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Effects of Land Use Land Cover Changes on Vegetation Cover Types in Khwisero Sub County, Kakamega County, Kenya

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Abstract: Land use land cover changes have to a great extent changed the world's landscapes rebuilding environments and what they provide to humans during the time spent supporting the rising population across the globe. However, the LULCCs affect land quality in terms of loss of vegetation cover types and altering soil quality to great extent. Misango Hills natural forest and other forms of vegetation cover types in Khwisero Sub County have been changed over completely to farming and built up regions. Cross sectional descriptive and longitudinal research designs were used. Purposive sampling was used to select the key informant while random sampling was used to obtain a sample size of 384 from a study population of 113,476. Primary data was collected through interviews and discussions with key informants, field observations and questionnaires administered to individual households in Khwisero Sub County. Secondary data involved downloading Landsat images (Landsat 7, 8 and 9; 30-meter multispectral), summaries and citation of other works carried in journals articles, original documents, annual reports, development plans and internet. Quantitative data analysis involved measures of central tendency and measures of dispersion (SPSS) and analysis of variance (ANOVA). Qualitative data was analysed by organizing and grouping the arising issues into various categories relevant to the study. Landsat images data for effects of LULCC on vegetation cover types were analysed using ENVI software. The study revealed that LULCCs are driven by settlement, poverty and climate change mostly thus affecting cropland vegetation and soil fertility majorly. Furthermore, cropland occupied 60% and lost up to 40.1% to built up, road construction, bare land and forests; forests occupied 23% of the study area and lost up to 60.4% to agricultural expansion and built up while shrubs and grassland covered 18% and 13% respectively and lost to built up and road construction mostly at 31.8% and 29.7%. NDVI indices indicated a range of 0.035 to 0.429 in 2002 showing average greenness due to more cropland and forest, -0.184 to 0.037 in 2012 showing lower greenness due to increased built up, reduced forest cover and increased bare land and 0.023 to 0.529 in 2023 showing increased greenness due to increased forest cover. This study showed that LULCCs affected all the vegetation cover types. The study recommends creation of awareness of understanding importance of land quality specifically vegetation cover types then locals be enlightened on how to manage land resource. and methods of improving the already damaged soils in Khwisero Sub County.

Keywords: Land use Land cover change, Drivers, Land use Land cover, Vegetation cover Types, Landsat, NDVI

INTRODUCTION

Land cover refers to the physical qualities of land while land use includes human administration and exercises on land (FAO, 1999). Changes in uses and covers of land happen continually and at many scales, and can affect air and water quality, watershed work, age of waste, degree and nature of untamed life territory, environment and human wellbeing (Schwartz, 2004). Throughout recent years, the most unmistakable land changes inside the USA have been in the sum and sort of forest cover because of logging practices and development in South East and North West and to urban expansion in North East & South West (Berke *et al.*, 2006). Furthermore, increased soil erosion is experienced in the watershed due to deforestation thus leading to loss of soil productivity (Hua, 2015). Anderson (1982) noted that most studies are not putting clear to what extent that LULCC causes deforestation because there are other causes of deforestation that could be holding a higher percentage than LULCC.

In Zimbabwe, forests have reduced by 36% between 1984-2013 and cultivated areas increased by 13% (Gumindoga *et al.*, 2014). Ruti Dam which is situated in Nyazvidzi catchment is going through natural changes whose effects are not yet completely comprehended (Gumindoga *et al.*, 2014). Increased deforestation has resulted in increased temperatures by 2°C and precipitation decreased by 20% in West Africa (Hulme *et al.*, 2001). The land use land cover changes influence watershed overflow, miniature climate resources, groundwater tables, cycles of land degradation and landscape level biodiversity (Lambin and Geist, 2008). Deforestation has brought about evacuation of around 32 million hectares of woodland from 1990-2010 (FAO, 2010). In Kenya forested areas have reduced over time due to increased land use land cover changes in Cherenganyi, Taita Taveta, Bungoma, West Pokot, Mt. Elgon, Narok, Trans Nzoia and Malava areas (Rotich and Ojwang, 2021; Ndalilo *et al.*, 2021; Machuma *et al.*, 2021; Peterson *et al.*, 2021; Masayi *et al.*, 2021; Anne, 2022; Chepkwony, 2009 and Masayi, 2021).Kakamega County encounters a wide range of environmental issues

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like land resource exhaustion, deforestation, pollution, water catchment areas destruction and loss of biodiversity (C.G.K, 2018-2022).

