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Analysis of Land Use Change Trends in Kimilili Peri urban Areas from 1990 to 2020 Using GIS

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This study sought to establish land use change trends in Kimilili peri urban areas from 1990 to 2020. Landsat data for 1990,2000,2010 and 2020 were downloaded from USGS Website. Digital image processing and GIS analysis was carried out using ERDAS imagine version 2018 and Arc GIS version 10. Supervised classification using Maximum Likelihood classification Algorithm was used to obtain imageries for the following land use classes: Built up area, agricultural land, dense vegetation and bare land. Ground truthing was conducted to gather the necessary reference data. Accuracy assessment was performed for the years 1990,2000,2010 and 2020 LULC maps using Google maps at different times of the year. The results obtained were within 85% which is within stipulated accuracy standards by USGS. Land use conversions between time intervals under study was performed through change detection analysis. The areal extent occupied by each of the land use types was calculated in hectares. Overall, a significant increase in built up area was noted increasing by 16.6% over a span of 30 years. Results further showed a decline in agricultural land by 16.7%. The research study established significant land use changes between 1990 and 2020. There is an urgent need to put into force management regulations to ensure that urban expansion is controlled.

Keywords Land use change, peri urban, Remote sensing, Geographic Information Systems, Kimilili Town

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1.0 Introduction

Several research studies on land use changes in small and medium urban centres in Kenya have been documented in literature. For instance (Mandere et al.,2010) investigated peri urban development, livelihood change and household income in Nyahururu town, Kenya. Mutua (2013), studied the effect of peri urban development on the livelihoods of indigenous households in Lower Kiandani, Machakos Municipality. These studies made use of questionnaires as the instrument of investigation which is mere perception of land use by residents. The approach and contribution of the present study differed considerably from these studies in terms of data sources and methodology. This study constituted the first attempt to apply remote sensing and GIS technologies to quantify urban expansion in a small and medium urban center such as Kimilili town. The use of remote sensing to determine past and present land use changes in small and medium towns in Kenya is scanty, an indication that little is documented on the effect of growth and development of towns in Kenya on peri urban land use. Against this background, the present study sought to determine the influence of the spatial expansion of Kimilili town, a medium urban centre in Kenya on peri urban land use, using remote sensed data for the year 1990,2000, 2010 and 2020.

Urbanization is an inevitable socio-economic phenomenon occurring all around the globe, given that more than half of the world's population currently lives in urban areas (United Nations,2018). This trend is reliably predicted to continue over the next few decades worldwide with population dynamics strongly linked to this rapid growth (Araya and Cabral,2010; UNDESA,2018). The global population increased from 3.3 billion in 1965 to 7.7 billion in 2019. This figure is predicted at 8.5 billion by 2030 and 9.7 billion by 2050. Currently, 55% of the world's population lives in urban areas. In 1950, 30 percent of the global population was metropolitan, with 60 percent expected to be urban by the year 2030. The estimated global urban population will be 68 percent by 2050 if existing patterns persist (UN DESA, 2018).

Although Africa remains largely rural, it is undeniably one of the world's most urbanizing regions in the Global South (UNDESA, 2018). In the 1950s, just 14 percent of the population of the continent had been projected to live in towns. However, by 2018 the urban population increased to 43%, which is expected to rise to 50% by 2030 and 59% by 2050 (UNDESA, 2018). The rise in urban populations in many African countries is projected to be more prominent in comparison with migration (Pott, 2012).

Kenya is characterized, like most of Africa, by rapid urban growth and sprawl. The urban population of the country is expected to increase considerably over the next few years. In 1963, only 8% of the population were urban, which in 2018 increased to 27%. By 2030, the UN projects this figure to hit 33.4%. In 2050, this number is projected to hit 58 per cent, considering the latest global trends in population (UNDESA, 2018). The town of Kimilili is no exception. The town's population rose by 2.9 percent annually, from 13,929 in 2009 (KNBS, 2009) to 17,939 in 2019 (KNBS, 2019).

