SOCIETY OF EDUCATIONAL RESEARCH AND EVALUATION IN KENYA

Effects of Spatiotemporal Dynamics of Population in Urban Centers on Land Use Arrangement: A Case of Nakuru Town, Kenya

Mogire Dennis Annan, Dr. Jane Kagendo & Dr. Raphael Kweyu
Department of Humanities and Languages, Mount Kenya University
P.O. Box 342-01000, Thika, Kenya
Email: dennis2annan@gmail.com

Abstract

The study addressed the effects of spatiotemporal dynamics of urban of human population on land use arrangement in Nakuru town. Nakuru town attained its municipal status in 1952. Since then, its population has been growing steadily from 152289 in 1991 to 472126 in 2021 posing pressure on already limited urban land use arrangement. The study was guided by Hoyt Theory which assumes that urban land use arrangements are influenced by historical, economic and concentration of similar land use. The researcher used descriptive research design. Through Remote sensing, the study showed that area under settlement use increased from 7.66 to 54.78 km2, Lake increased from 36.02 to 44.01 km2 while area under Agricultural use decreased from 117.94 to 112.01 km2 and area under 'Others' decreased from 163.38 to 114.20km2. Field data from A sample size of 400 households showed that Settlement increased from 32. 67 to 42.34 km2, Lake increased from 36.02 to 44.01 km2, 'Others' decreased from 35.44 to 29.42 km2 and Agricultural decreased from 195.95 to 158.72 km2. Fragmentation and zonal use mix-ups were cited by 24.9% and 46.9% of the respondents respectively. Pearson's Correlation between spatiotemporal dynamics of urban human population and Urban Land Use Arrangement disruptions was r=0.94. The study concluded that urban population affects urban land use arrangements. The study recommended that human population in urban centres should be checked in order to promote sustainable urban land use arrangements. In addition, there is a need to eliminate factors that affecting urban zoning policy implementation.
Keywords: Urban Land-use Arrangement; Nakuru Town land use arrangement, Spatiotemporal dynamics of human population, Urban centre

1 Introduction

Urban centers are categorized morphologically as cities, town and conurbation (Lan & Longley, 2021). Urban population, urban growth and development has expended a lot of urban land resources (Kuang et al., 2020). Study that was done by Kuang et al. (2020) in China found that China's urbanization (both urban population and physical urban expansion) stimulates Urban Land Consumption Intensity (ULCI). They also found that ULCI is caused by population. Over half of the world inhabitants lives in urban areas (Das et al., 2019). This phenomenon is being fueled mainly by migration and natural birth. The global urban population was 13% of the total world population in the year 1900 (Kii, 2021). In the year 2010, the global urban population was estimated to be 3.5 billion people out of the world's human population of seven billion (Kii, 2021). Developed nations are the most urbanized countries. Urbanization levels in North America, Latin America, Caribbean, Europe is at 81.6%, 79.9%, 79.9%, 73.9% respectively (World Bank, 2017).

There is a lot of urban land use inefficiencies in many cities (Koroso et al., 2021). In most towns, the rate of land use far surpasses the rate of population growth. On the other hand, they also found that urban infill is low and slow. Their analysis indicated that some cities had had urban land that sat idle within the built-up area for many years. According to them, Urban Land Use Efficiency (ULUE) is what fuel urban land fragmentation. The geospatial analysis that was done by Atasoy, M. (2018) showed that an increase of built-up areas and population in Osmaniye city significantly

127

decreased the urban green space. The reduction was due to high levels of urban land fragmentation in urban city center. This subsequently led to urban land use arrangement change. In Bangladesh, the study indicated that the southern part of this city underwent intensification because of urban population increase (Rahaman & Shermin, 2021) leading to urban land use disruptions that is characterized with residential buildings. Sun eta al. (2020) carried a study using meta-analysis. They assessed urban land resources' carrying capacity in relation to urban population. They found that due to large influx of people in urban areas, the urban land resources carrying capacity in Shanghai was decreasing at alarming rate.

Sub-Saharan African countries have an annual urban population increase at the rate of 4.1 % (UNDESA, 2019; World Bank, 2019). Maconachie (2016) carried a study in the Settlements of Benue state of Nigeria. He found that there is a lot of land use disruptions. For example, agricultural land was being changed into settlement areas. A study that was done in Egypt to estimate dynamics in agricultural land in relation to urban sprawl between 1986 and 2019 showed that the area under agriculture reduced by 6000 ha while Urban area increasing by 5880 ha (Das & Angadi, 2021).

According to Kenya National Bureau of Statistics report of 2021, the country had 27.51% of its total population living in urban centers. The annual rate of urban population in Kenya is approximated to be 0.48% (KNBS, 2021). Nakuru is the fourth largest urban center after Nairobi, Mombasa and Eldoret in terms of population size (KNBS, 2021). Nakuru town was made municipal town in 1952 by colonialist who dominated the present CBD. Its size was 0.75km2 by then. The size of Nakuru town was increased to 325km2 in 1974. According to KNBS, Nakuru town's urban population has been growing steadily from 152000 people in 1991 to more than 470000 in 2021(KNBS,2021). The annual average rate of urban population of Nakuru town is 2.7% (UN, 2020). Urban population dynamics have social, economic and environmental effects (Dzator et al., 2022). This rapid increase of urban population in Nakuru town expected to have a great effect on urban land arrangement use because Urban land supply is static while its demand increases with an increase of urban population (Mbuyi, 2019). Study that was done by Willkomm et al. (2020) showed a complex pattern of replacement, fragmentation, and intensification of Nakuru town urban land. They noticed that large-scale production is increasingly splitting and replaced by both small-scale agricultural land use as well as residential and industrial built-up areas. Another study that was done by Willkomm et al. (2019) in Nakuru town found out that built-up almost doubled from 22.0km2 to 40.4km2 in only 7 years prior to 2019. Kiplagat.P, (2018) in his thesis about the impact of devolved functions on sustainable land use plans within Molo sub-county indicated that devolution of Land use planning to Counties has enabled the realization of maintainable urban land use planning.

The purpose of this study was to examine spatiotemporal dynamics of human population in urban areas and their effects on urban land use arrangements in Nakuru town in Kenya by combining the use of Remote Sensing and socio-economic data. With the current population growth in Nakuru town, it is critical to understand the spatio-temporal dynamics of human population for the town's future land use arrangement development. The specific objectives of this research were: (1) To assess disruptions in urban land use arrangement between 1991-2021 in Nakuru town. (2) To establish the relationship between spatial-temporal dynamics of urban population and land use arrangement in Nakuru town. (3) To identify challenges facing the implementation of urban land use zoning policies in Nakuru town. This study may be relevant to the Nakuru County Government, precisely the Nakuru town East and West Sub-Counties, in terms of planning and controlling land use development and disruptions. The study's discoveries may be beneficial to urban land use planners, developers, and administrators for forthcoming changes and policy making in order to safeguard Nakuru town's land use arrangement sustainability.