KIPPRA (2021) and KNBS (2020) reports shows that Kakamega County is leading in poverty index across the members of the population with 65% of its household lack food stock followed by Homabay at 55%, then Turkana at 52% while counties like Kisii are at 11%, Bungoma 8% and Vihiga is at 40% which is attributed to increased LULCCs as indicated in C.G.K (2018-2022) resulting from the environmental issues experienced in the county. Misango Hills forest in Khwisero Sub County has been deforested so as to create more land for agriculture, road construction and urban extension to a great extend increasing soil destruction thus reducing agricultural yield (SOFDI, 2022)**.** In addition, the C.G.K (2018-2022) noted that land uses land covers together with the changes practiced in Khwisero Sub County varies from one location to the other thus variations in the effects. The changes in the uses and covers of land were clearly shown in all the studies and how they affected various aspects of vegetation especially forests. Most of the studies used Landsat images which gave historical data. However, it was clear that most of the researchers concentrated on forests form of vegetation with very little knowledge on the other vegetation types. Most studies were not putting it clear to what extent LULCC caused deforestation because there were other causes of deforestation that could be causing more harm to forests than LULCC. This study therefore established the effects of LULCC on all the vegetation cover types and also established the contribution of LULCC on vegetation cover loss by use of both Landsat images data and field observation data determining the actual contribution of LULCC on vegetation cover types loss alongside other factors. Field data was used to validate and calibrate the Landsat images data which is historical data. This study used sensitivity analysis on the vegetation cover types found within the study area. The analysis showed which vegetation cover types were more sensitive to LULCCs to less sensitive in every location. From the NDVI data the study considered other causes of vegetation cover types destruction. The study used sensitivity analysis to show which activities are more sensitive to vegetation cover types and which are less sensitive. Finally, the study arranged the causes from more sensitive to less sensitive.

LITERATURE REVIEW

The changes in uses and covers of land affect the vegetation cover which is related with huge adverse consequences on biological systems saw at nearby, territorial and worldwide scales (Ellis and Pontius, 2007). This is supported by UNFCCC (2007) that LULCC because of deforestation of forests was the significant supporter of carbon dioxide emanations during the 1990s. Efrymson *et al.* (2005) found out that LULCC in the U.S.A reduced forest thus destructing wildlife habitat. Deforestation leads to loss of native habitat (Schenker, 2000). The LULCC leads to the spread of invasive species plants (Westbrooks, 1998) in the USA. According to Ellis and Pontius (2007) biodiversity is diminished when land is changed from generally undisturbed state to an additional serious use like cultivating, keeping animals, particular tree gathering among others. This is supported by Ganasri and Ramesh (2016) whose study linked habitat destruction to loss of forests. The Himalayan catchment in India is affected by decrease of natural forests to agricultural land and urbanization leading to land degradation (Sharma *et al.*, 2007; Chauhan and Nayak, 2005). In Hazira Gujarat shrubland and grass land has been changed to cropland exposing the earth surface to erosion (Jayakumar and Arockiasany, 2003). It is evident that land cover is important for the other resources to prosper.

The largest increase of runoff was found when converting forests and savannah to agriculture (Wilk and Hughes, 2002). Gary and Carmen (2007) found out that loss of forest cover in Pennsylvania led to land degradation. China seems to be ahead of the rest of the countries in the world as the effects of LULCC are both positive and negative (Zhihui *et al.*, 2014). Forests converted to urban and agricultural areas lead to loss of ecosystem function (Zhuihui *et al.*, 2014). The conversion of cultivated areas to grasslands and forests lead to land improvement as it led to increase in rainfall (Zhihzui *et al.*, 2014). Poorzady and Bakhtiari (2009) found out that the Hyrcanian forest which contains one of the significant critical natural normal environments has diminished and Talar watershed impacted because of fuel, timber carrying, animals grazing, road improvement, mines exploitation and development of industrial facilities. This has led to destruction of habitat endangering unique species.

Deforestation in Africa has led to removal of millions of hectares of forests leading to loss of ecosystems (FAO, 2010). Gumindoga *et al.* (2014) supported this with a study conducted in Zimbabwe that forests reduced by 36% increasing cultivated areas by 13% thus loss of biodiversity and increasing surface runoff. Forests in West Africa are destroyed due to agricultural extension, populace development, unlawful logging, out of control fires and mining (Kouassi *et al.*, 2018). Vegetation cover in the Central Rift Valley in Ethiopia contains thick acacia woodlands which have been changed over completely to rural agricultural and grazing animals land prompting loss of biodiversity (Lambin and Geist, 2008). Hassan and Hertzler (1988) figured out that unnecessary tree cutting for energy uses is a serious deforestation issue in Sudan. Unnecessary deforestation causes commonly more friendly expense than benefit (Galal, 2005).