In order to satisfy the rising metropolitan population, the unavoidable effect is the spatial extension of urban areas beyond legal limits into their hinterlands. Globally,

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metropolitan areas expand twice as quickly on average as urban communities (Seto et al.,2011; Angel et al.,2011). Several reports have also shown that the average household volume has decreased gradually in recent decades (Haase et al.,2013). As a result, most cities in developed countries faced an increase in living space per capita, undoubtedly one of the many factors that greatly influenced the cities' spatial development. Land use changes around the urban areas of the world are expected to increase tremendously in the years ahead, thus exerting pressure on land resources (UNDESA,2018).

As cities expand, the peri-urban region is the main area of direct impact. Peri urban areas with complex land use are transitional in nature. Due to its diversity of land uses, the community includes heterogeneous groups, including indigenous people, growers, migrants, leisure users, industrial users, natural resource users, developers and builders and investors (Thuo,2010). As a result, the peri-urban areas undergo unregulated physical growth intensively and continuously. This puts pressure on land resources causing an increased conversion of prime agricultural land into residential and business use (Amoateng et al.,2013).

Due to the weaknesses of the dichotomy between rural and urban, the importance of peri-urban areas grew over half a century ago. Peri city settlements are also classified as metropolitan neighborhoods, urban peripheries, suburban areas and peri city areas. The word "peri urban" is popular in literature and policy debates (Kamau., 2015). The unifying elements/characteristics are extracted from literature about defining urban areas: sites of conflict or rivalry between new (urban) and traditional (rural) use of the land; secondly, the external boundaries of the peri-urban areas are differentiated with regular maximum commuting distances in CBDs from the urban areas identified by transit available in high proportion (CEMAT,2007).

The County Integrated Development plan Bungoma 2013-2017 recognizes unchecked spread of urban centers to agriculturally suitable land as the key challenge that the town faces (CGK,2013). Prime agricultural land and fragile ecosystems are being converted to residential and commercial development (ISUDP,2020). The main objective of the study was to establish land use change trends in Kimilili peri urban areas for the past three decades (1990-2020) using GIS.

1.1 Statement of the problem

Rapid urban growth and development is a significant factor influencing economic, social and spatial restructuring. Urbanization creates a demand for consumer goods and services as well as ready market for agricultural products in the hinterland. Despite this advantage, rapid growth and development of towns beyond designated urban-rural boundary has led to conversion of arable land to residential and commercial use, yet agriculture as a source of livelihood for peri urban residents continue to decline. The available literature on urban sprawl has focused more on major cities such as Nairobi, Kisumu and Nakuru. No study to establish land use change trends in peri urban areas of small and medium urban centres using GIS has been conducted so far. In view of this discrepancy, there was need to analyse the land use change trends in peri urban areas of Kimilili town. The findings of this study would enable the stake holders in urban management to formulate a feasible framework to guide land use planning, development and management in small and medium urban centres in Kenya.

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1.2 Review of Related Literature

The expansion of urban land space beyond legal limits into the hinterland is attributed to population growth resulting from natural growth, migration and transformation of rural settlements into towns (Fox,2014). A report by United Nations Department for Economic and Social Affairs (2019) projects that world population will reach 60% in 2030 and rise to 68% by 2050. Although Africa remains largely rural, it is undeniably one of the world's most urbanizing regions in the Global South (UNDESA, 2018). In the 1950s, just 14 percent of the population of the continent had been projected to live in towns. However, by 2018 the urban population increased to 43%, which is expected to rise to 50% by 2030 and 59% by 2050 (UNDESA, 2018). The rise in urban populations in many African countries is projected to be more prominent in comparison with migration (Pott, 2012).

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Previous studies by Seto et al. (2011) and Angel et al. (2013) revealed increased spatial expansion of urban areas into their hinterlands in sprawled patterns. The resultant effect is accelerated land use changes in the peri urban areas leading to increased conversions of land under for agricultural use to residential and commercial use (Appiah et al.,2019). Land conversions and fragmentation have led to a reduction of agriculture as source of livelihood for peri urban residents.