2. Location of the Study

The study was carried out in Nakuru town, Kenya. The study area is located in the former Rift Valley Province of Kenya. It encompasses Nakuru West Constituency and Nakuru East Constituency. Nakuru town is the newest City in Kenya due to this she is experiencing undesirable disruptions within its urban zones. In connection to this, if proper frameworks are not going to be in place, we will have unsustainable urban land use arrangements. The size of Nakuru town is 325km2. Geographical coordinates of Nakuru town are 0.29'S to 1.03'S and 33.15'E to 36.10'E. It is located at a strategic point surrounded by high-populated counties whose people find their way into Nakuru town. Nakuru town consist of eleven administrative wards i.e. Biashara, Kivumbuni, Flamingo, Menengai, Nakuru East, Barut, London, Kaptembwa, Kapkures, Rhoda and Shabab.
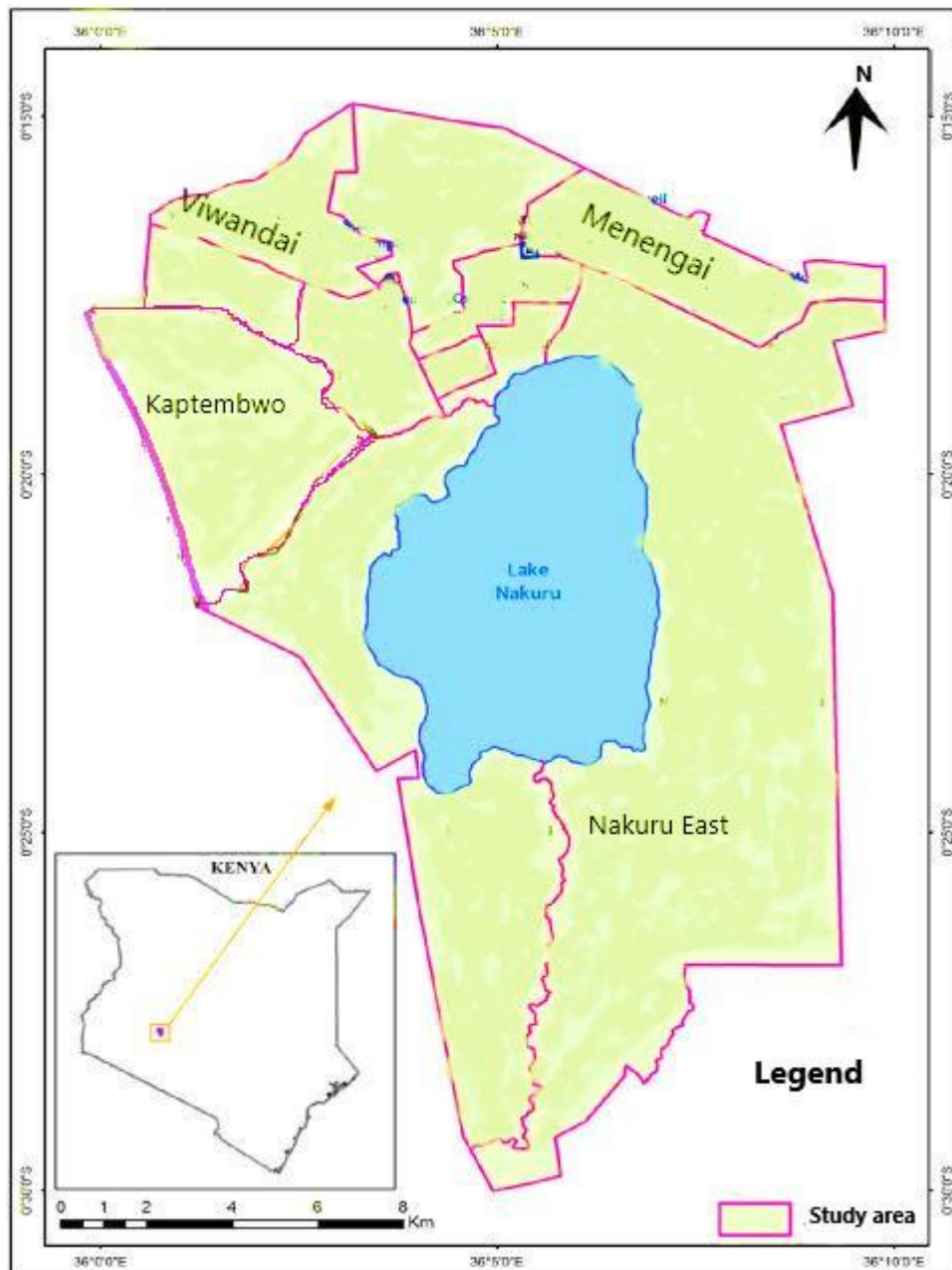
Figure 1 Geographical Location of the Study Area

3.Data Used

Data used here were gotten from diverse sources. It comprised primarily of LANDSAT satellite covering the area under study and complimented with socioeconomic data.

3.1 Social-economic data

The dominant urban land use arrangement in Nakuru town includes forest, settlements, grasslands, Central District Business area, Industrial area and croplands (CIDP, 2018). The land use arrangement had high temporal dissimilarities with the wet period revealing high vegetation cover and the dry season showing very low vegetation cover. The northern and south eastern part of Nakuru town is mostly forested but is currently vulnerable to encroachments into these areas. A sample size of 400 households were distributed among the eleven-sample frame identified. As shown.

129

3.2 Remote Sensing Data

Land resources data was collected using remote sensing/Geographical Information System (GIS). GIS technology was used to produce Landsat images for the year 1991, 2001,2011 and 2021 to show trend of unconventional urban land use arrangement in Nakuru town. The Landsat images was gotten from the USGS Website (glovis.usgs.gov). Landsat imageries of MS, TM and ETM+ were attained from USGS within the same time of the year. Same spatial resolution for the periods 1991, 2001,2011 and 2021. This made change comparison possible.

4. Methodology

Digital images were processed and analysis done to produce a thematic map of the study area

4.1 Image pre-processing

This was done through geo-referencing. It was done in order to get scenes of the study area which gave a true image of the actual state on the ground. Geographical Vector Interpretation System (GEOVIS) software for geo-rectification was employed. MSS image of April 1991 was used as the base image. It was used to geo-reference the other images. Coordinates of conjoint features in the image of 1991 and the other images were recognized. GCPs (Ground Control Points) stipulating the coordinate of target point were placed in. This diminished errors during analysis. Each epoch in each of the interested images was enhanced in terms of hue and light for clarity. The images were classified into five macro- classes: Lake, Others, agricultural use, Industrial use and Settlement.

4.2 Image Classification

The researcher used supervised classification to extract land use classes. This research therefore, used a modified CORINE land use. CORINE stands for Coordination of Information on the Environment. This is a map of European ecological landscape founded on satellite images. Based on this classification, the researcher came up with the following classes. Pixel based supervision was done through a number of processes. The primary step involved gathering of training samples for each urban land use classes. The training samples were based on the researcher's individual experience and physiological knowledge of the area. More than 250 training samples were collected for each Landsat imagery. Image classification was done using Maximum Likelihood Classified (MLC) through ArcGIS.

4.3 Change detection analysis

Finally post classification comparison was used to detect urban land use arrangement disruptions. Urban Land use change was calculated in way (Kiggundu et al., 2017): (a) The rate of ULU= $\mathbf{R} = \frac{\mathbf{Q_2 - Q_1}}{\mathbf{Q_1}} * \mathbf{100}$ (Where Q2= recent year of ULU in Km2, Q1= initial year in ULU in Km2.

5 Result and discussion
5.1 Disruptions in Nakuru town's urban land use arrangement between 1991-2021 based on unconventional land use arrangement

1991-2021

There was a significant disruption in Nakuru town urban land use between 1991-2001. Urban Land use map of 2001 shows a significant reduction of the surface area of the land under "Others" compared to the year 1991 (Figure 2). It decreased from 163.38km squared to 139. 39 km squared. On the other hand, area under settlement, forest, agriculture and the lake increased between the year 1991 and 2001. Settlement increase from 7.66km squared to 14.03km squared an increase of 83.2%. This was attributed to an increase of urban population due to natural birth and immigration. Area under forest increased from 21.98km squared to 29.86km squared Table 4.9which was an increase of 35.8%. on the same period there was a slight increase of area under agriculture from 95.96km squared to 99.82km squared which was an increase of 4.0%. The surface area of lake Nakuru increased from 36.02km squared to 41.91km squared an increase of 16.4%. as clearly shown by Table 4.9 and Figure 2. However, this increase of land use size did not take any formal arrangement or pattern.

2001-2011

Slight changes were detected within this period. Urban land use under the lake declined from 41.91km2 to 31.86km2 which was, a decrease of 23.9% (Table 4.9). This can be attributed to deforestation of Mau Forest. Insignificant decrease of land use under agriculture from 99.43km squared to 98.43km squared. This was 1% decrease. Area under

"Others" reduced from 139.39km squared to 135.75km squared (Table 4.9), a decrease of 2.6%. this can be attributed to conversion of more land to settlement. Urban land use under forest also recorded a decrease from 29.86km squared to 27.92km squared Table 4.9which was a percentage of 6.5. on the other hand, area under settlement increased from 14.03km squared to 31.04km squared, an increase of 121.2%. This was accredited to increase of urban population in Nakuru town.