Deforestation and timberland degradation are the main LULCC processes in Pangani River Basin in Tanzania (IUCN, 2003). LULCC can be a significant danger to biodiversity because of the obliteration of normal vegetation and the fracture or seclusion of regular regions (Verburg, 2006). The forested and grassland areas converted to cultivated areas leads to biodiversity loss thus reduction in size of habitat in Kilombero in Tanzania (Ntongani *et al.*, 2014). Kiage *et al.* (2007) conducted research in Lake Baringo catchment which found out that forested areas decreased thus increasing sedimentation. Loss of vegetation cover prompts soil erosion which prompts land degradation (Kirimi *et al.*, 2018). This is supported by studies conducted in Lake Victoria basin and Mara River which linked increased soil degradation to loss of vegetation cover affecting biota (Matano *et al.*, 2015). The studies indicate clearly that destruction of forests and other vegetation pose a threat to the land resource.

A review by Twesigye *et al.* (2011) figured out that land cover was persistently diminished in size being overtaken by development of factories, farming and settlement exercises. This leads to loss of land productivity deteriorating ecosystems health and loss of forest genetic resources thus community livelihoods (Isager *et al.*, 2002). Lake Victoria Basin experiences loss of land cover due to LULCC. This opens soils to both wind and water erosion thus escalating degradation issue (Ochola, 2006). Further it leads to loss and destruction of biodiversity. Olang *et al.* (2010) found out that Nyando river basin experiences deforestation leading to loss of biodiversity. LULCC due to increased population pressure for the need of more land for agriculture and urbanization activities have exerted a lot of pressure on forest habitat thus destructing ecosystems (Adhiambo, 2018). Saidi (2017) found out that River Isiukhu catchment area experienced deforestation that has prompted the openness of the ground to surface run-off. Most studies underline on biophysical part of LULCC (Geist & Lambin 2001). Understanding LULCC according to drivers gives fundamental data to LULCC planning and sustainable management of resources of land. These studies showed variety among the causes of deforestation and land degradation. Notwithstanding, the elements of these drivers, their connection to regional and national level, their socio-economic setting and ranchers' responses in creating adoptable arrangements are ineffectively perceived.

Theoretical Framework

The world's landscapes have been generally changed (Ellis, 2011), rebuilding biological systems and their administrations during the time spent supporting a populace moving toward eight billion at the time when materials consumed by man are at the highest level. The collection of these changes makes ecological effects that challenge the basic construction and capacity of the world's framework (Arbault *et al.*, 2014; Steffen *et al.*, 2011), with flowing effects on biodiversity, biogeochemical cycling, and climate change (De Chazal *et al.*, 2009). A theory of land frameworks would make sense of the components and cycles creating land uses and land covers concerning social and natural subsystems (Rounsevell *et al.*, 2012). Theories of land frameworks stay tricky (Zhou *et al.*, 2019) as those for human natural connections overally (Roy Chowdhury and Turner, 2019). Briassoulis (2020) figured out that not very many hypotheses make sense of about land use change which she credited to the accompanying reasons; the speculations manage changes of determinants, most speculations are interconnected in nature which implies they don't permit various historical, institutional, political human organization and other more profound variables to go into illustrative schemata used, the description of the focal point of most speculations, joined with a presumption about framework balance produces static speculations for the most part which can't oblige elements of progress which is the pith of clarification, lastly level of investigation assumes a basic part as the genuine informative components of progress may not work at the degree of reference of a given theory. This present circumstance exists regardless of the calculated acknowledgment of natural administrations as a bio directional connect between the two subsystems i.e. human ecological (Angelstam *et al.*, 2019; Bannet *et al.*, 2015; Mace *et al.*, 2012) and hence the call for integrating ecological criticisms in land use theory and models (Lambin and Meyfroidt 2010; Pogratz *et al.*, 2018). After the improvement of different numerous incorporated evaluation and specialist-based models on components of human climate relationship and the different structures of the subsystem has not yielded the advancement of land framework theory (Turner *et al.*, 2020).

The current theories, speculation and clarifications on land elements don't completely integrate both social and natural aspects, rather they center around the construction, cycle and results in a single subsystem than the other, however completely address the cooperation (Chowdhury and Turner, 2019). As elaborated in their audit; ecological subsystem will in general treat human exercises i.e. land use as aggravations to the biological system working or administrations with negligible thought of the communications inside the social subsystem (Wu and Hobbs, 2002). The social science way to deal with land use will generally focus on components of social subsystem (Rounsevell *et al.*, 2012). Only a rare example of ecological variables will generally impact land use, like soil quality or are impacted by those land uses i.e fossil fuel byproducts, biodiversity misfortune or soil erosion however underemphasizing the interconnection (Roy Chowdhury and Turner, 2019). Briassoulis (2020) noticed that theories that record for the spatial-temporal intricacies don't appear to exist yet.

