Impacts of Population Growth on Land Cover Change. Case of Nyanza District.

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ABSTRACT

Loss of biodiversity and pressures on ecosystem services are among the most pressing global challenges. At global scale, countries continue to convert land from its more natural state to more anthropogenic systems. In Nyanza district, land cover change over time. This study set out to assess the impacts of population growth on land cover change in Nyanza district. It aimed to analyze how land cover has been changing in the past twenty years, assess the trend of population and their effects on land cover and establish the relationship between population growth and land cover change. The study mapped land cover using GIS and Remote Sensing to detect changes during the period of 1999, 2009 and 2019. The maximum likelihood classification was applied to classify images into seven classes named built up, bare land, cropland, grassland, forest, wetland and water body. The quantities for land cover classes, accuracy for classification were calculated. It has been found that built up area, bare land, and cropland and water body has increased at a considerable rate; while grassland, forest and wetland have decreased. Moreover, population growth is the main driver of land cover change in Nyanza district. Rapid increase of human population put extraordinary pressure on natural resources. The study recommends awareness on family planning to slow the rate of population growth, promote land use planning and use spatial data in analysis so as to take effective decisions on a sustainable natural resources management including land and forests.

Key words: Population growth, GIS and Remote Sensing, Natural resources, Land cover change, Nyanza district.

1. INTRODUCTION

Loss of biodiversity and pressures on ecosystem services are among the most pressing global challenges. At global scale, countries continue to convert land from its more natural state to more anthropogenic systems, with potentially harmful impacts on biodiversity and ecosystems (OECD, 2018).

The history of man's dependence on natural resources for survival is as old as the origin of man (Mmom, Prince, & Mbee, 2013).Worldwide, 2.7% of natural vegetated land has been lost to other land cover types since 1992 (OECD, 2018).In the past decade alone, about 130 million hectares of forest were lost (FAO, 2012).The primary source related to land use has been the conversion of native vegetation like forests and grasslands to croplands, which in turn has released carbon from vegetation and soil into the atmosphere (Daniel & Colin, 2013).

The world population was 2.52 billion in the year 1950, which increased to 6.06 billion in 2000 and is likely to reach 9.8 billion by the year 2050(UN, 2017). Developing countries are facing and suffering a serious problem of high population growth which is causing environmental degradation. A rapidly growing population exerts pressure on agricultural land and raises demand for food and shelter (Maximillian, Brusseau, Glenn, & Mathias, 2019).

The global land area is 13.2 billion ha. Of this, 12 percent (1.6 billion ha) is currently in use for agriculture, 28% under forest. The global area of cultivated land has grown by a net 159 million ha since 1961, and since 1850; croplands has converted some 6 million km^2 of forests or woodlands and 4.7 million km^2 of savannas, grasslands and steppes (FAO, 2011).

Much of the rapid deforestation today is taking place in developing countries, where people are struggling for living and provide for their families. Rain forests will completely disappear in a hundred years with the current rate of deforestation (Tran, Lewis, Lu, & Mills, 2010). However, over recent decades, Africa has been the continent experiencing the highest rate of deforestation, 0.49% per year. This represents 3.4 million hectares lost annually. Small-scale agriculture, urbanization and fuel wood collections are the main drivers of deforestation and forest degradation (FAO, 2012).

Rwanda is one of the most populated countries in Africa and land is scarce. The Nation is experiencing a steady period of growth, in terms of both population and economic development. The result is an increase in competition and conflict of land use, exacerbated by effects of climate change (ROR, 2017).

Nyanza district has the high population density of 482 inhabitants per km^2. Mukingo, Busasamana, Muyira and Kigoma are the mostly populated sectors with over 35 thousand residents. That high population induces natural resources degradation by converting the existing land

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uses in search of more agricultural land, built up area (Nyanza district, 2013).

The major aim of this study was to assess how population growth have impacted land cover change especially in Nyanza district by using remotely sensed data acquired between 1999, 2009 and 2019. These include the quantification of land cover classes in Nyanza district, show the trend of population growth and their effects on land cover and finally establish the relationship between population growth and land cover change.

The present study focused on the use of spatio temporal data for analyzing land cover change. The indicator measured quantity of forest, wetland, built up, bare land, grassland, water body and cropland of each land use type in different time scale (1999, 2009 and 2019).It cannot distinguish the loss of habitats; also it does not capture degradation of the land if the class remains the same.

Furthermore, many studies have been undertaken in different regions and various research methods were applied. However, there some key issues that have not yet been addressed, concerning the rapid growth of human population in relation to land management, the use of spatial data to take informed decisions about land use.

Land is essential to civilization and is the basis for economy and survival. It plays an indispensable role in enhancing the quality of environment (Rahul & Chandi, 2013). There is a pressing need to protect, conserve and restore so as to keep its functions.The results from analysis of the spatial data would be helpful for policy makers and government authorities to prioritize the area where more attention is needed, take measures for effective planning, conservation and management of natural resources and prediction for the future.

2. Materials and Methods

2.1. Study Area Description

Nyanza district is located in the south of Rwanda. It is one of the eight Districts which constitute the Southern Province. It is subdivided into 10 Sectors, 51 Cells and 420 villages (Imidugudu). It has a surface area of 672.4 km^2 and an estimated population of 388,338 people by the end of 2019 (Nyanza district, 2020).