In their study on Modelling spatial processes of urban growth in an African City, Mundia et al. (2010), underscored the need to incorporate remote sensing and Geographic Information System in urban studies. The authors concluded that Geographic information derived from remote sensed data was useful in monitoring and predicting land use changes in urban settlements.

To address challenges associated with sprawling pattern of small and medium urban centres in Kenya such as Kimilili, a spatially feasible planning framework that identifies and anticipates urban land use changes and their resultant effects is required. Geographic information techniques therefore play a significant role in mapping urban land use pattern and provides remote sensed data that is needed in formulating policy and planning intervention necessary to manage peri urban land uses in small and medium urban centres in Kenya.

2.0 Research Methodology

2.1 Study Area

Kimilili town is one of the urban centers in Bungoma county in Kenya and an administrative headquarter of Kimilili Sub County. It lies on the slopes of Mount Elgon at an altitude of about 1,700 m above sea level; with cool climate, fertile soils that supports various agricultural activities. The town is situated approximately 00^0 47’ North of the Equator and 34^0 43’ East of the Greenwich. It is about 500km West of Nairobi city and 300km North of Kisumu city. It is situated along Kisumu-Kitale Road and Kitale-Kenya-Uganda border road.

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Functionally, Kimilili town is a residential, industrial, educational, recreational, administrative, commercial, service, transportation and marketing center. The land in the study area is mainly held under freehold tenure.