It is consequently that the land system science community contends that coupling theories gotten from every subsystem stays the most productive integrative right now (Filatova *et al.*, 2013; Vadjunec *et al.*, 2018). This is supported by Briassoulis (2020) who proposed the use of combination of theories as opposed to depending on a solitary theoretical schema by inspecting basically which theories are reasonable for which spatial-temporal level. Subsequently, with the different land use and land cover designs, this study depended on two theories; Alonso's Bid lease theory and Von Thunen's agricultural land use theory. Bid lease theory in light of crafted by Alonso (1964) and Muth (1969) which focuses on how land use patterns are set on the land values (Shieh, 2003).

Land users battle for the most open land inside CBD, accordingly the sum they will pay is called offered lease (Shieh, 2003). This prompted the improvement of concentric land use structure by Alonso and was propelled by Von Thunen (Shieh, 2003). The concentric land use structure portrays city designs from the human natural theories which were created through the cycles of attack and progression; new interests attack specific pieces of the city succeeding the previous tenants who thus move to attack different parts, e.t.c bringing about specific land use designs i.e., concentric rings (Briassoulis, 2020).The concentric zones include: the focal business area, zone of progress, low-pay housing zone, middle pay housing zone and roving zone (Shieh, 2003). Bid lease theory can be related with LULCC of urban extension and road construction. Von Thunen theory of agricultural area makes sense of that the land use types considered are different kinds of agricultural land basically and optionally woods land. It explains that land which is formed into developing kinds of harvests from crops and ranger service of forests. Land is thought to be uniform with motion to all points and it is just leasing that changes with distance from the middle (Braissoulis, 2020). Von Thunen theory of agricultural area can be related with LULCC of farming encroachment, deforestation and wetland alteration. Bid lease theory has been operationalized in computational model displaying, where it has been used to mimic the change of agricultural land into metropolitan improvement in a concentric city model (Filatova *et al.*, 2009). Von Thunen theory and bid lease theory have been used by Walker (2004) in theorising land cover and land use change in tropical deforestation in the Amazon basin.

Conceptual Framework

The conceptual framework (Figure 1.1) defines four key wide and commonly interlinked variables in particular: drivers of LULCC across the world including; settlement, agricultural development, wood extraction, populace tension, policy and institutional disappointments, timberland fires, urbanization, beliefs, poverty political issues. The changes in covers and uses of land activities in the different parts of the world's surface including; agricultural encroachment, built-up extension, deforestation and road construction. The intervening variables of LULCC; policy changes, tenure insecurity together with time. The final variables are from land quality that are affected by the LULCC. The interlinkages between the independent and dependent variables are given at two levels. First, LULCC as an independent variable and dependent variable when it linked to the cause of the changes. This means that the LULCC will be dependent on the existence of any of the named causes for it to occur, without which no changes may be experienced in the uses and covers of land on the earth's surface. The study concentrates more on LULCC being an independent variable while land quality is the dependent variable. Land quality depend on the uses and covers of land to experience changes that have been shown in the conceptual framework (Figure 1). This includes the following; increased LULCC causes loss of vegetation cover which leads to destruction of habitats and loss of biodiversity. Increased LULCC leads to reduced levels of soil nutrients thus leading to reduced soil pH, NPK, SOM and tampering with the soil temperatures which will cause effects on crop yields during harvesting. Finally, increased LULCC activities affect the soil water levels thus reducing the soil water quantity and soil relative wetness. This has an effect on crop production too because soil moisture is one of the variables in determining where and how well different crops grow.