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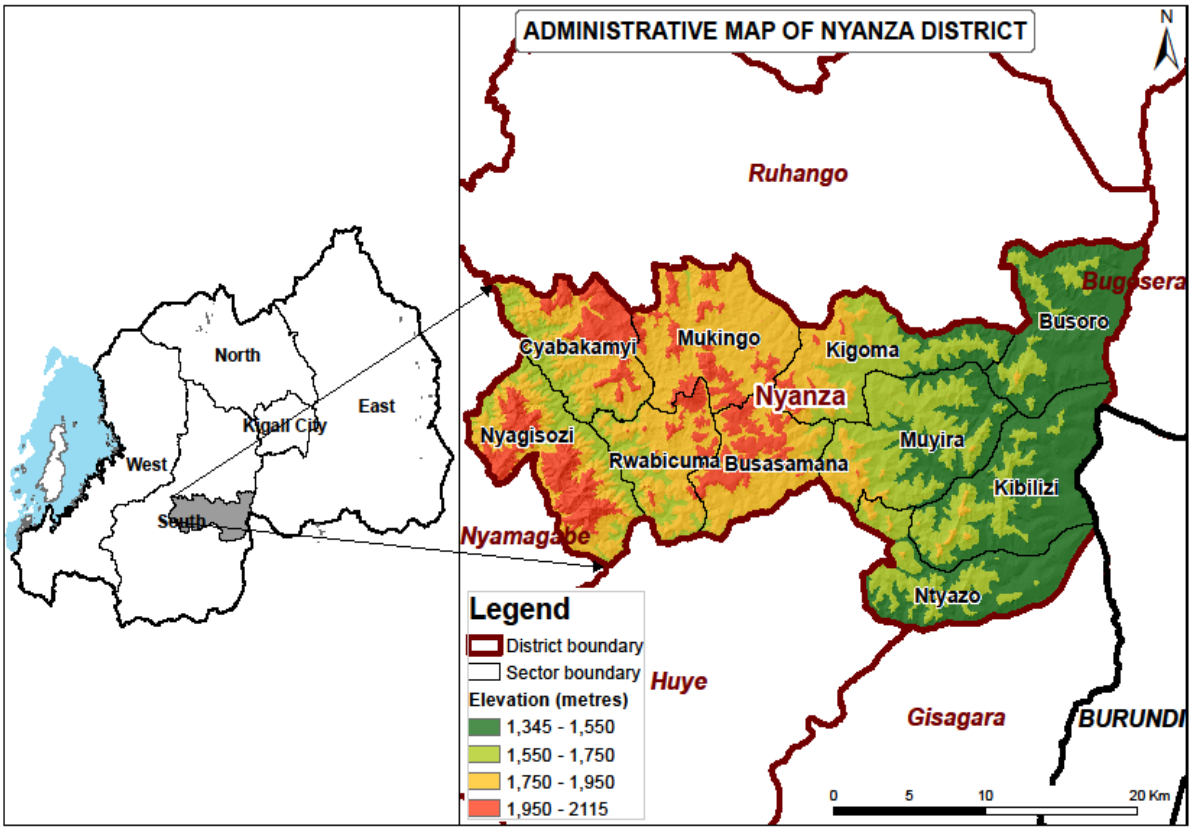

Figure 1: Administrative map of Nyanza district

2.2. Data Gathering Procedures

Primary Data Source: Methods used to collect primary data includes visiting the study area to take samples for each land cover types using GPS and take photos by camera and interview with local leaders in Nyanza district in charge of environment, forestry and land use planning at district and sector level. Thus, those data completed others obtained from field observation and existing data of the study area.

Secondary Data Sources

a) Literature Review: These include books, documentation unit of the government, internet sources such journals, reports, and other scientific papers related to the topic.

b) Population Datasets: The existing statistics available about population in Nyanza district was collected at district level and NISR portal and used to assess the population status and trend in the selected study time in the area.

c) Spatial Datasets: To facilitate spatial analysis; Landsat images of 1999, 2009 and 2019 were collected from United State of Geological

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Survey (USGS) for land cover classification. Rwanda Orthophoto and Google satellite images in 1999, 2009 and 2019 were also used to select and recognise sample areas for accuracy assessment and define land cover classes. Administrative boundaries, Road network, river network shapefiles of Rwanda from Rwanda Natural Resources Authority were also used to recognize the administrative boundaries and key features of the study area and Digital Elevation Model to extract information about elevation.

2.3. Data Analysis Procedure

In this study; Arc Map (10.8 version), Quantum GIS (3.8 version) and Erdas Imagine were used for spatial data manipulation, analysis and presentation. Those included Digitization, georeferencing, overlay tools, image classification and accuracy assessment.

To facilitate land use/land cover classification, polygonal areas of interest was selected (200 samples) as training sites to represent each land use/ land cover types in the study area. And those samples were drown in the whole area in order to develop representative spectral signatures for each class. Some of the training sites were recorded during ground visits of the study area and special analysis of supervised classification was done by using digital reference data from 1999, 2009 and 2019 so as to get the quantities of each land cover class

Based on the satellite image, Google earth image and field observation; seven land cover classes created are forest, built up, bare land, Cropland, grassland, wetland, and water body.