2011-2021
Area under settlement increased further in this period from 31.04km2 to 54.78km2 an increase of 76.5%. the surface area of a lake increased from 27.92km2 to 25.06km2 Table 4.9a decrease of 10.2%. this can be attributed to government policies that aimed at ensuring that 10% of the country's land is covered with trees/forest. This encouraged people to plant more trees. This led to a reduction of area under "Other" from 135.39km2 to 114.20km2. This was a decrease of 15.7%. urban land use under agriculture decreased further from 98.43km2 to 88.95km2, a decrease of 9.6% (Table 4.9and Figure 2)
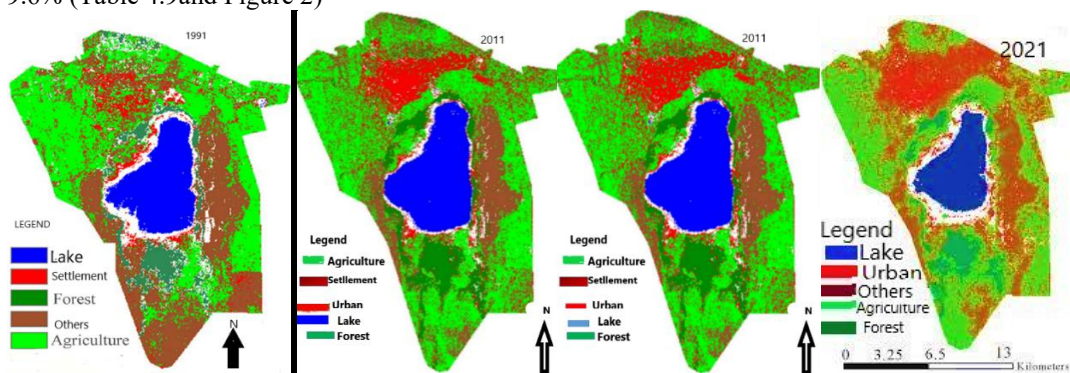

Figure 2 Nakuru town's Unconventional Urban land use arrangement
Source: USGS

Therefore, unconventional land use arrangement underwent changes in the manner in which they were used. Nakuru town Urban Land use area estimates in Table 1 clearly shows dynamics in land use between 1992-2021.

Table 1 Nakuru town's Unconventional Urban Land Use Estimates using Land sat (30.0 spatial resolution)

Urban Land Use (km²⁾)	1991	2001	2011	2021	Average Change after every 10yrs
Settlement	7.66	14.03	31.04	54.78	**+15.71**
Forest	21.98	29.86	27.92	25.06	**+1.03**
Others	163.38	139.39	135.75	114.20	**-18.36**
Agriculture	95.96	99.82	98.43	86.95	**-3.00**
Lake	36.02	41.91	31.86	44.01	**+2.06**
Total	**325**	**325**	**325**	**325**	

(+) increase (-) decrease

When plotted on a compound line graph, each urban zone/area in Nakuru town depict a trend that should worry stakeholders. Land use under "Others" has been declining for the last thirty years since the year 1991. Area under forest and agriculture is facing the same fate. On the other hand, area under Built-up is increasing at alarming rate. The graph also shows that the surface area of lake Nakuru has been increasing steadily in the last ten years specifically as from the year 2009 (Figure 3).
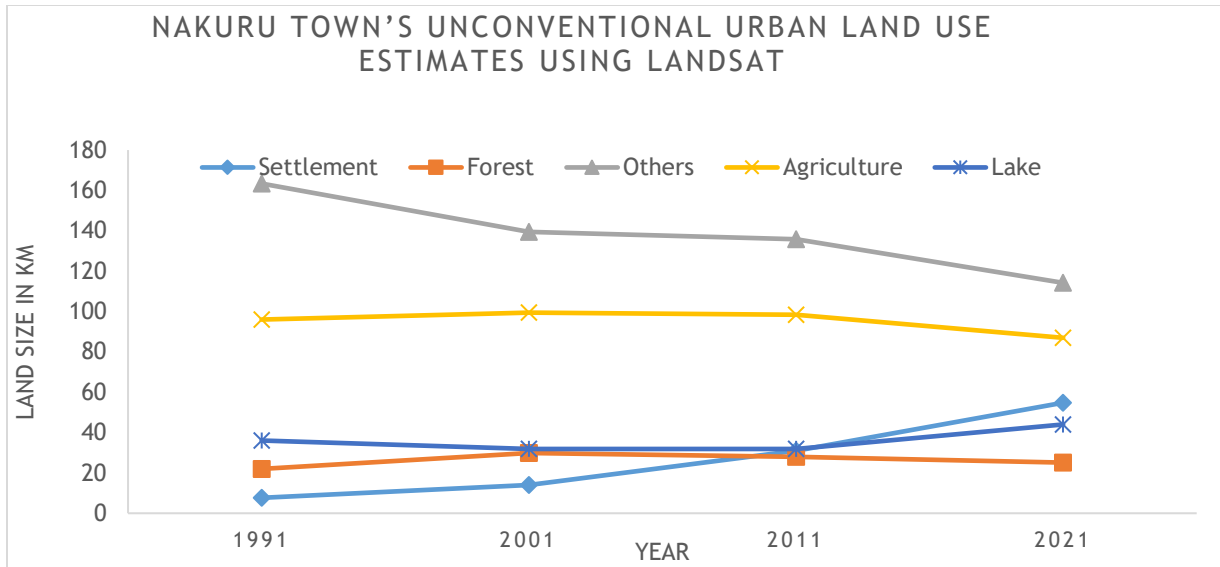
Figure 3 A graph of Nakuru town's Unconventional Urban Land Use Estimates using Landsat (30.0 spatial resolution)

Gains and losses were noted among all land use taxonomies that were under study. Generally, between 1991-2021, area under 'Others' lost an average of 18.36 km2 to other land use. Agricultural land lost an average of 3.00 Km2. Settlement areas increased with an average of 15.71 Km2 followed by the surface area of Lake Nakuru which had an average increase of 2.06 Km2. Within the same period of time, forest area had a minimal average increase of approximatly1.03 Km2 as shown by figure 4.
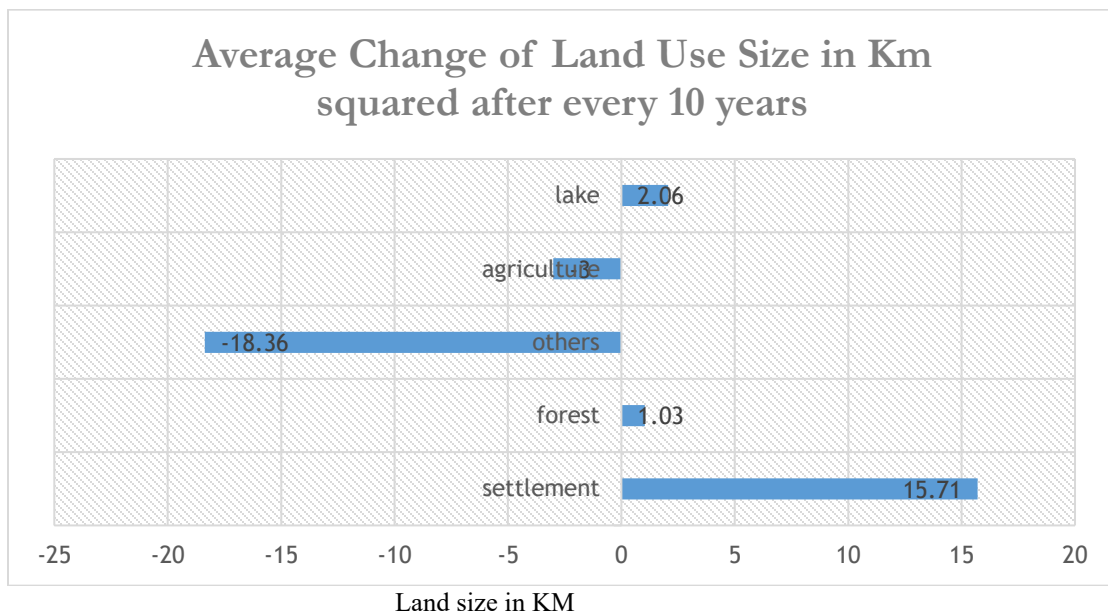
(Negative side Indicate a reduction while Positive side Indicate an increase)
Figure 4 Gains and losses of land use in Nakuru town between 2021-1991 based on Unconventional Urban Land Use Estimates using Landsat (30.0 spatial resolution)

Accuracy Assessment

132

The researcher compared a map generated from remote sensed data to a map from Google Earth map. The evaluation of accuracy of a classified image was done using an error matrix known as confusion matrix. The column represented the referenced data while the row represented the classified image data from Landsat imagery. From this error matrix, user's accuracy and producer's accuracy was calculated. In this research, 220 total samples for image 1991, 116 for image 2001, 252 for image 2011 and 290 for image 2021were randomly selected from the image of 1991 and Google Earth image for 2001, 2011 and 2021. The agreement and disagreement were then analyzed as shown in Table 3,4,5 and 6.

