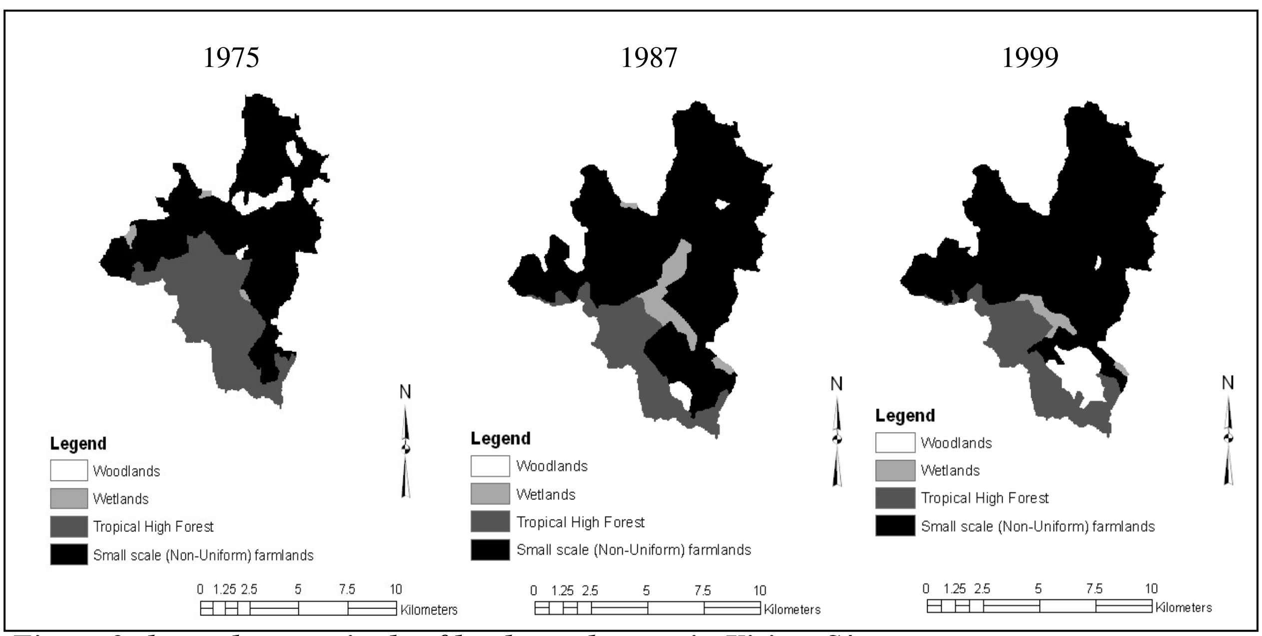

Figure 2 shows the magnitude of land use changes in Kirima S/county

DISCUSSION

The main drivers of land use/cover change

The study findings have revealed that household size, weak land use laws, type of crops grown, extension agents' visits, and customary land tenure are vital drivers of land use/cover change. On the contrary, increasing livestock activities and education levels turned out to be non important drivers of land use/cover change in Kirima sub-county. These findings reveal that the drivers of land use/cover change are location specific. Floriane & Amezaga (2008) highlighted that local and historical factors specific to geographic areas and individual communities, combine to drive land use/cover change. According to Framer-Browers *et al.,* (2006) there are two categories of land use/cover change drivers; mega drivers which we have control of and environmental factors which we hardly have any control over. All the identified drivers in this study therefore, fall in the later category of the mega drivers.

Results have further reinforced the notion that population is a key driver of land use/cover change over time. The fact that the higher the household size the more likely a household was to drive change falls into the land use/cover-population destabilization notion. This argument is reinforced by the assertion made by Ramankutty *et al.,* (2002) that the driving force for most land use change is population growth. Indeed the population and household size of Kirima has been growing overtime. The mean household size was 4.7 persons (Census Atlas, 2002). Equally social ties of extended families in the area have kept the household sizes larger and this has a bearing on land use patterns especially cultivation of gardens so as to meet the household food requirements.

Ngo Mpeck (2003) discussed that with the rapid population growth, forest resources are being depleted owing to the increasing demand for productive land for agriculture, which is met by clearing more forest. Deforestation in turn reduces species diversity and erodes the genetic base of tropical trees, including those vital for the very survival of the population of the region. This scenario seems apparent in Kirima sub-county.

In another string of agreements the USDA Forest Service (2004) holds that much of the pressure to convert forests to agricultural uses comes from increasing population growth and development demands. More land may be needed to provide food and commodities or to enable division of property into smaller parcels for new families. New communities and populations also require the development of new or improved transportation infrastructure and all these in part call for conversion of other land use/cover units to the new desired uses.