Table 1: Description of land cover classes

Land cover class	**General description**
Built up area	This class includes residential area, commercial centres, schools, health centres, churches,
Bare land	Are area with mining site, quarry, unpaved roads
Forest	Forest plantation (private and state). It includes trees with close and open canopy like eucalyptus, pinus, grevellia,
Grassland	Grazing area, shrubs and very sparse vegetation,
Wetland	Land consisting of Cultivated marshland, swamps or saturated land
Water body	These includes inland water, mainly dam reservoir

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Cropland	Land generally used to grow crops. These includes seasonal crops (soja, beans, maize.) and perennial crops (coffee and banana which are dominant in the area).

Accuracy assessment: Land use maps derived from image classification usually contain some errors; there is a need for the validation of the results from land cover classification. Error/confusion matrix is a common method used for measuring the accuracy of the classified images. This matrix compares information obtained by reference points to that provided by the classified image in certain sample areas. The reference points of 1999, 2009 and 2019 were obtained from high-resolution images (Google Earth of 1999-2019 and Orthophoto of 2009) and field visit.

In total, 210 reference points were used to generate an error/confusion matrix whereby 50 reference points were considered for the land cover types that have large area coverage (Cropland and forest), land use and cover type with medium coverage 30 reference points were considered (Wetland, grassland and built up) while land cover type with low area coverage such as bare land and water body, 10 reference points were considered.

Land cover change detection is one of the most important applications of remote sensing techniques. This study employed GIS Analysis tools of overlay for the creation of the land use matrix model that described the changes in land use types between the two study periods of 1999 and 2009, and 2009 and 2019.

Moreover, the degree of land use dynamics of various land cover types was quantitatively analyzed. It is expressed as: $K = \frac{U_2 - U_1}{U_1} \times \frac{1}{T} \times 100$; where K indicates the degree of the land use dynamics; U1 and U2 are the area of a land use type at the beginning and the end of a period, and T is the time interval (years). This equation was used to analyze and compare the rates of change among the different land use types in the study area.

Additionally, for the analysis of population growth and land cover change in Nyanza district, Interview of key persons was also used. This helped to obtain more information from informed and knowledgeable people on the historical trends in land use/ cover change, population growth and their impacts, as well as socio-economic status.

The results was analyzed through Microsoft excel and SPSS through its ability of table construction system, to provide graphs, diagrams, mean, percentages and differences that are important in providing

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accurate, effective and efficiency in result interpretation. The analysis of spatial data helped to produce maps, graphs and images that were interpreted to well visualize the environmental changes. This step of data analysis and interpretation are crucial while helped the verification of hypothesis and formulation of conclusion and recommendations.

3. Results and Discussion

3.1. Land cover change in Nyanza district

Three maps presented in figure 2 show land cover classes of Nyanza district in 1999, 2009 and 2019. Seven classes are displayed namely built up, bare land, forest, grassland, water body, wetland and cropland.

The results presented in figure 2 and table 2 shows that Nyanza district have been experiencing rapid land cover dynamics. According to ROR, 2017; Rwanda is one of the most populated countries in Africa, land is scarce and nation is experiencing a steady period of growth, in terms of both population and economic development. The result is an increase in competition and conflict of land. The tremendous change and conflict on land cover and use has been observed between 1999 and 2019. The major causes of change are linked to population growth and their associated economic activities.

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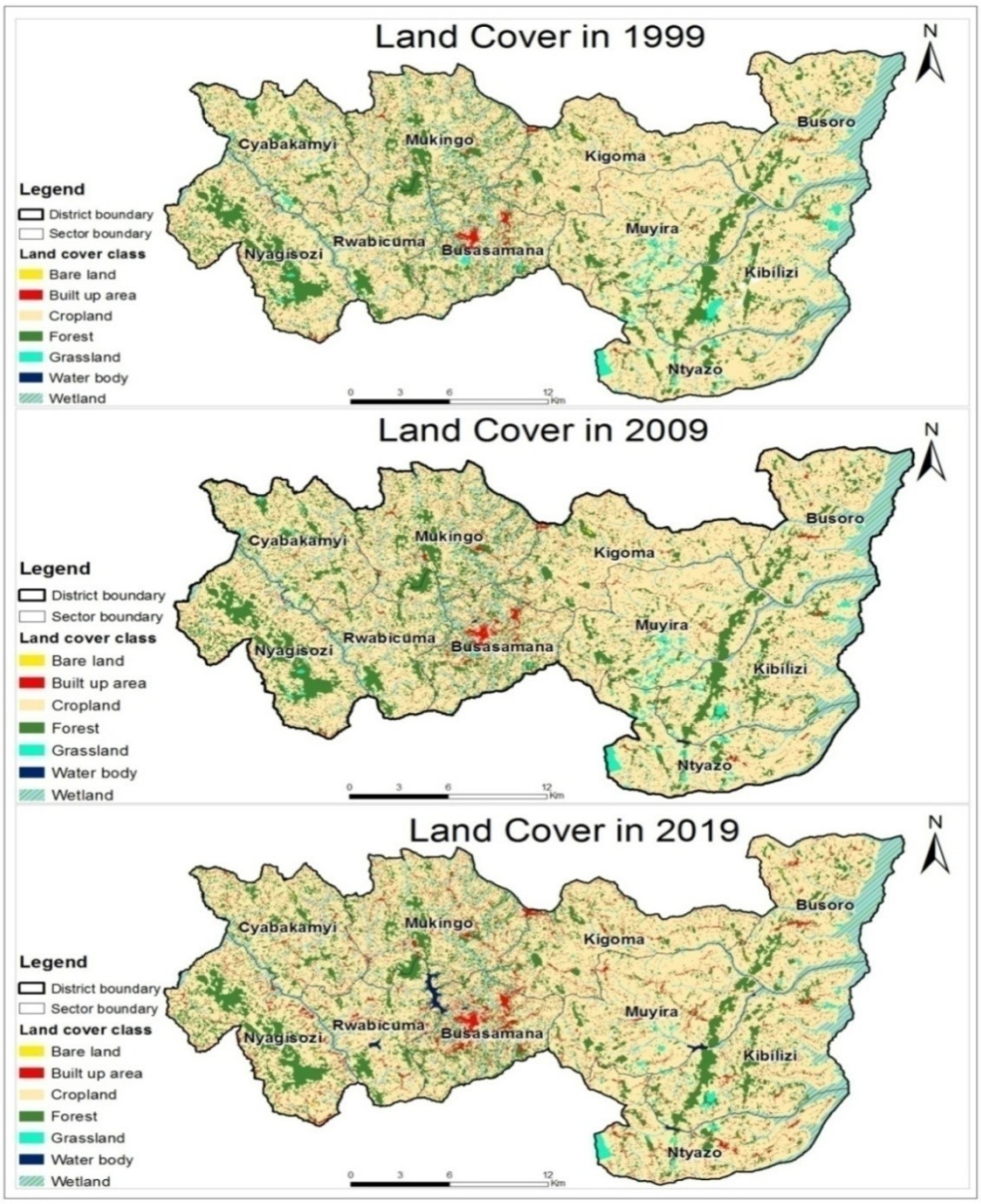