Table 3 Confusion matrix for land use map of 1991

		Reference Map						
	Land use class	Forest	Built up	Water bodies	Others	Agricultural area	Grand total	User's accuracy
Classified Map	Forest	43	1	0	2	1	47	91%
	Built up	0	37	0	3	1	41	90%
	Water bodies	0	0	51	0	0	51	100%
	Others	1	3	0	29	3	36	81%
	Agricultural areas	0	0	0	0	45	45	100%
	Grand total	44	41	51	34	50	220	
	Producer's accuracy	98%	90%	100%	85%	100%		
	Overall accuracy	93%						

Table 4 Confusion matrix for land use map of 2001

		Reference Map						
	Land use class	Forest	Built up	Water bodies	Others	Agricultural area	Grand total	User's accuracy
Classified Map	Forest	18	0	1	1	1	1	86%
	Built up	0	22	0	1	1	24	92%
	Water bodies	0	0	26	0	0	26	100%
	Others	1	2	0	14	3	20	70%
	Agricultural areas	0	1	0	3	21	25	84%
	Grand total	19	25	27	19	26	116	
	Producer's accuracy	95%	88%	96%	74%	81%		
	Overall accuracy	87%						

Table 5 Confusion matrix for land use map of 2011

		Reference Map						
	Land use class	Forest	Built up	Water bodies	Others	Agricultural area	Grand total	User's accuracy
Classified Map								

Forest	48	2	0	1	3	54	89%
Built up	0	61	3	2	5	71	86%
Water bodies	2	1	50	0	1	54	93%
Others	2	2	0	24	2	30	80%
Agricultural areas	0	3	0	3	37	43	86%
Grand total	52	69	53	30	48	252	
Producer's accuracy	92%	88%	94%	80%	77%		
Overall accuracy	87%						

Table 6 Confusion matrix for land use map of 2021

	Land use class	Forest	Built up	Water bodies	Others	Agricultural area	Grand total	User's accuracy
Classified Map	Forest	50	0	0	0	4	54	93%
	Built up	0	58	0	0	5	63	92%
	Water bodies	16	0	55	0	0	71	77%
	Others	2	3	0	30	1	36	83%
	Agricultural areas	0	3	0	1	62	66	94%
	Grand total	68	64	55	31	72	290	
	Producer's accuracy	74%	91%	100%	97%	86%		
	Overall accuracy	88%						

5.1.1 Disruptions in Nakuru town's urban land use arrangement between 1991-2021 based on conventional land use arrangement

Conventional Urban Land Use Arrangement as noticed during Content/Documentary Analysis
Nakuru town has a master plan of how land is supposed to be used. The master plan caters for commercial, industrial, agriculture, residential among other important urban land use. Content analysis from the department of land and physical planning of Nakuru County showed that Nakuru town has a total area of 325km2 which is shared among the following main land use taxonomies as shown in Table 7.

Table 7 Conventional Urban Land Use Arrangement in Nakuru town from Physical and Urban Land Planning Department (**conventional land use arrangement)**

Nakuru town Urban Land Use Arrangement		
Urban Land Use Zone	Area in Km^2	Area as % of the total area of town
Residential use	$25.97km^2$	7.99%
Industrial use	$2.9km^2$	0.89%
Agricultural use and forest use	$236.95km^2$	60.29 %
CBD/commercial zone	$3.8km^2$	1.17%
Others	$55.38km^2$	17.04%
Lake	$41km^2$	12.62%
Total	$\mathbf{325km^2}$	**100%**

134

Source: Nakuru county department of land and physical planning, 2022

According to Table 4.2, Physical and Urban Land Planning allocated more land for agriculture and vegetation cover (236.95km2) followed by land under "Others," surface area of lake Nakuru, residential use and finally area under industries. After population influx in Nakuru town, urban zones have been disrupted a lot. This has forced Nakuru town urban planners to extend CBD area southwards in order to accommodate daily needs of Nakuru dwellers as shown in **figure 5**. Zonal boundary extension is one of the numerous forms of Urban Land Use Arrangement disruption.
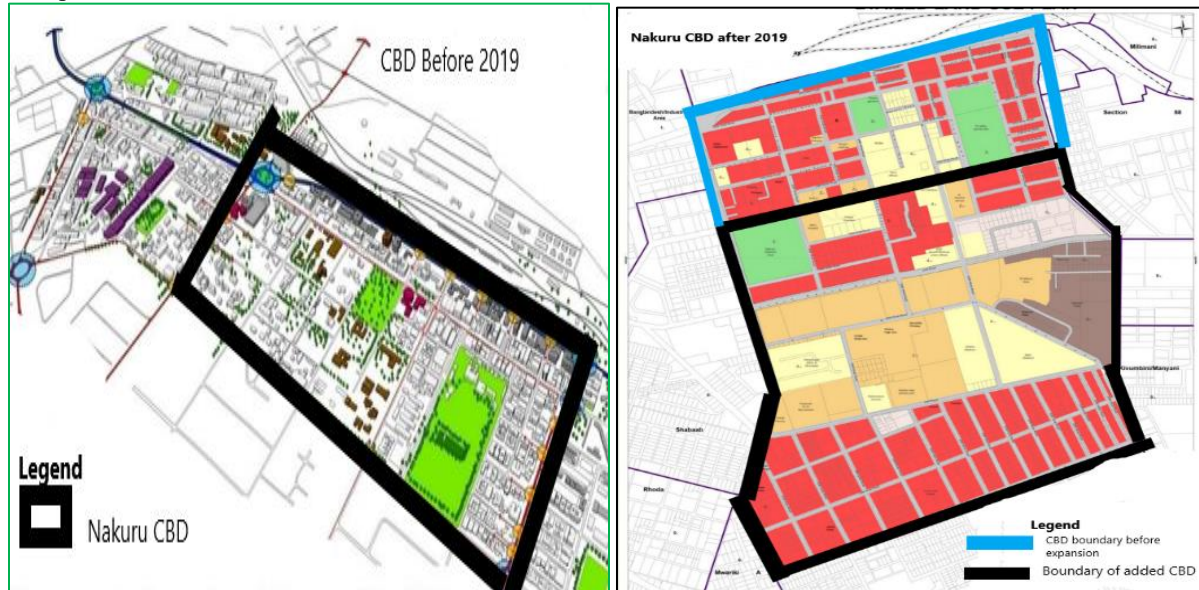
Nakuru town's old CBD   New redrafted CBD of Nakuru town as from 2020
Figure 5 CBD of Nakuru town before and after 2019
Source: Nakuru Land and Physical Planning, 2022

This disruption had detrimentally impacted Urban land use/zonal arrangement in Nakuru town. According to the department of land and physical planning of Nakuru town, agricultural zone/area has been disrupted by the need to have residential and commercial houses.

5.1.2. Nakuru Town Urban Land Use Arrangement and Disruptions Based on Field Data
5.1.2.1 Demographic Information of the Respondents
Majority of the respondents had lived within the study area for more than ten years (63.9%) compared to 36.1% who had stayed within the study area between 1-9 years (Table 8). The longer stay of the respondents within the study area enabled the researcher to obtain a reliable information. In terms of gender, 50.3% of the respondents were male while the female constituted 49.7% (Table 8). Although females are slightly more than males in Nakuru town (KNBS, 2021), the researcher had more males in the study sample. When asked about land ownership, 63% of the participants in the research did not own land while 27% of the respondents indicated that they owned land within the study area as shown on Table 8. Therefore, in there were in a good position to give a reliable judgement about urban land use arrangement.

Table 8 Demographic information of the Participants

Item	Response	% of the respondents
Sex	Male	**50.3%**
	Female	**49.7%**
Length of Stay in the study area	Less than 1 year	**12.1%**
	1-9 years	**23.7%**
	10-15 years	**32.5%**
	16 and above years	**31.4%**

135

Land ownership	Owning land	**37%**
	Renting/ not owning	**63%**

The findings show that 98.6% of the respondents cited that urban population increase led to Urban land fragmentations, zonal use change, zonal use mix-ups among other disruptions. Therefore, they agreed that there is a connection between spatiotemporal dynamic and Urban land zonal use arrangement change hence concurring with remote sensing data about Nakuru town urban land use disruptions as shown in Table 8.