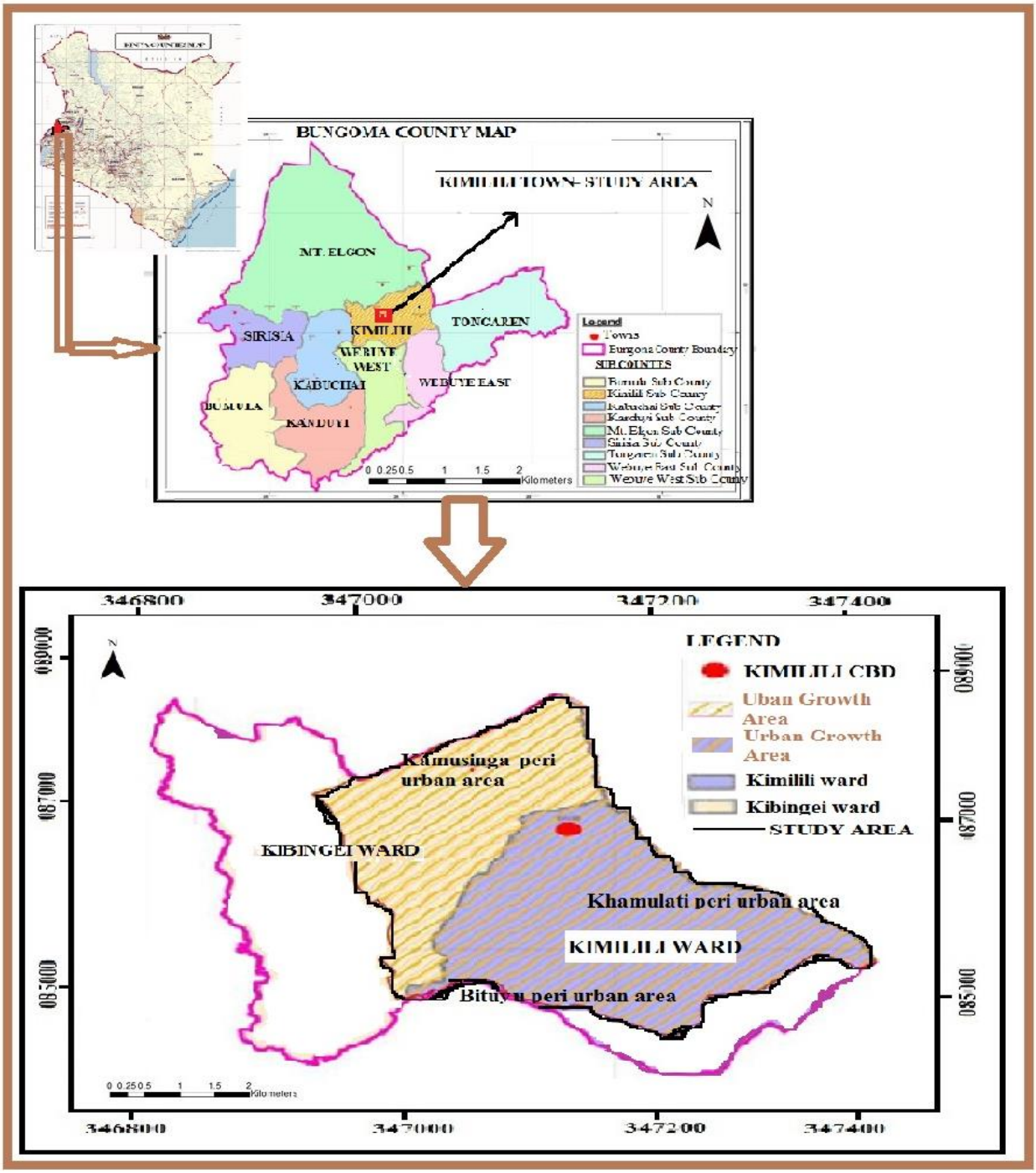

Figure 1: The Study area
Source: Adapted from Integrated Urban Strategic Development Plan for Kimilili Municipality (2020).

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2.2 Methods of Data collection

2.2.1 Key informant interviews
Key informant interviews were employed to obtain data from the department of physical planning, department of survey, Lands office and Municipal manager.

2.2.2 Remote sensing images
A set of remote sensed data was utilized to determine the extent of land use changes in Kimilili peri urban areas over a period of three decades from 1990 to 2020. This was done by identifying changes in peri urban land use for the period of study. Landsat data for 1990,2000,2010 and 2020 was acquired from USGS website. Landsat data was preferred because it is open for free access. The Landsat images used for the study are indicated in table 1 below.

Table 1: Landsat Images Used in the Study

Data	Year	Band	Spatial resolution
Landsat 4	7.02.1990	TM	30m
Landsat 7	14.09.2000	Enhanced TM	30m
Landsat 5	21.01.2010	TM	30m
Landsat 8	13.09.2020	OLI	30m

Source: USGS Explorer

2.2.3 Methods of Data Processing and Analysis
Erdas imagine Version 2018 and ARC GIS version 10 were used to process and analyse spatial data. All the satellite images downloaded from USGS Website were rectified to the same Universal Transverse Mercator (UTM) projection system with datum world geodetic system (WGS) 1984 UTM Zone 36N for Kimilili town. Data analysis was done by clipping areas that covered the study period of 1990,2000.2010 and 2020 using the boundaries of Kimilili ward and Kibingei ward in order to extract images of the targeted study area. Supervised classification in ERDAS Imagine using Maximum Likelihood algorithm was carried out to obtain the following land use classes for the aforementioned period of study: Built up area, Agricultural land, dense vegetation and Bare land. Percentage change for each land use category for each year was determined. Tables were used to quantify, in hectares, land use change trend for the period under study.

3.0 Results and Discussion
This section presented the results and discussions of the present study.

3.1 Land use classification
After performing supervised classification, four main land use classes were obtained: Built up area, Agricultural land, Dense vegetation and bare land. From the classification results for 1990,2000,2010 and 2020, land use maps were generated depicting change over time (Figure 1). The results of the trend of land use change in the study area from 1990 to 2020 are presented in table 2 below.