Figure 2: Land cover maps of 1999, 2009 and 2019

Table 2 shows the quantities of land cover classes and their respective percentages to the total land cover. It shows a decrease in forest cover, wetland and grassland while at the same time there is an increase in cropland, bare land, water body and built-up areas.

Table 2: Areas of Land cover types in 1999, 2009 and 2019

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Land use/Cover type (Area in Ha)	1999		2009		2019		Land use/ cover change					
							1999-2009		2009-2019		1999-2019	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Built up	1792	2.7	2214	3.3	3315	5	422	0.6	1101	1.6	1523	2.2
Bare land	5	0.007	16	0.02	42	0.06	11	0.01	26	0.03	37	0.05
Cropland	44544	66.2	45836	68.1	45972	68.5	1292	2	136	0.2	1428	2.1
Forest	12228	18.2	10997	16.34	10186	15.1	-1231	-1.8	-811	-1.2	-2042	-3
Grassland	1420	2.1	933	1.5	496	0.7	-487	-0.7	-437	-0.65	-924	-1.4
Water body	6	0.009	28	0.04	215	0.3	22	0.03	187	0.27	209	0.3
Wetland	7253	10.8	7223	10.7	7021	10.4	-30	-0.04	-202	0.3	-232	-0.3
Total Ha	67247	-	67247	-	67247	-	-	-	-	-	-	-

Source: Author, 2020

The results of the accuracy indicated the good overall accuracy for classification was 88.36 % in 1999; 91.18% in 2009 and 93.8% in 2019.

The statistics of the main types of land cover change in the area shows that cropland, forest and wetland are among the dominant land cover types in Nyanza district covering 66.2%, 18.2% and 10.8% of the total land cover types respectively in 1999 (table 2). From 1999 to 2009, cropland, built up, water body and bare land area increased by 2%, 0.6%, 0.03% and 0.01% respectively. However, during this period, the forest decreased from 18.2% to 15.1% implying a decrease of 1.8%. Grassland and wetland showed a decrease of 0.7% and 0.04% respectively.

From 2009 to 2019; built up showed a high increase of 2.2 % compared to other land cover types, followed by cropland which increased by 2.1%, water body increased by 0.3% and bare land increased by 0.05%. While forest, grassland and water body decreased by 3%, 1.4% and 0.3 respectively.

The cropland area occupied 66.2%, which has changed to 68.1% in 2009 and finally to 68.5% in 2019.The results are supported by FAO study conducted in 2017, which shows that agricultural land totals 81 million hectares, covering almost 48 percent of the sub region's total land area. The reason for being over 65 % in Nyanza

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is justifiable as there is no extensive natural vegetation like forests and grasslands in the area. Those abrupt changes are linked to the search of more agricultural land so as to increase the production in the area. At the same time, considerable amount of forest, Wetland and grassland area have reduced.

Forests in Nyanza district are located mainly in areas with high elevation. The main sectors with forest resources are Nyagisozi, Cyabakamyi, Mukingo, Busasamana, Kigoma and Rwabicuma. According to the classified land cover, forest covers 18.2%, 16.3% and 15.1% of the total land cover in 1999, 2009 and 2019 respectively. This shows a reduction where from 1999 up to 2019; 2042 hectares have been lost to other land cover types in that period. Other findings shows that demand for charcoal, construction materials and agricultural land, lead to continued deforestation, forest degradation and soil degradation (Oliver, 2018).

In the past 20 years. There has been a drastic increase in built up, cropland and water body at the expense of other land cover in Nyanza district. The diagonal values (shaded) in the table indicate classes of no change (the stable values within 10 year interval).