In 1991, the area under "Others", Agriculture had the lion's share at 56% and 26% respectively of the total area of Nakuru town. On the other hand, area under commercial, residential and industrial use had 6%, 11% and 1% of the total area of Nakuru town.
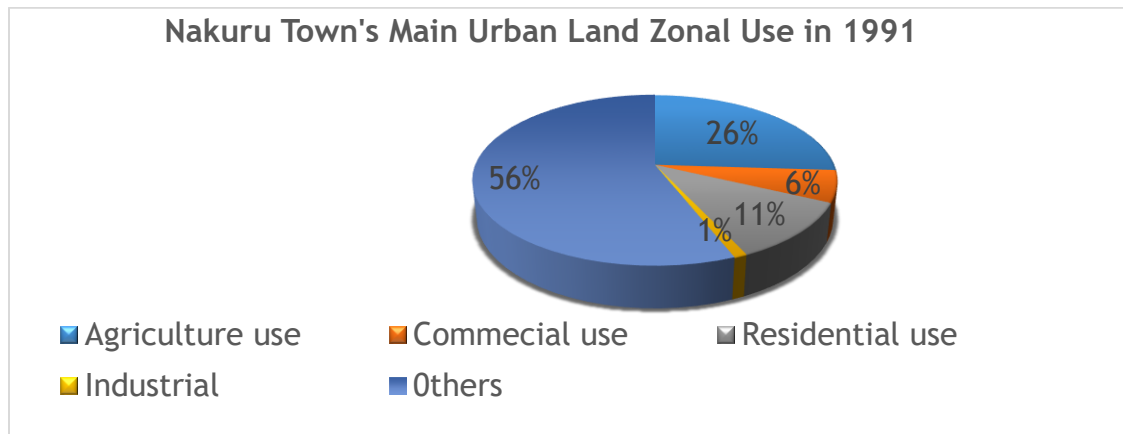
Figure 6 Pie Chart of Nakuru town land use arrangement in 1991
Source: The figure is built from socio-economic data gotten from the field

In 2001, the largest portion of Nakuru town urban land was under agriculture by 34% although it was a reduction from 56% of 1991. Residential use was 30% which was an increase from 11% of 1991. Industry had the least portion of 3% although it was an increase from 1% of 1991. Area under commercial use had 12% of the total area of Nakuru town in the said year, an increase from 6% of 1991 as shown in Figure 7 and Appendix 2.
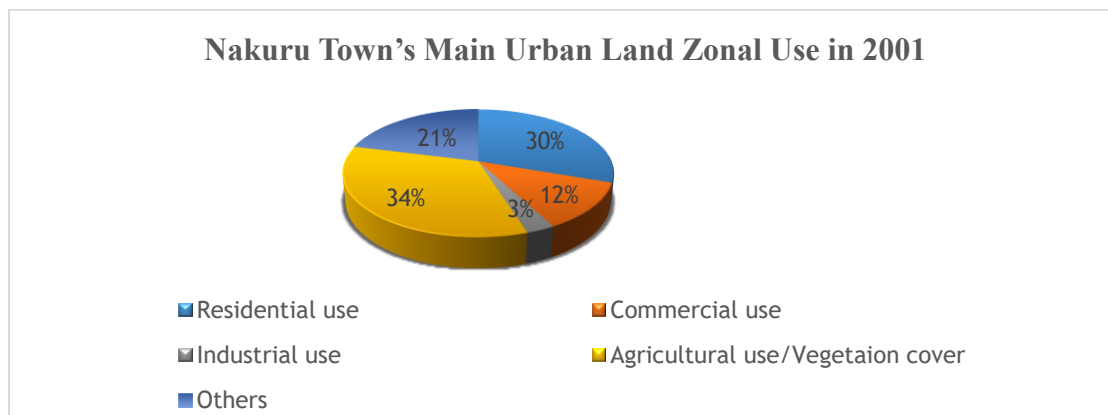

Figure 7 Pie Chart of Nakuru town land use arrangement in 2001
Source: The figure is built from socio-economic data gotten from the field

Data concerning urban land use in 2011 indicated that residential area covered the largest part of Nakuru town at 42%. Area under industry was 1% of the total area of Nakuru town. Commercial urban land use was the second largest

portion which recorded 21%. Area under "Others" covered only 16% compared to area under agricultural use which had 20% as shown in Appendix 3 and Figure 8.
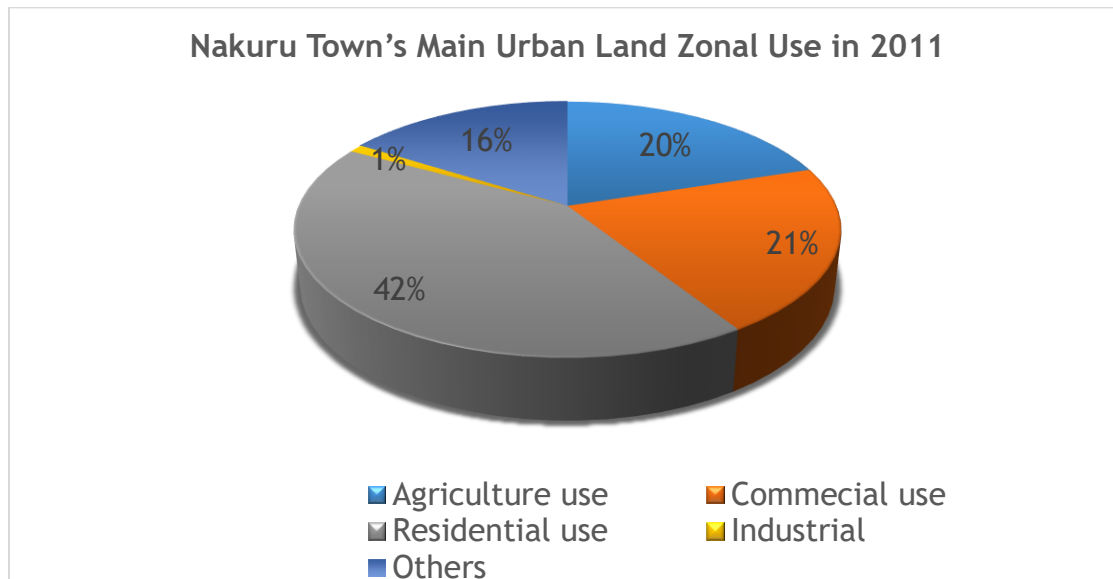

Figure 8 Pie Chart of Nakuru town land use arrangement in 2011

The year 2021 recorded a further reduction of area under agriculture from 20% to 7% probably because of urban population increase who need more land for settlement and commercial use. This year, the area under industrial use increased from 1% to 5%. probably due to change of preference and need to promote industrialization through revival of factories that were closed in early 2000s and start-up of small processing industries such milling industries.
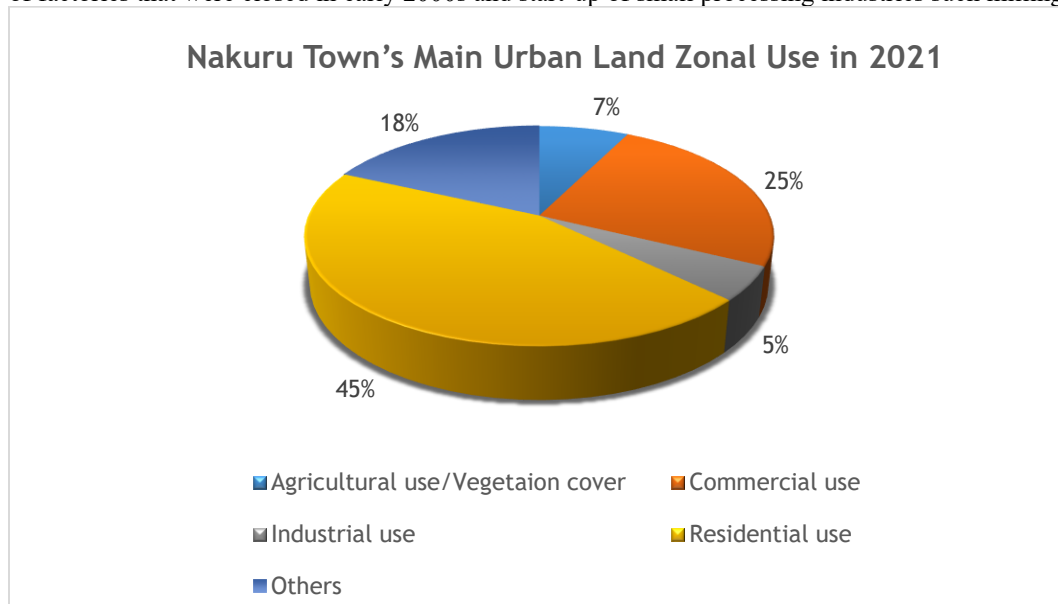