Another driver of land use/cover change in Kirima sub-county is the weak environmental laws and policies. This is comparable to the findings made by Olson *et al.,* (2004) in his study about local communities surrounding tropical high forests in Uganda. The weak land use/cover conservation laws in Kirima Sub-county have been exploited by the local communities especially the on-going small scale illegal pit sawing and timber harvesting activities in tropical high forest and wetlands. Mwavu (2008) also noted that the weak laws are responsible for the clearances of land cover because they are highly violated and usually have lighter penalties. This is also inline with results made by Kamusoko and Aniya (2007), in a study conducted in Zimbabwe that rapid land use/cover change is a result of colonial imbalances in land distribution, government policies and environmental factors such as drought. However Abonyo *et al.,* (2007) also stressed out that much as there are weak land use/cover laws in Ssese islands they have led to the establishment of oil palm plantations by BIDCO and out-growers who have contributed to an increase in household income and revenue for Uganda.

Customary land tenure as a major driver of land use/cover change does not come as a shock; the tradition of inheritance and parcel sub-division to sons who have either reached marital age or have already married and started their own families has encouraged further sub-division of land. Land fragmentation in the area has therefore been unavoidable circumstance. There are particularly two issues that this has raised in the area; establishment of new homesteads in itself requires land clearance, there is a cultural erosion of environmental custodianship as the elders relinquish their powers to the newly created households. Place and Ostuka, (1997) had earlier on argued that land use and land cover change is closely linked to customary land tenure institutions and poor access to markets.

The major types of crops grown are also responsible for the clearances of land cover in Kirima sub-county. Crops grown such as tobacco, bananas, matooke, beans, maize have led to the massive clearances of areas covered by tropical high forest and wetlands. However, the findings are divergent with Nkonya's *et al.,* (2002) who argued that as commercialization increases in importance, the value of productive land and incentives to increase yields will eventually increase in East Africa.

The frequencies of agricultural extension agent's visits in the sub-county are also responsible for the clearances of land cover and intensifications of agricultural activities. The frequent monitoring of local community's agricultural activities by agricultural officers in all the parishes has accelerated the acquisition of new agricultural fields for mainly tobacco growing and matooke production. This is responsible for the clearances of areas covered by wetlands and tropical high forest in Kirma sub-county. This is similar to Germano (2001) who observed that the larger the number of extension workers per farm, the greater the intensity and effectiveness of the agricultural extension service delivered to farmers over a specific time period. Thus, for a fixed number of farms, the larger the number of extension staff, the higher the farm yield. The extension workers visits have greatly contributed to the increase in household income levels and thus raising the standards of living in the sub-county. This was also stressed by UBOS (2002) that the lower poverty rates in Kirima sub-county reflect the impact of relative fertile soils, reliable rainfall and peace.

Many of land use activities practiced are directly dependent on natural resources in the sub-county and tend to change as these resources are utilized by the local communities. For example, the fall in coffee prices in the late 1970s and associated poor marketing, policies badly affected the people's income in Kanungu and Kirima sub-county in particular. People switched from coffee to growing bananas and other food crops which assured them with high market prices free of government control.

The magnitude and trend of land use/cover changes in Kirima Sub-county

The results portrayed in Table 2, generally show that the rates of change in land use/cover units have not been uniform across board. The variations are distinct; increases in small-scale farming carried out by resource-poor farmers are held accountable for decreases in areas covered by wetlands, tropical high forests and woodlands. According to Egeru and Majaliwa, (2009) small-scale farming has a significant influence on land use/cover changes; they observed that in Soroti District Eastern Uganda, the recovery efforts and cultivation for self reliance led to drastic increases in small-scale between 1986-2001 at the expense of woodlands and bushlands as more hectares were converted to cropland. Therefore Kirima residents are encroaching onto forests and wetlands areas this explains the magnitude of change experienced in these land cover units between 1987 and 1999.

The rapid changes experienced in the wetlands between 1975 and 1987, are intricately difficult to point to a signal factor to explain this land use/cover trend. However, residents in Kirima during the focus group discussions attributed this to increase in population and the realization that there was a shortage of land. This made the communities to encroach the wetlands for cultivatable land to establish agro-forestry gardens of eucalyptus. In addition, the break down in civil laws at this time as the communities were emerging out of conflict that had plunged the country in the 1980s further explains the declines in wetland cover. Participants in the focus group discussions recognised that during the conflict period, people lost their stewardship and custodian roles to protect the Kirima sub-county natural resources.