Table 3: Transition matrix of land cover in Nyanza district from 1999 to 2009

	Built up	Bare land	Cropland	Forest	Grassland	Water body	Wetland
Built up	1200	1	921	76	12	0	4
Bare land	0	1.9	5	8	1.1	0	0
Cropland	453.3	1.8	42708.5	2100	501	1	70.4
Forest	115	0.3	683	10013	183	1.7	1
Grassland	23	0	211	12	687	0	0
Water body	0	0	3	1	0	2.5	21.5
Wetland	0.7	0	12.5	18	34	0.8	7157

Table 4: Transition matrix of land cover in Nyanza district from 2009 to 2019

	Built up	Bare land	Cropland	Forest	Grassland	Water body	Wetland
Built up	1809	0	1375	111	19	0	1
Bare land	0.3	5.7	13	20	3	0	0
Cropland	390	9.6	43362.1	1704	415	1	70.4
Forest	12	0.7	1009.3	9134	29	0	1
Grassland	1	0	26	2	467	0	0

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Water body	0.3	0	5.6	1	0	23.5	184.6
Wetland	1.5	0	25	25	0	3.5	6966

The table 3 and 4 clearly shows that most of the deforestation (decrease in forest cover) in the past 20 was caused by the conversion to cropland, built up area and bare land. From 1999 to 2009, the deforestation was caused 12% by the conversion to built up area, 70% conversion to cropland and 18.5% degraded to grassland with the stable forest remained 10013 hectares. The reforested area within this time interval was 2215 hectares.

From 2009 to 2019, the deforestation was caused mainly by agricultural expansion 96% and built up increase 1%, the degradation to grassland 3%, and 1 % by bare land especially by quarrying and mining site development. The stable forest was 9134 hectares with new planted forest of 1863 hectares

Other studies revealed that population growth are important drivers of deforestation whereas the top 10 countries experiencing the greatest forest loss associated with land degradation have large populations and many of which continue to grow rapidly (PAI, 2011).This has resulted in the loss of substantial parts of the forest cover through clearing for agriculture, settlements, charcoal manufacturing and other human activities (AfDB, 2015).

However, over recent decades, Africa has been the continent experiencing the highest rate of deforestation, 0.49% per year. This represents some 3.4 million hectares lost annually. Small-scale agriculture and fuel wood collections are the main drivers of deforestation and forest degradation (FAO, 2012).

According to the Republic of Rwanda, 2017; before 2000s there was no proper forest protection and management in the country. This period was characterised by extreme deforestation. The moderate changes from 2009-2019 compared to the other year intervals is that the government of Rwanda has put in place the National Forestry Authority (NAFA) with the responsibility of coordinating the forest management and agroforestry development in Rwanda in 2008. And this NAFA should refer to other programs of Vision 2020 and the Economic Development and Poverty Reduction Strategy (EDPRS), the Environment and Natural Resources Sector Strategic Plan (ENRSSP), the National Forestry Policy and other sectoral policies (REMA, 2011).

From 1999 to 2009 the built up area has increased, shifted from 1792 to 3315. The

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new built up area has been constructed 90.8% from agricultural land, 7.5% from forest destruction, 1% from grassland. While from 2009 to 2019, the increase resulted from 92% in cropland, 10% from forest and 2% from grassland. These imply that from 1999 to 2019 the increase trend in built up is due to the conversion of cropland, forest and grassland to residential or other form of built up use like schools, health posts, industries.

Grassland in Nyanza district occupied a large portion as it was the area for livestock in the past years (Nyanza district, 2013). Due to the development in agricultural practices, some of the grassland area like bush has been cleared. During the study time, it changed from 1420 hectares in 1999 to 496 hectares in 2019.

The bare land has been increased at a considerable rate. Those are mainly due to the development of mining and quarry in the area sometimes linked with the infrastructure development like roads. In 1999, the area for bare land was 5 hectares which increased to 16 in 2009 and then 42 in 2019. The rate of change per year in is high compared to other land cover types in Nyanza district. The bare land increases the rate of soil erosion and water pollution (Adam, 2019). Human activities are the mostly the cause of change in search for other non farm income generating activities and infrastructure development.

The bare land increase resulted 35% in conversion from cropland, 56.7 from forest and 7.8 % grassland from 1999 to 2009. From 2009 to 2019, 26 hectares were also added to the existing bare land converted from cropland, forest, grassland and built up and by 36%, 55%, 8% and 1 % respectively.

The study shows that the wetland land area has decreased in the past 20 years, while at the same time the water body surface are increasing. From 1999 to 2019, water body showed a rapid increase resulted from the conversion from cropland by 11%, 3.8% from forest while 85 % are converted from the existing wetland. The results from interview revealed that in order to increase the production to support the growing population, Dam are constructed to support irrigated agriculture. Sample of areas includes a dam reservoir located between Muyira, Kibirizi and Busoro sectors, the other one is in Mukingo sector and in Rwabicuma and between Kibirizi and Ntyazo sectors. The landscape has also changed as new radical terraces have been created.

The large wetland area of Bishya located between Busasamana, Rwabicuma and Mukingo has been drained due to dam constructed for water supply in Nyanza and Ruhango district. This has reduced the total area allocated from wetland to water body class. As new infrastructure developed

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(Dam), it attracts other human activities like settlement, road construction, warehouse construction and others.

Even though cropland has changed to other land cover types, in the past 20 years, it increased by 1428 hectares. 14% were from built up, 67% from forest, 16% from grassland (from 1999 to 2009). While from 2009 to 2019, the stable cropland area was 43362.1 hectares. With 65% of the increase were from forest, 16% from grassland, 16 % from built up; 0.2 % from bare land, while 3% from wetlands.