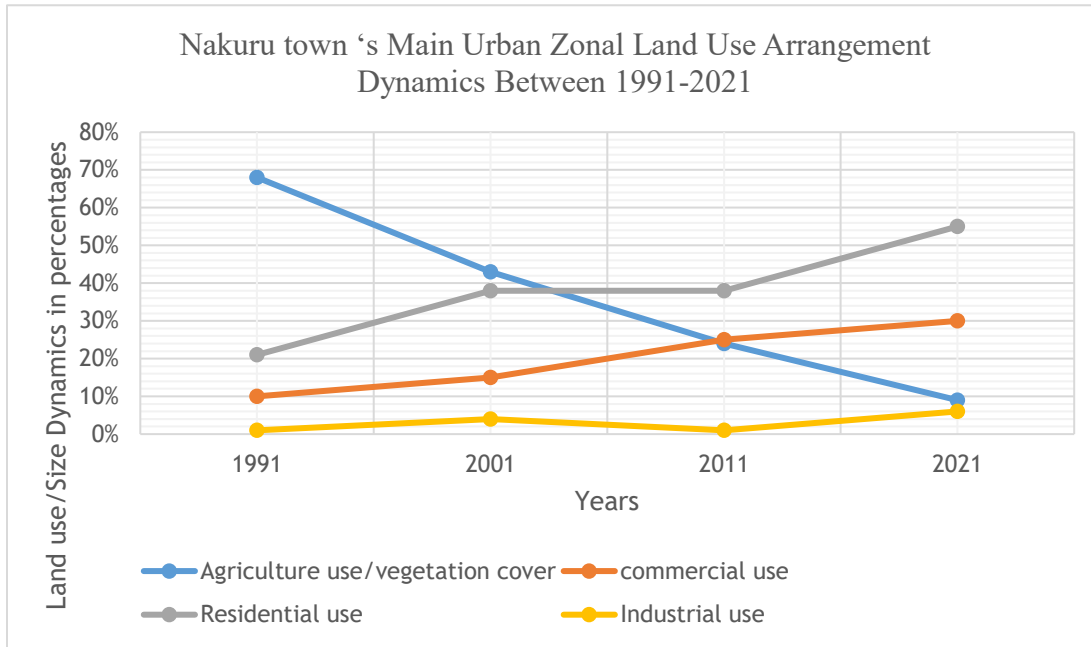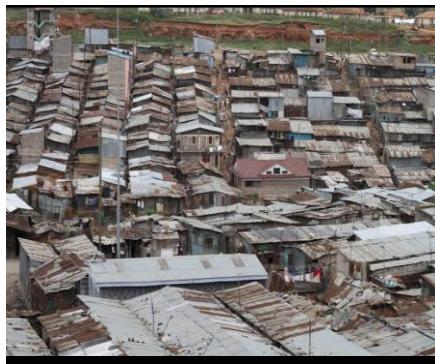Figure 9 Pie Chart of Nakuru town land use arrangement in 2022

Figure 10 Nakuru town 's Main Urban Zonal Land Use Arrangement Dynamics Between 1991-2021

Generally, as shown in Figure 10, areas of all Urban Land Use under study except commercial and residential use recorded a decrease as urban population increases. After every ten years, there was an average of 5% decrease of land use under agriculture. However, within the same period, there was an increase of 1.7% of land under commercial, residential and industrial use. Urban intensification was in all sample units under study as shown in the sampled areas in Figure 11.

Intensification of Rhoda residential area in Nakuru town

Linea urbanization of Nakuru town

Figure 11 Nakuru town Built-up areas

5.1.3 Nakuru Town Urb an Land Use Arrangement and Disruptions Based on Field Data based and Documentary Analysis

Documents gotten from Nakuru town physical planner indicated that Nakuru town urban land use arrangements are undergoing disruptions through land use mix-ups and subdivision. According to records that was availed, for the past one year, they have been giving more than 10 permits monthly in terms of subdivision. This translates to more than 120 permits per year. However, before giving these permits, they consider the impact of the proposed change of use,

conformity to any approved developments plans, trends in the particular area among others. Although procedure is being followed, various challenges are being experienced.

A general increase of Nakuru town's population from 1991-2021 is clearly shown by the bar graph in Figure 4. 60. Nakuru town had a population of 152289 people in the year 1991. In 2001, the population rose to 216906 people. The upward trend continued in 2011 where 300473 people were recorded. During the study year, Nakuru town had more than 472126 people (Figure 12). Following this trend, it can be easily predicted that Nakuru town will continue to have an influx of people in the years to come as depicted on Figure 12 and Appendix 6.
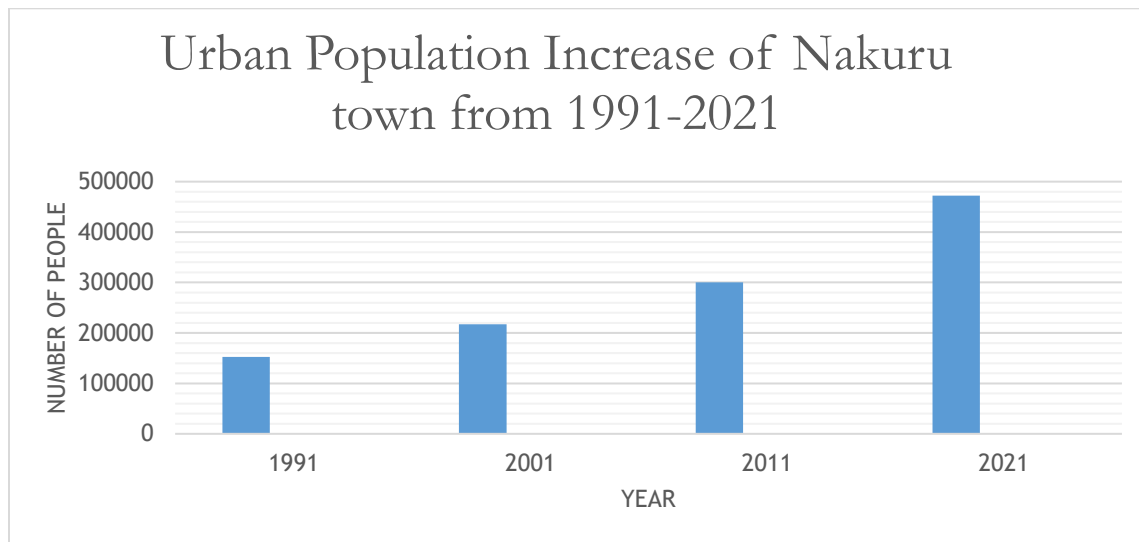

Figure 12 Urban Population Increase of Nakuru town from 1991-2021
Source: KNBS, 2022

Frequencies in response to Nakuru town Urban Land Use disruptions between 1991-2021 were recorded and plotted in the line graph as shown in figure 4.10. In 1991, 421 urban land use arrangement disruption were recorded. Land use disruptions increased to 492 in the 2001. Upward trend continued in the year 2011 where 577 urban use arrangement disruptions were noticed. In the 2022, the highest frequencies of land disruptions (622) were noted. This implies that Urban Land Use disruptions increased as the years goes by in line with population increase. The findings concurred with the assertion of Simwanda et al. (2020) who found pout that urban population aspects (socio-economic, population and political factors have been the major drivers of urban land use changes by 55.11%, 27.37 % and 13.07 % respectively) leads to urban land use arrangement disruptions.
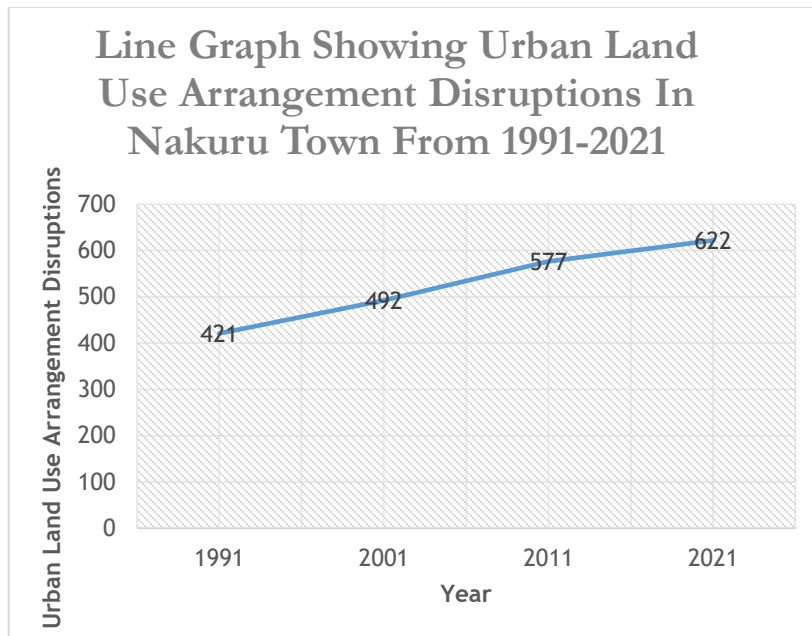
Figure 13 Urban Land Zonal Use Arrangement disruptions in Nakuru Town from 1991-2021

The study area experienced both land fragmentation and zonal use mix-ups. Zonal use mix-ups were cited by 62% of the respondents while land fragmentation was cited by 38% of the respondents (Table 9). This finding was similar to those of Menakanit et al. (2022) who found that urbanization (urban dwellers increase) led to clearance of vegetation and finally fragmentation of urban land in Bangkok city that was initially under vegetation. The responses also revealed that Rhoda and Free Area/East Ward witnessed land fragmentation and zonal use mix-ups by 39.9% and 31.6% respectively. Interestingly responses cited the least disruptions in urban land zonal disruptions in Central/Biashara &Lion Hill and Kivumbini/ Bondeni area with a percentage of 5% and 4.6% respectively.