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Table 2: The Trend of Land use Change in the Study area from 1990 2020

	1990		2000		2010		2020		1990-2020 % Change
Land use type	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**	**%**
Agricultural land	2876	**59.5**	2742	**56.8**	2536	**52.5**	2067	**42.8**	**- 16.7%**
Bare land	526	**10.9**	56	**11.6**	1010	**20.9**	1591	**33.0**	**22.1%**
Built up area	54	**1.1**	287	**5.9**	378	**7.8**	856	**17.7**	**16.6%**
Dense vegetation	1474	**28.5**	1241	**25.7**	906	**18.8**	317	**6.5**	**- 22.0%**
TOTAL	4830	**100.0**	4830	**100.0**	4830	**100.0**	4830	**100.0**	

Source: Researcher's Analysis (2021)

The decadal area of land use land cover change was computed using simple arithmetic where the area of a given land use type in the initial year was subtracted from the final year. The difference represents land use change in terms of spatial coverage and direction of change. The percentage of each land use type was computed to establish the percentage increase or decrease of each land use as indicated in table 2 above.

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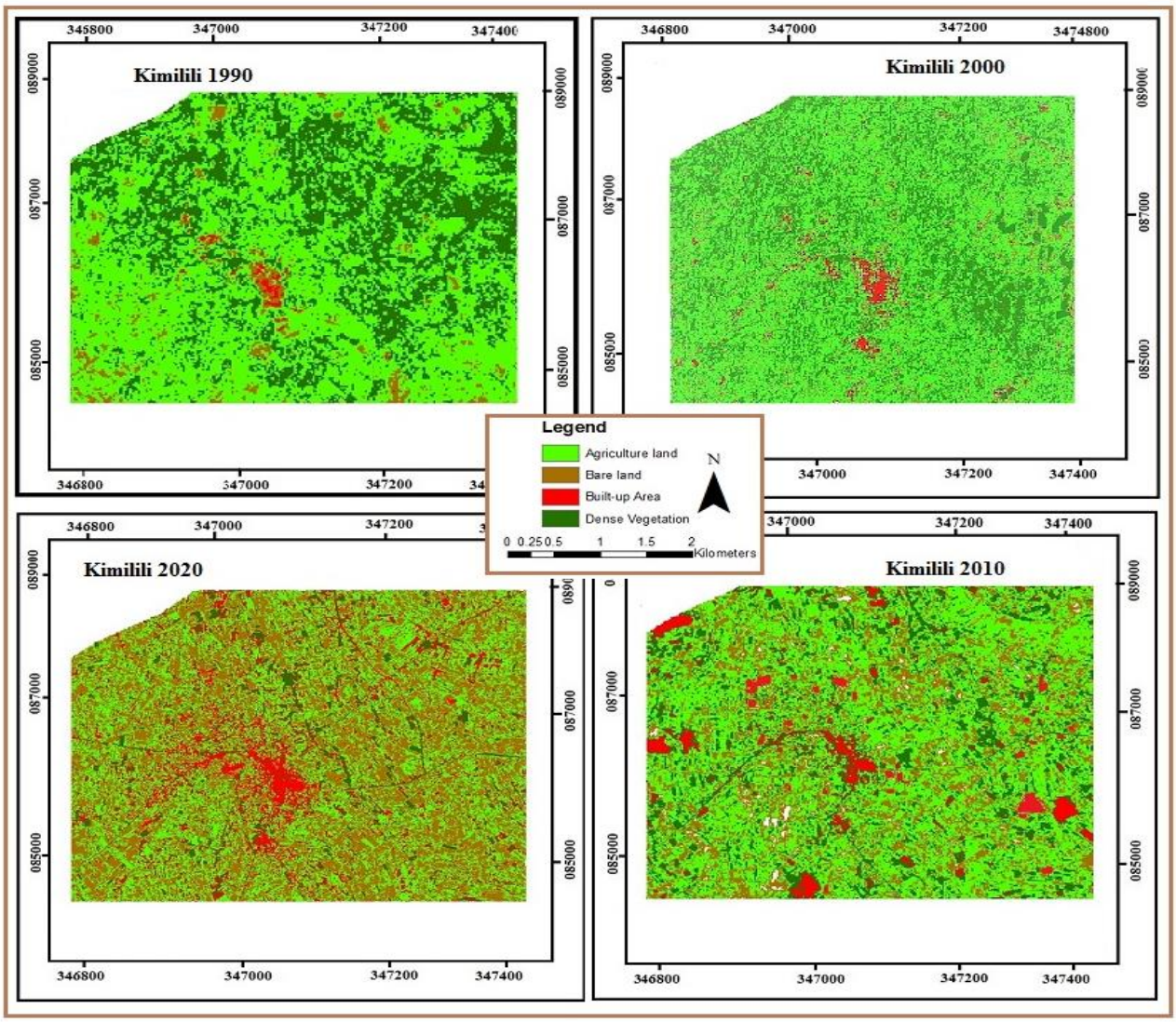