According to NISR, 2015; about 88.3% of Nyanza district population are engaged in agricultural activities and land is generally fertile. The Amayaga region is dominated mainly by agriculture and in line with other sectors of Nyanza district which are rural except Busasamana with a large urban part. The increases are due high population searching for food and other agricultural products as expressed by interviewers during the study so as to support their living conditions. And are linked to poorly industrial sector development in the area with poorly developed socio economic infrastructures like road, electricity, thus the increasing population are mostly engaged in agricultural activities as revealed by Nyanza District, 2013

In summary, land use change in the study area are clustered into three major categories: Built up and bare land expansion (from forest, cropland and grassland to bare land and built up), deforestation (from forest to cropland, built up and grassland), cropland extension (from forest, grassland and others to cropland) and wetland conversion (involving the change from wetland to water body and cropland).

3.2. Trends of Population Growth and its Effects on Land Cover in Nyanza

3.2.1. Trends of Population Growth in Nyanza district

The rate of population growth in Rwanda took a sharp upswing around 2000 following the genocide that took so many lives in 1994 but has since steadied into consistent annual growth of over 2%. This growth is a challenge for the development of Rwanda, as it is Africa's densely populated non-island nation (Tom, 2013).

The population in Nyanza district are changing year after year according to figure3. It has the land area of 67,247 hectares with the estimated population of 388,338 by the end of 2019.Which has shifted from the population of 323,719in 2012 national census according to the NISR. The increased population have to share the same resources of land for survival.

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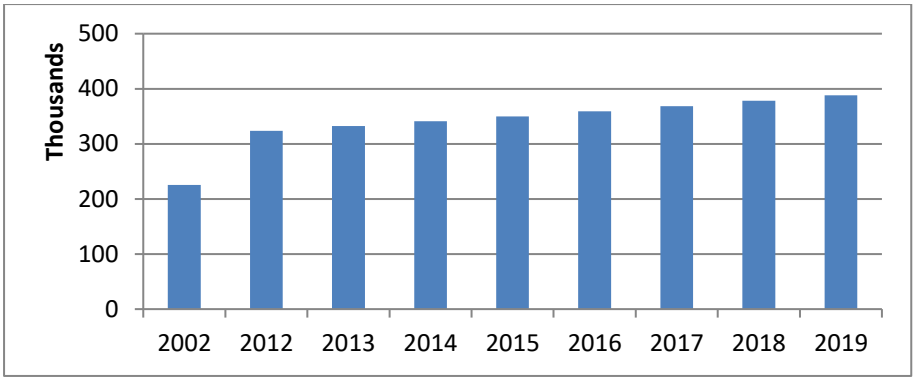

Figure 3: Population trend in Nyanza district from 2002 to 2019
Source: Nyanza district, 2020

Mukingo, Busasamana, Muyira and Kigoma are the mostly populated sectors with over 35 thousands residents each. They represent 16%, 13%, 11. % and 11 % of the total population of the district, respectively. The less populated sector is Rwabicuma (21 thousand inhabitants). It represents 6% of the total resident population of Nyanza District in 2019.

It is evident certain sectors are more populated than others. This are linked to internal migratory movements of unemployed population seeking off farm income generating activities. Apart from rural exodus phenomenon, the concentration of the population in Sectors of Busasamana, Kigoma, Busoro and Mukingo is influenced by the availability of development infrastructures such as schools, markets, hospitals, means of communication, water accessibility, etc(Nyanza, 2013).

An increase in food supply must match the rate of population increase, yet there is no more space for additional agriculture while the main industries within Rwanda are agriculture, energy, industry, and tourism, thus this hinder proper management of natural resources.

3.2.2. Effects of population Growth on Land Cover in Nyanza

Population growth and their associated economic activities have resulted to several land cover changes in the study area. This increase in population has implications for land resources as the need to produce food, demands for shelter and fuel wood increase in response to growing population needs.

The large proportion of the respondents from interview agreed that population growth is the main driver of land cover change in Nyanza district. They have also highlighted other causes of land cover change including market price and access, land use policies, intensification of human

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activities, biophysical drivers and agro-technical advancement. The increased demand and market price for agricultural production and forest products (wood and charcoal) influence people to degrade forest and convert to agricultural use.

The impact of population growth in Nyanza district include deforestation which is attributed to the expansion of agricultural land, mining, logging as well as the increased demand for the forest products such as fuel wood and charcoal; all to respond the demand of the increasing population.

Figure 4: Change in land cover from forest to bare land in Ntyazo sector

A

(b)

The image (a) of 2009 and the image (b) of 2019 show a clear land cover change resulted from human activities. It changed from forest to bare land (mining site), in Ntyazo sector, The symbol X and Y are located on the same place on both images.

Worldwide, during the last two decades, agricultural expansion and other human activities caused the deforestation of more than 120,000 km^2each year (Rahul & Chandi, 2013). In Nyanza district, population growth has led to unsustainable management of the forest and grassland and wetland. 86 % of the deforestation is caused by agricultural expansion, 7% by built up increase. The study is similar to Simon, 2017, who revealed that densely populated area had led to disappearance of ecological systems and change in land cover.

According to the results from land cover mapping, in the past 20 years population growth has influenced settlement expansion whereas 1523 hectares has been added to the existing built up area, 37 hectares of bare land, 209 of water body and 1428 of cropland has been added to the existing land cover accordingly These are due high population searching for food and other agricultural products as expressed by interviewers during the study so as to support their living conditions. While 2042 of forest, 924 of grassland and 232 of

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wetlands have been converted to other land covet types as an impact of increased population.