There was much clearance of forest cover to make settlements in the Forest Reserve during the troubled 1970s and 1980s. Residual encroachment of the government lands still continues in Kirima sub-county. Most of the boundaries of the encroached reserves have not been reopened and are not clearly demarcated, which forms part of the reason for the current confusion in the sub-county (SOER, 2007)

Another explanation to this trend was advanced by Muhebwa (1992) cited in Tukahirwa (2002) that; the period between 1973-1977 was characterised by land privatization, this saw an influx of herdsmen most of whom were in the Lake Mburo game reserve corruptly. This increased competition for land for grazing and cultivation reduced availability of woodlots and increased swamp reclamation in the sub-region as people continued to settle. While countrywide, the size of Uganda's forest cover has continuously declined by 25.7 percent between 1990 and 2000 and by 9.4 percent since 2000. The major declines were observed in woodlands, broadleaved and pine plantations (SOER, 2007).

The R-square values posted from the regressions vary distinctively; Small-scale farmlands (0.723), tropical high forest (0.697), wetlands (0.049), and woodlands (0.053). This scenario reflects two strands; the first explains the relatively high R-square values for small-scale farmlands and Tropical High Forests. In these two units, the rates of change are still very high; land is more sought from the tropical high forest by small-scale farmers that are expanding their cultivable land. On the other hand, the lower R-Square values from wetlands and woodlands is a situation of exhaustion of these type of land cover units thus the rates of change are no longer drastic because there is very little to clear. In essence therefore, there is a lower rate of change occurring within the woodlands and wetlands compared the Tropical High Forest.

CONCLUSION

Household size and the weak environmental laws were the main drivers of land use/cover changes. Other drivers included; type of crops grown, extension agents' visits, and customary land tenure, all were statistically significant predictors of land use/cover change ($P<0.05$). The magnitude of small scale farming (non-uniform) largely increased by 5% from 1975 to 1999 while areas covered by Tropical high forest relatively decreased by 16% between 1975 and 1987 but slightly increased by 1% in 1999. The areas covered by wetlands comparatively increased by 4% from 1975 to 1987 and by 1999 they slightly decreased by 3% while the woodland areas also moderately decreased by 3% from 1975 to 1987 and to some extent increased by 2% in 1999 in Kirima sub-county.

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REFERENCES

Abonyo, C.K., Isabirye, M., Mfitumukiza, D., Magunda, M.K., Poesen, J., & Deckers, J. (2007). Land use change and local people's perception of the effects of change in Ssese islands, Uganda. National Agricultural Research Organisation, Uganda.

Abu, M.,(2005) Homegardens in Smallholder Farming Systems: Examples from Bangladesh. *Human Ecology*, Vol. 33, No. 2. pp. 245-270. Published by Springer. DOI: 0300-7839/05/0400-0245/0

Bagoora, F., (1988). Mountain Research and Development. Vol. 8 No. 283. Department of Geography – Makerere University, Kampala.

Bancy, M., Simon, M., Patrick, H., Felix, M., and Hussein, G., (2005). Land Use Changes in the Trans-boundary Mara Basin: *A Threat to Pristine Wildlife Sanctuaries in East Africa*. Paper presented at the: 8th International River Symposium, Brisbane, Australia, and September 6-9, 2005.

Bengt, P., (1992). Urban applications of satellite remote sensing and GIS analysis. Published by the International Bank for Reconstruction and Development/ the World Bank, USA. Pp 1-39.

Borden, D. (1999). Cartography, thematic map design. Published by McGraw-Hill Boston USA. PP 50-84.

Boserup E. (1965): The Conditions of Agricultural Growth. Faber, London.

Burrough, P., and McDonnell, R. (1998). Principles of geographical information system. Published by Oxford University Press. Pp 1-47.

Carol, J. (1998). Geographic information systems in ecology. Published by Blackwell Science, USA. Pp 1-49.

Clark, J., and Steven, M. (1996). Application of remote sensing in agriculture. Published by Butterworths, London. Pp 337-397.

Census Atlas (2002). Uganda population and housing census. Mapping socio-economic indicators for national development.

Dale, V., Archer, S., Chang, M., and Ojima, D., (2005). Ecological Impacts and Mitigation Strategies for Rural Land Management. Ecological Applications, Vol. 15, No. 6, pp. 1879-1892, Published by Ecological Society of America.