Figure 2: Land use and land cover maps for the study area.
Source: Researchers Analysis in Erdas Imagine V.2018 (2021)

As demonstrated (Table 2), in a period of 30 years, built up area recorded an increase from 1.1% to 17.7% of the study area representing 16.6% increase. On the other hand, agricultural land decreased from 59.5% in 1990 to 42.8% in 2020 accounting for 16.7% change. From the results, there is a near direct relationship between built up area and agricultural land. This may possibly suggest land use conversion from agricultural land to non-agricultural land uses such as residential and commercial use.

The sprawling pattern of Kimilili town has disrupted peri urban agriculture to the extent that households intending to continue engaging in agriculture for food and income are constrained. This supports the findings by Mutua (2015) who observed that agricultural production as a source of livelihood around sprawling towns was insufficient to sustain peri urban households and meet their income needs. Disruption of peri urban agriculture has led to increased incidences of food shortage, economic hardships and poverty. Food prices have

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increased and households are compelled to purchase food to supplement the little they get from their farms.

Findings of the study revealed that households when faced with factors that render farming an unviable land use activity have responded by devising various adaptive strategies to augment their household sustenance. These strategies include diversification, intensification, seeking of farm opportunities and out migration. However, these strategies largely depend on the household's proximity to the town centre. Research findings indicate that households in the study area took advantage of the expanding consumer needs of the growing urban population and are currently utilizing their land to grow fast moving and high value crops such as kales, tomatoes and horticultural crops. Besides cultivation of high value crops, households are also engaged in zero grazing of dairy animals, pigs and poultry keeping within their household land parcels.

The results of this study are consistent with the findings of Willkom et al. (2016) who observed that growing and dynamic consumer demand around urban centres presented peri urban households with opportunities for commercialization and value addition. On the contrary, some residents who are unable to cope with urban sprawl and whose livelihoods have been completely eroded by urban expansion opted to move out of the study area further into the periphery in order to access large pieces of land for farming.

4.0 Conclusion and Recommendations

The purpose of this study was to analyse land use change trends in Kimilili peri urban areas from 1990 to 2020 using GIS. Spatial temporal analysis of the study area indicate that built up area increased exponentially from 1.1% in 1990 to 17.7% in 2020. This happened at the expense of agricultural land. Results further indicate that over the same period of time, agricultural land decreased from 59.5% in 1990 to 42.8% in 2020. The greatest change is observed in the built-up area and agricultural land use, with the later decreasing as the former increases.

The decrease in agricultural land has resulted to a decline in agricultural production. This poses a threat to peri urban households who depend on agriculture for daily sustenance. Disruption of agriculture has resulted to increased food shortage leading to high food prices, economic hardships and poverty. To cope with these changes, households adopt three strategies; farm strategies (intensification and diversification), non-farm strategies (formal and informal employment) or both farm and non-farm strategies. Theses adaptive strategies gives households an alternative source of income (Thuo,2010). In order to safeguard peri urban livelihoods, there is an urgent need to put into force management regulations to ensure that urban expansion is controlled to avert food insecurity.

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