Population growth increase demand for arable land and encourages the conversion of natural vegetation to agriculture and cropland. Since the people living in rural areas are those who are dependent on agriculture as a livelihood, one would expect deforestation to increase with rapid population density as well as rising demand for wood products According to Khalid et al., (2011).

In order to increase the production to support the growing population, Dam are constructed to support irrigated agriculture (land cover has changed from cultivated marshland to water body to support irrigated agriculture). Sample of areas includes a dam reservoir located between Muyira, Kibirizi and Busoro sectors, between Muyira and Ntyazo sectors, in Rwabicuma sector and the other one is between Mukingo. Rwabicuma and Busasamana.

A rapidly growing population exerts pressure on agricultural land and raises demand for food and shelter which encourages the conversion of forest land for agricultural and residential uses. The growing population is also a major cause of air, water, and solid waste pollution (Mohsin, Usman, Syed, & Zeshan, 2005).But also it increases excess use of pesticides, fertilizers, causing land degradation and water pollution (Khan, Inamullah, & Shams, 2009).

On the global basis, the soil degradation is caused primarily by overgrazing (35%), agricultural activities (28%), deforestation (30%), over exploitation of land to produce fuel-wood (7%), and industrialization (4%) (Rahul & Chandi, 2013). Most life on earth depends on soil as a direct or indirect source of food. Soil consists of air, water, minerals, and organic material and is one of the world's most important natural resources where plants and animals gain nutrients. The acceleration of erosion in agricultural soils is the result of human activities and global degradation on environment (Sara, 1997). As consequence; soils lose their ability to store nutrients and be productive, production is decreasing leading to poverty and slower economic development (Poston & Bouvier, 2016).

3.3. The relationship between population growth and land cover change

According to the study, land cover have been changing according to time and the main driver is the increasing population. The results are supported by the study of Nangware in 2019, which shows that the intensification of human activities seeking to ensure the food supply and improve the income of the growing population is the major proximate driver of land use change.

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It is also supported by the study of Arnout in 2016, which shows that in general, land cover change in developed regions such as Europe is mainly a result of changes in production systems (crops, fertilizer, and livestock numbers).While in the developing countries, however, demand for new agricultural land, construction land from a rapidly expanding human population continues to be the main driving force for land cover changes. Changes in forest cover, mainly through deforestation, and changes in agricultural areas and in built up, are the most significant types of land Cover change, the same as the results found.

More population means more space to construct houses and availability of more consumer goods. More cultivable land has been made available by clearing forests and by reclaiming wetlands, ponds and green belts. It also requires more means of transport, more consumption of fossil fuels and more pollution of air, land and water. Thus, growth of population leads to pollution of air, land and water (Rahul & Chandi, 2013). Demand for wood products and agricultural land, lead to continued deforestation, forest and soil degradation (Oliver, 2018).

Between 1999 and 2019, the built up area, bare land, cropland and water body have been increasing as population increase while at the same time forest, grassland and wetland have reduced while population statistics have been increasing in Nyanza district. From the analysis, the increased land covers are all linked to human activities in search of means of survival and basic needs in life. To get the space the existing land cover changes either from forest or grassland or cropland to built up area.

The bare land has been increased at a considerable rate from 5 to 42 hectares in 20 years; they are mainly located in Nyagisozi, Mukingo and Rwabicuma sectors. Those are due to the development of mining and quarry in the area linked with the infrastructure development like roads.

The water body is also linked to human activities as the dam reservoir located between Kibilizi- Muyira, Kibirizi - Ntyazo and in Rwabicuma was created for improving agricultural practices in Nyanza district by practicing irrigated agriculture so as to produce more and avoid the dependence on climate so as to feed the increasing population.

The increasing population calls for increasing numbers of factories. In Nyanza district, there was about 12 coffee washing stations, two centres for seedling variety improvements, there are also agro processing dairy industries according to the report of Nyanza district in 2013. This leads

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to various kinds of pollution, including water and air pollution.

Population growth in Nyanza district also influenced infrastructure extension in transport (roads, airports, parking lots,..)Markets (public & private), water lines, electrical grids, schools, sanitation (Hospitals, health centres and health posts), mining, landfills, quarries, urban green spaces (parks, gardens) and these involves land use change and affect natural resources as published by the Republic of Rwanda, 2017.

Rapidly growing population not only increases pressure on marginal lands, over exploitation of resources, overgrazing, over cutting of wood, soil erosion, silting, loss of biodiversity, greenhouse gas emissions, rates of soil erosion, the extinction of species, air and water pollution, increased pressure on arable land, flooding, production of wastes (Khalid, Himayatullah, Muhammad, Zohra, & Muhammad, 2011).But also increases excess use of pesticides, fertilizers, causing land degradation and water pollution (Khan, Inamullah, & Shams, 2009).

Forests contribute to food production and food security; they protect agricultural land from degradation; improve the fertility and texture of forest soils and productivity. On the global basis, soil degradation is caused primarily by overgrazing (35%), agricultural activities (28%), deforestation (30%), over exploitation of land to produce fuel wood (7%), and industrialization (4%) (Rahul & Chandi, 2013). Those substantial positive impacts are lost when forests are cut down. As consequence; soils lose their ability to store nutrients and be productive, production is decreasing leading to poverty and slower economic development (Poston & Bouvier, 2016).