Deborah, L., (2004). Erosion of Tree Diversity during 200 Years of Shifting Cultivation in Bornean Rain Forest. Ecological Applications, Vol. 14, No. 6, pp. 1855-1869. Published by Ecological Society of America.

Defries, S., Jonathan, A., and Gregory, P. (2004). Land use choices: Balancing Human Needs and Ecosystem Function. *Frontiers in Ecology and the Environment,* **Vol 2**. Pp 249-257. Published by Ecological Society of America.

Egeru, A & Majaliwa, M.G.J. (2009). Land use/cover trend in Soroti District Eastern Uganda. *Journal of Applied Sciences and Management* Vol. 13(4) 77 – 79

EPB (2007). Environmental Policy Brief for Lake Victoria Basin, school of economics and commercial law. Göteborg University

Falloux, F., (1989). Land information and remote sensing for renewable resource management in Sub-Saharan Africa. Published by the World Bank, Washington, D.C. Pp 1-34.

FAO (2006). Livestock's long shadow; 00153 Rome, Italy

Floriane, C. & Amezaga, J.M. (2008). Land use change and reforestation in Viet Nam. Id21 natural resources highlights 7.

Framer-Browers Q., Crosthwaite, J., Collaghan, J., Hollier, C., & Straker, A. (2006). Drivers of land use change: matching opportunities to motivations. A report by department of sustainability and environment, Melbourne.

Gastellu-Etchegorry, J. (1990). Satellite remote sensing for agricultural projects. Published by the World Bank, Washington, DC. USA. Pp 1-42.

Germano, M., and Evenson, R. (2001). The Effect of Agricultural Extension on Farm Yields in Kenya. Published by African Development Bank.

Gifford-Gonzalez, D., (2000). Animal Disease Challenges to the Emergence of Pastoralism in Sub-Saharan Africa. The African Archaeological Review, Vol. 17, No. 3, pp. 95-139. Published by, Springer. 0263-0338/00/0900-0095$18.00/0.

Hosmer, D., & Lemeshow, S. (2000). Applied logistic regression (2nd ed.). New York; Wiley

Howard, J., (1991). Remote sensing of forest resources; theory and application. Published by Chapman and Hall, London. Pp 2-20.

Huxhold, W., and Levinsohn, A. (1995). Managing geographic information system projects. Published by Oxford University Press, USA. Pp 1-25.

Jan P. L., Peter H. V., & Steven J. S., (2005). Statistical methods for analyzing the spatial dimension of changes in land use and farming systems. LUCC Report Series 7. Published by: International Livestock Research Institute. ISBN: 92-9146-178-4, ISSN 1138-7424

Jarosz, L., (1993). Defining and Explaining Tropical Deforestation: Shifting Cultivation and Population Growth in Colonial Madagascar (1896-1940), Economic Geography, Vol. 69, No. 4, Environment and Development, Part, pp. 366-379. Published by Clark University.

Jensen, J., 1986. Introductory digital image processing – A remote sensing perspective. Prentice Hall, New York, USA.

Kamusoko, C & Aniya, M. (2007). Land use/cover Change and Landscape Fragmentation Analysis in the Bindura District, Zimbabwe. *Land Degradation and Development* 18: 221–233

Krishna, P., Stinner, B., Deb, S., Cardina, J., Moore, R., Prabhat, K., Harao, T., Kiyoto, T., Badarinath, K., and Casey, H., (2003). Trends in food production and nitrous oxide emissions from the agriculture sector in India: environmental implications. *Regional Environmental Change.* Vol.3. no.4. pp. 154-161. DOI: 10.1007/s10113-002-0055-y.

Lambin, E., Helmut, J., and Erika, L. (2003). Dynamics of Land-Use and Land-Cover Change in Tropical Regions. *Annu. Rev. Environ. Resour*. Vol. 28:205–401.

Lang, L. (2001). Managing Natural resources with GIS. Published by ESRI, New York Street USA. PP 1-15.

Lo, C. (1986). Applied remote sensing. Published by Longamn Group Ltd, UK. Pp 227-278.

Longley, P., Goodchild, M., Maguire, D., and Rhind, D. (1999). Geographical information systems. 2nd edition. Published by John Wiley and Sons Inc, USA. Pp 909-1002.

Martin, D. (1996). Geographic information systems, socio-economic applications. 2rd edition. Published by Routledge, London. Pp 10- 35.

McCloy, K. (1995). Resource management information systems process and practice. Published by Taylor & Francis Ltd, UK. Pp 342-345.

Morain, S. (1999). GIS solutions in natural resource management. Published by Onword Press 2530 Camino Entrada Santa USA. Pp1-8.