Table 9 Effects of spatiotemporal dynamics of urban population on Urban Land zonal use Arrangement in Nakuru town

Sample Area	Subdivision of land		Zonal change/ Zonal mix-ups	
	frequency	Percentage	frequency	Percentage
Langalanga/Flamingo	8	**4.9**	20	**6.2**
Kivumbini/ Bondeni	2	**1.2**	9	**3.4**
Mwariki	11	**6.8**	11	**4.1**
Barut	16	**9.8**	13	**4.9**
Shabab	11	**6.8**	18	**6.7**
Free Area/East Ward	26	**15.9**	42	**15.7**
Kaptembwo	16	**9.8**	12	**4.5**
Viwandani/London	26	**15.9**	33	**12.3**
Central/Biashara &Lion Hill	4	**2.4**	7	**2.6**
Rhoda	27	**16.5**	60	**23.4**
TOTAL	**153=38%**		**253=62%**	

140

Source: Source: The figure is built from socio-economic data gotten from the field

5.2 Relationship between spatial-temporal dynamics of urban population and urban land use arrangement disruptions in Nakuru town

Population in Nakuru town is in an upward trajectory from its creation in 1929. When she was made a town in 1929, she had a population of 38181 (KHPC, 1970) and currently she has more than 384884 people (KNBS, 2021). In 1991, Nakuru town had a population of 152289, 216906 people in the year 2001, 300474 people in the year 2011 and 472126 people in the year 2021. Data from the field survey showed that Nakuru town urban land use arrangement experienced disruptions between 1991-2021. In the year 1991, 421 disruptions were noted followed by 492, 577 and 622 disruptions in the year 2001, 2011 and 2021 respectively.

When Urban Land Use disruptions were plotted in relation to Urban population increase, linear relationship was obtained as shown in Figure 14. This implies that as Urban population increases, Nakuru town will experience more disruptions in the land use.
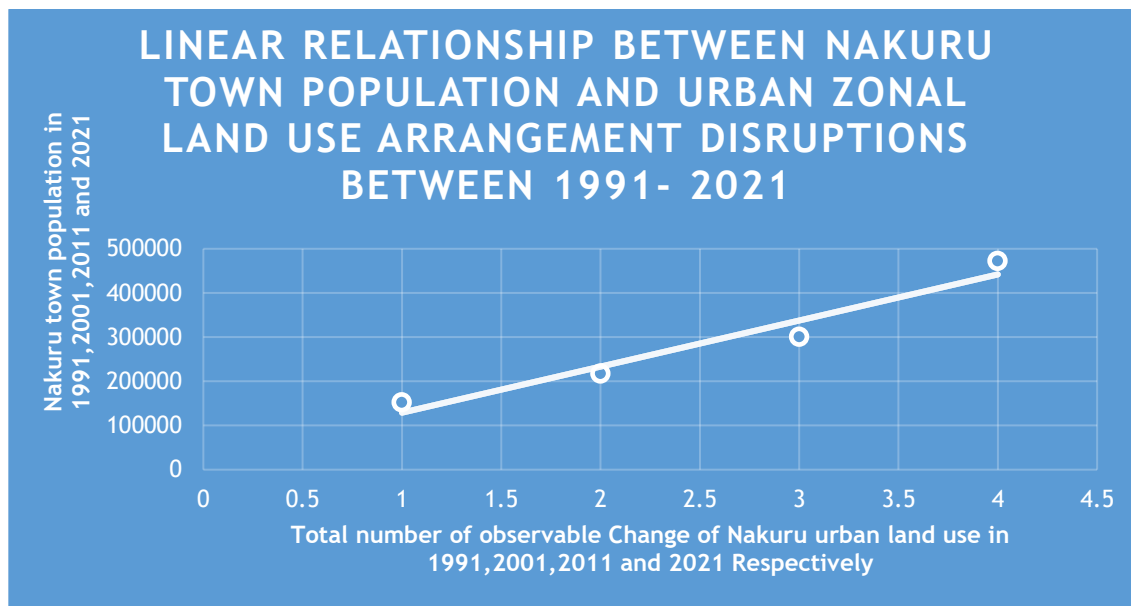

Figure 14 Relationship between Urban Population in Nakuru town and Urban Land Use Arrangement Disruptions Between 1991-2021

Regression analysis results showed that Urban Population dynamics was significantly associated with Urban Land Use Arrangement (p=0.06 two tailed)). Appendix G shows a result of a correlation between Nakuru town urban population dynamics and Nakuru town urban land use arrangement disruptions. It indicated a positive association of 0.94 between urban population dynamics and urban land use arrangement changes (r=0.94, p=0.06 two tailed). Therefore, null hypothesis that says that there is no significant relationship between Urban Population dynamics and Urban Land Use Arrangement was rejected hence accepting the alternative hypothesis. These findings reaffirm assertion of Kuang et al. (2020) who found a strong relationship between urban people increase and urban land consumption intensity which usually lead to urban land modifications.

This clearly shows that urban land use arrangement disruptions increased as the urban population increased. This is because the influx of people needed more land for settlement and establishment of other crucial infrastructures. Study done Simwanda & Murayama (2018) showed that Lusaka city in Zambia exhibited a disordered pattern of urban land use due to population influx in the city. Another study that was done by Tendaupenyu et al. (2016) in Lake Chivero Catchment area had similar findings. it showed that human population dynamics in Lake Chivero catchment area was the major cause of land use change between 1986 and 2014.

141

5.4 Challenges facing urban land use zoning in Nakuru town

98.6% of the respondents said that an increase of urban human population had an impact on urban land use arrangement while 1.4% gave a contrary opinion. Participants' response on what prevents them from implementing Nakuru town urban land zonal use policies was that 30.7%, 5.7%, 3.6%, 22.9%, 26.8% and 11.1% cited Lack of capital/ poverty, Ignorance, Lack of awareness, Population increase, Political instability/change of needs in the society and Others respectively as challenges facing Nakuru town urban land use zoning and its implementation policies among Nakuru urban dwellers (Table 10). Although at the moment of carrying out this research, Nakuru town did not have urban land use arrangement policies in place, more respondents (30.7%) cited inadequate capital as the main challenge facing the implementation of urban land use zoning in Nakuru town.

Table 10 Participants' response concerning the effects of spatiotemporal dynamics on urban land use arrangement

Item	Response	% Of the Participants
Whether urban population increase affects urban land use arranngement	Yes	**98.6**
	No	**1.4**
Factors preventing the use of land according to Nakuru Urban Land Use arrangement Policy	Lack of capital/ poverty	**30.7**
	Ignorance	**5.7**
	Lack of awareness	**3.6**
	Population increases	**22.9**
	Political instability/change of needs in the society	**26.8**
	Others	**11.1**
Measures that can be put forward to ensure that Urban Land Use Zone Policies are implemented	Creating awareness	**10.6**
	Giving incentives	**30.2**
	Improving infrastructure	**7.4**
	Closure supervision	**22.1**
	Strictness and others	**18.7**
	Population increase control	**19.3**

Also 10.6%, 30.2%, 7.4%, 22.1% 18.7 and 19.3% (Table 4.11) alluded to creating awareness, giving incentives, improving infrastructure, closure supervision, strictness and population control respectively as measures that can be used to ensure Urban Land Use Zoning and Implementation of Policies are adhered to. Also, the respondent said that lack of approved physical and land use development plans as well as insufficient man power to enforce planning regulations affects zoning process and the implementation. In addition to these, Nakuru town physical planner alluded that they are encouraging densification in the already residential areas in order to reduce the impact of urban population influx in other crucial designated zones. They also suggested that county spatial plan, ISUDP zonal guidelines should be prepared by Nakuru City Planning Section as crucial measures to solve challenges facing urban land use zoning. Disruptions in Nakuru town's urban land use arrangement between 1991-2021.

These results are in harmony with study findings of Güneralp et al., (2017) who carried a study to determine challenges caused by the growing cities in Africa. They found that urban land use zoning polies are facing societal, institutional and environmental challenges among others. Thuo (2014) found out that landless people are causing nightmares in urban centers. In connection to this, they revealed that there was a mushrooming of squatters due to urban population influx. According to Mubea and Menz, (2012) findings, 19.70 km2 of land in Nakuru town was converted to urban land-use from their initial use between the years 2000 to 2010. They also found that the growing of human population in urban areas is also posing threats on the sustainability of the urban land use arrangement.