The population increase without proper management degrades natural resources. There is a need for a proper management so as the future generation will also use them. Society will have to balance competing needs for land to feed the growing global population, to provide resources and energy to satisfy ever accelerating human consumption, to slow global warming and to reduce the rate of loss of ecosystem services and biodiversity.

4. Conclusion and Recommendations

The present study used geospatial technologies to analyse the extent at which land cover has been changing in Nyanza district over the past twenty years. The study has shown land cover type dynamics, some of the land cover types increased in the area whereas others reduced. The Reduced land cover types includes forest land which moved from 12,228 hectares in 1999, to 10,997 hectares and then to 10,186 hectares in 2019; grassland and wetland.The built up area as land cover has nearly doubled in the period of 20 years. It

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shifted from 1,792 ha to 3,315 in 2019. At the same time bare land has increased from 5 ha in 1999 to 42 ha in 2019, water body and cropland has also increased in that time scale. While the population has increased from 225,209 in 2002 to 388,338 in 2019 according to the statistics from the district.

This geospatial analysis between 1999 and 2019, show a comprehensive view of land cover change and population dynamics in Nyanza district. The study revealed a strong relationship between population growth and land cover change, it is the main driving force to land cover change and land cover is changing in relation to population increase. Forest, grassland and wetland are reducing as population increases while bare land, cropland, built up and water body are increasing as population increases. High population density induced shortage of land for cultivation and thus encroach natural resources. Land degradation and soil erosion are the underlying effects to land cover change. There is pressing need to manage land use so as to slow poverty and sustainable economic development.

As recommendation, Promote awareness on family planning and investing in girl's education so as to slow the rate of population growth is a major tool to control land cover change.Satellite and remote sensed data could also be used to assist the government of Rwanda to survey land cover change with the aid of geospatial technologies, they could help to take effective decisions.Programs intended to increase the living conditions of local communities in Nyanza district should be initiated by creating non agriculture income generating activities to reduce dependency on cropland and forest resources.

5. References

Adam, L. (2019). *Over-exploitation of natural resources is followed by inevitable declines in economic growth and discount rate*. *Nature communications* .

African Development Bank. (2015). *Payment for environmental services: A promising tool for natural resoures management in Africa.* Abidjan.

Arnout, v. S. (2016). *A review of land use change models* . MacArthur Foundation.

Daniel, G. B., & Colin, P. (2013). *Land Use and Land Cover Change.*

FAO. (2011). *The state of the world's land and water resources for food and agricultur,Managind system at risk.*

FAO. 2012. *The State of Food Insecurity in the World.* Rome.

FAO. (2017). *FAO's pivotal role in Natural Resource Management in Eastern Africa.*

Khan, H., Inamullah, E., & Shams, K. (2009). *Population, environment and poverty in Pakistan: linkages andempirical evidence*, Environment, Development and Sustainability. *11*, 375-392.

http://eajournal.unilak.ac.rw/EAJST (online Version) ISSN: 2227-1902 Email: eajst_editor@unilak.ac.rw /eajscience@gmail.com

Khalid, Z., Himayatullah, K., Muhammad, M. K., Zohra, S., & Muhammad, N. (2011). *The impact of population on environmental degradation in South Asia:application of seemingly unrelated regression equation model*. Environmentaland Pollution Science.

Maximillian, J., Brusseau, M., Glenn, E., & Mathias, A. (2019). *Pollution and environmental perturbations in the global system.* Environmental and Pollution Science.

Mmom, Prince, C., & Mbee, D. M. (2013). *Population pressure and forest resources depletion in Gele Gele forest reserve of Edo state , Nigeria*. International Journal of Physical and Human Geography, 1 (2), 31-42.

Mohsin, H. A., Usman, A., Syed, A. w., & Zeshan, I. (2005). *Interaction between Population and Environmental Degradation.* The Pakistan Development Review , 1135–1150.

Nangware, K. M., Lianxi, S., & James, L. (2019). *Land Use Change Trends and Their Driving Forces in the Kilombero Valley Floodplain, Southeastern Tanzania.*Sustainability .

NISR. (2015). *Fourth Population and Housing Census, Rwanda, 2012: Nyanza District Profile.*Republic of Rwanda,

Nyanza. (2013). *Nyanza district development plan (2013-2018).* Rupublic of Rwanda.

Nyanza. (2020). *Population statistics in Nyanza district by sector.*

OECD. (2018). *Monitoring land cover change.* Manitoba, Canada.

Oliver, J. (2018). *Managing natural resources in Rwanda's districts under competing development pressures.* Stockholm Environment Institute - Africa.

PAI. (2011). *Why population matters to forests?*

Rahul, M., & Chandi, G. M. (2013). *Impact of population explosion on the environment*. We School "Knowledge Bulider", 1 (1).

REMA. (2011). *Rwanda biodiversity Policy.* Kigali.

ROR. (2017). *Rwanda National Land Use Planning guidelines.* Kigali.

Sumeeta, S., & Rogers, P. (2009). *Land use change in developing countries: Comparing India and China.* .

Tran, D., Lewis, R., Lu, J., & Mills, J. (2010). *Population & Natural Resources case study: Is population growth responsible for the loss of rainforests?*

United Nations. (2017). *World Population Prospects: The 2017 revision.* Department of Economic and Social Affairs, Population Division.

United Nations. (2019). *World Population Prospects 2019: Data Booklet.* Department of Economic and Social Affairs, Population Division.

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