Morgan, W., & Jerzy, S., (1994). Agricultural Crisis in Sub-Saharan Africa: Development Constraints and Policy Problems. *The Geographical Journal,* Vol. 160, No. 1, pp. 57-73. Published by the Blackwell Publishing.

Mulders, M. (1987). Remote sensing in Soil Science. Published by Elsevier Amsterdam. Pp 256-287.

Mundia, C., & Aniya, M., (2006).Dynamics of Landuse/Cover Changes and degradation of Nairobi City, Kenya. *Land Degrad. Develop.* 17: 97–108. DOI: 10.1002/Ldr.702

Mwavu, E., & Witkowski, T. (2008). Land-use and cover changes (1988–2002) around Budongo forest reserve, NW Uganda: implications for forest and woodland sustainability.

NBS (2003). National Biomass Study Technical Report of 1996-2002. ISBN: 9970863002

NEMA (2001). Uganda State of the Environment Report 2000 Version 2. Kampala, Uganda: National Environment Management Authority, Ministry of Natural Resources, Government of Uganda.

Ngo Mpeck, M.L., Asaah, E., & Tchoundjeu, Z. (2003). Contribution of Tree Domestication to the Conservation of Indigenous Medicinal Plants of African Forests. A Paper submitted to the XII World Forestry Congress, Canada.

Nieuwenhuis, G., Vaughan, R., and Molenaar. M. (1999). Operational remote sensing for sustainable development. Publised by A.A. Balkema Publishers, Rotterdam. Pp 37-45.

Nkonya, E., John, P., Sserunkuuma, D., and Jagger, P., (2002). Development Pathways and Land Management in Uganda. In *Policies for Sustainable Land Management in the East African Highlands*, edited by S. Benin, J. Pender and S. Ehui. Washington, D.C. and Nairobi, Kenya: International Food Policy Research Institute and International Livestock Research Institute.

Olson, M., Jennifer, S., David, J., Milline, M., and Sam, M (2004). The spatial patterns and root causes of land use change in East Africa. LUCID Project working Paper 47. International livestock Research Institute, Nairobi.

Oosterom, P. (1993). Reactive data structures for GIS. Published by Oxford University Press, New York. Pp 1-22.

Peng, J., Wu, J., Yin, H., Li,Z., Chang, Q, and Mu, T., (2008). Rural land use change during 1986-2002 in Lijiang, China based in Remote Sensing and GIS data*. Sensors* Vol.8 Pp.8201-8223.

Place, F. & Otsuka, K. (1997). 'Population, land tenure, and natural resource management: the case of customary land area in Malawi', Environment and Production Technology Division Discussion Paper No. 27, International Food Policy Research Institute, Washington, D.C.

Ramankutty, N., Foley, JA and Olejniczak, NJ (2002). People on the land: Changes in global population and croplands during the 20th century. *Ambio* 31: 251-257

Rolf, L., & Lennart, S. (1991). A practical approach to satellite image analysis for environmental monitoring. Published by Swedish Space Corporation. Pp 53-61.

SOER (2004). State of Environment Report for Kanungu District.

SOER (2007). State of Environment Report for Uganda, published by NEMA

Tukahirwa, J., (2002). Policies, people and land use change in Uganda. A case study in Ntungamo, Lake Mburo and Sango Bay sites. Land use change impacts and dynamics project working paper 17; Nairobi. International livestock Research Institute.

UBOS (2002). Uganda Population and Housing Census Atlas

UNEP (1997). GIS awareness package in agricultural research. Published by UNEP. Pp 1-5.

Unna, C., Suyanto, P., Iwan, K., Josni, M., Andy, D.,, Noviana, K., and RH Susanto (2007). Community fire use, resource change and livelihood impacts: The downward spiral in the wetlands of southern Sumatra. *Mitigation and Adaptation Strategies for Global Change.* Vol. 12, Pp 75-100.

USDA Forest Service (2004). Land Use Conversion: Addressing the Four Threats in an International Context. USDA Forest Service International Programs.

Wilkie, D., and Finn. J. (1996). Remote sensing imagery for natural resources monitoring. Published by Columbia University Press. Pp 29-60.

Zake, J., Nkwijn, C., and Magunda, M.,(1999). Uganda. In Integrated Soil Management for Sustainable Agriculture and Food Security in Southern and East Africa: Proceedings of the Expert Consultation, edited by H. Nabhan, A. M. Mashali and A. R. Mermut. Harare, Zimbabwe: Food and Agriculture Organization of the United Nations.