6 Conclusions

The outcomes of this research disclose that Nakuru town is experiencing Urban population increase and this may be experienced for a long time if the current trend is something to go by. This is causing a serious urban land use challenge in Nakuru town. In fact, Urban land use areas/zones of Nakuru town continue to be depleted given that the town is sandwiched between lake Nakuru and Menengai Crater which hinder its radial growth. Spatiotemporal

dynamics of urban population was found to be the reason for the urban land use area/zone arrangement change. Therefore, there is need to embrace measures that will control the influx of Urban population. This will assist in reducing pressure on limited Urban land use areas in Nakuru town. Results also indicate a very good association between spatiotemporal dynamics of urban population and the urban land use arrangement. Although Nakuru town had no zoning policies or regulations that govern urban land use, the department of Physical and Urban Planning in Nakuru County is trying to contain undesirable urban land use arrangement changes as they wait for relevant policies and regulations to be in place. The study revealed challenges facing the implementation of urban land use policies/ zoning process in Nakuru town.

7 Recommendations

From the outcomes and conclusions of this research, the researcher made the following recommendations:

1. The national and the County government departments/ Agencies that deal with population should educate the people on importance of having a manageable birth growth rate and rural-urban migration. They should encourage people to have children that they can support economically with the limited natural resources. Opening up rural areas through improvement of infrastructure and delocalization of industries are the key solution to rural-urban migration.

2. Proper Urban Land Use Planning and implementation Policies is dearly needed in order use the limited Urban land zones/ areas sustainably. This require provision of necessary resources that are needed for the operation activities. The government and other stakeholders should emphasize on human resources, financial resources and modern technologies to ensure urban limited land is used sustainably.

3. To promote vertical urbanization. This is the process of building towers as opposed to outwards (horizontal urbanization). Vertical urbanization reduces those chances of clearing forest to give way for settlement and other land use. This approach conserves space. The government should promote construction of flats (building upwards) to maximize the use of the limited urban land use zones/areas. This can be done through giving financial resources in the form of loans or grants to private developers and individuals in the real estate. This will lead to densification of the already residential areas instead of colonizing adjacent urban lands. This approach will limit destruction of nature and agricultural areas.

4. Formulation of zoning policies and regulations. At the time of this research, Nakuru town had no zoning policies or any regulation concerning urban land use zoning. Relevant bodies like Physical and Urban Planning, Kenya National Land Commission, Ministry of Lands should exercise their authorities and avail the necessary frameworks needed in the realization of a sustainable urban land use arrangements.

References

Ariti, A. T., Van Vliet, J., & Verburg, P. H. (2019). The role of institutional actors and their interactions in the land use policy making process in Ethiopia. Journal of Environmental Management, 237, 235-246. https://doi.org/10.1016/j.jenvman.2019.02.059

Atasoy, M. (2018). Monitoring the urban green spaces and landscape fragmentation using remote sensing: A case study in Osmaniye, Turkey. Environmental Monitoring and Assessment, 190(12). https://doi.org/10.1007/s10661-018-7109-1

Das, M. B., & Sabina A. E. (2019). Inclusion Matters in Africa. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/32528

Das, S., & Angadi, D. P. (2021). Land use land cover change detection and monitoring of urban growth using remote sensing and GIS techniques: A micro-level study. GeoJournal. https://doi.org/10.1007/s10708-020-10359-1

Dzator, J., Acheampong, A. O., & Dzator, M. (2022). Urbanisation and sustainable development: Econometric evidence from Australia. Community Empowerment, Sustainable Cities, and Transformative Economies, 95-109. https://doi.org/10.1007/978-981-16-5260-8_7

Güneralp, B., Lwasa, S., Masundire, H., Parnell, S., & Seto, K. C. (2017). Urbanization in Africa: Challenges and opportunities for conservation. Environmental Research Letters, 13(1), 015002.

Kii, M. (2021). Projecting future populations of urban agglomerations around the world and through the 21st century. npj Urban Sustainability, 1(1). https://doi.org/10.1038/s42949-020-00007-5.

Kiplagat, Jactson. (2018). Influence of County Land Use Planning on Sustainable Development: a Case of Molo Sub-county, Nakuru County-kenya [Unpublished doctoral dissertation]. (n.d.) [Unpublished doctoral dissertation]. university of Nairobi.

Koroso, N. H., Lengoiboni, M., & Zevenbergen, J. A. (2021). Urbanization and urban land use efficiency: Evidence from regional and Addis Ababa satellite cities, Ethiopia. Habitat International, 117, 102437. https://doi.org/10.1016/j.habitatint.2021.102437

Kuang, B., Lu, X., Han, J., Fan, X., & Zuo, J. (2020). How urbanization influence urban land consumption intensity: Evidence from China. Habitat International, 100, 102103. https://doi.org/10.1016/j.habitatint.2019.102103

Mbuyi, K. (2019). Kinshasa: Problems of land management, Infrastucture, and food supply. African Cities in Crisis, 148-175. https://doi.org/10.4324/9780429048227-6

Menakanit, A., Davivongs, V., Naka, P., & Pichakum, N. (2022). Bangkok's urban sprawl: Land fragmentation and changes of Peri-urban vegetable production areas in thawi watthana district. Journal of Urban and Regional Analysis, 1(1). https://doi.org/10.37043/jura.2022.14.1.4

Rahaman, S. N., & Shermin, N. (2021). Identifying built-up area expansion and comparing two conventional built-up area extraction method from LANDSAT imagery: A case study on Khulna city. Academia Letters. https://doi.org/10.20935/al758

Simwanda, M., & Murayama, Y. (2018). Spatiotemporal arrangements of urban land use change in the rapidly growing city of Lusaka, Zambia: Implications for sustainable urban development. Sustainable Cities and Society, 39, 262-274.

Soria, K. Y., Palacios, M. R., & Morales Gomez, C. A. (2020). Governance and policy limitations for sustainable urban land planning. The case of Mexico. Journal of Environmental Management, 259, 109575. https://doi.org/10.1016/j.jenvman.2019.109575

Simwanda, M., Murayama, Y., & Ranagalage, M. (2020). Modeling the drivers of urban land use changes in Lusaka, Zambia using multi-criteria evaluation: An analytic network process approach. Land Use Policy, 92, 104441. https://doi.org/10.1016/j.landusepol.2019.104441

Sun, M., Wang, J., & He, K. (2020). Analysis on the urban land resources carrying capacity during urbanization——A case study of Chinese YRD. Applied Geography, 116, 102170. https://doi.org/10.1016/j.apgeog.2020.102170

Tendaupenyu, P., Magadza, C. H., & Murwira, A. (2016). Disruptions in landuse/landcover arrangements and human population growth in the lake Chivero catchment, Zimbabwe. Geocarto International, 32(7), 797-811.

United Nations. (2016). Transforming Our World: The 2030 Agenda for Sustainable Development, New York: 38 p

United Nations. (2017). Drivers of Migration and Urbanization in Africa, New York.

United Nations Department of Economics and Social Affairs. (2019). World Urbanization Prospects. The 2009 Revision. United Nation Department of Economic and Social Affairs

Waters, E. A., Kiviniemi, M. T., Hay, J. L., & Orom, H. (2021). Dismissing "Don't know" responses to perceived risk survey items threatens the validity of theoretical and empirical behavior-change research. Perspectives on Psychological Science, 17(3), 841-851. https://doi.org/10.1177/17456916211017860

Willkomm, M., Follmann, A., & Dannenberg, P. (2020). Between replacement and intensification: Spatiotemporal dynamics of different land use types of urban and Peri-urban agriculture under rapid urban growth in Nakuru, Kenya. The Professional Geographer, 1-14.

Willkomm, M., Follmann, A., & Dannenberg, P. (2020). Between replacement and intensification: Spatiotemporal dynamics of different land use types of urban and Peri-urban agriculture under rapid urban growth in Nakuru, Kenya. The Professional Geographer, 73(2), 186-199. https://doi.org/10.1080/00330124.2020.1835500

Willkomm, M., Follmann, A., & Dannenberg, P. (2019). Rule-based, hierarchical land use and land cover classification of urban and Peri-urban agriculture in data-poor regions with Rapid Eye satellite imagery: A case study of Nakuru, Kenya. Journal of Applied Remote Sensing, 13(01), 1. https://doi.org/10.1117/1.jrs.13.016517

World Bank. (2017). East Asia and Pacific Cities: Expanding Opportunities for the Urban Poor. Washington, DC: World Bank. https://openknowledge.world bank.org/handle/10986/27614

Yang, J., Li, S., & Lu, H. (2021). Quantitative influence of land-use disruptions and urban expansion intensity on landscape arrangement in Qingdao, China: Implications for urban sustainability. Sustainability, 11(21), 6174.