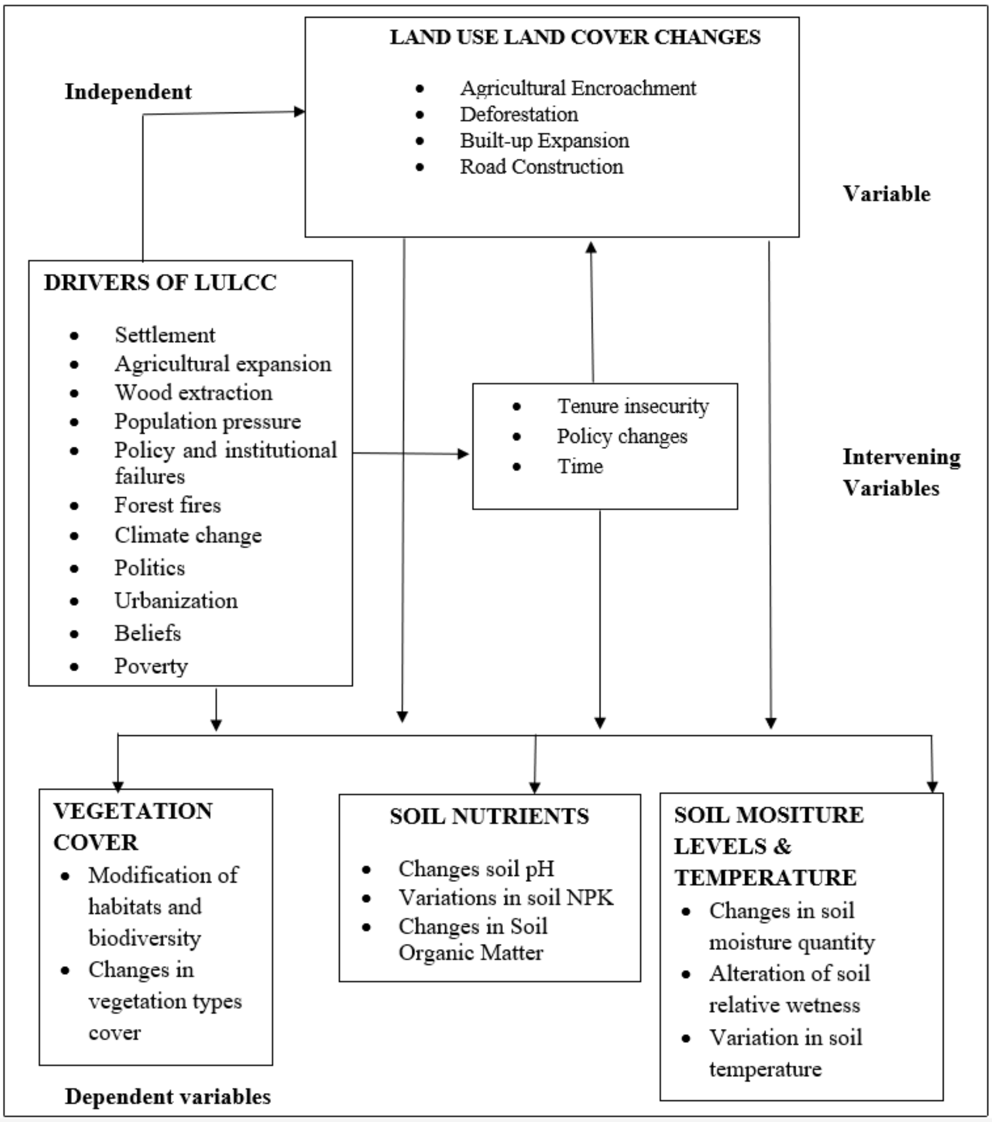

Figure 1: Conceptual Framework
Source: Researcher, (2024)

METHODS AND MATERIALS

Research Design

The study used multiple design; cross sectional descriptive research, longitudinal design and experimental design. Cross sectional descriptive research design targeted drivers of LULCCs and effects of LULCCs on vegetation types cover which involved visiting individual households. Longitudinal design involved Landsat images (Landsat 7, Landsat 8 and Landsat 9) for the years 2002 – 2023 observed the LULCCs experienced in Khwisero Sub County and their effects on land quality in terms of LULCCs effects on vegetation types cover by use of decadal NDVI, LULCCs effects on soil moisture levels availability and soil temperature by use of soil moisture index. Furthermore, the study used soil pH index and salinity index for effects of LULCC on soil pH and soil salinity respectively. Other measurable values of soil nutrients within satellite images were also considered by this study.

Study Area

Location

Khwisero Sub County is one of the twelve sub counties of Kakamega County. It borders Butere and Lurambi Sub Counties in the West Ikolomani Sub-County in the East and Vihiga County in the South. Khwisero Sub County lies between longitudes 34.55442° and 34.63442^0 East and latitude 0.13121° and 0.21121^0 North. Its average elevation is 1387 meters and covers a total area of 145.6km^2. It is the smallest sub county in Kakamega County. The Sub County is divided into four administrative units. Kisa Central leading with the highest numbers of village units and community areas since it covers a large area of 53.5km^2. Kisa East is the smallest ward in area (28.7km^2) but come second in terms of number of village units and community areas. Kisa North and Kisa West are approximately the same in area and have equal number of village units and community areas. The information can be summarized in the following Table 1.

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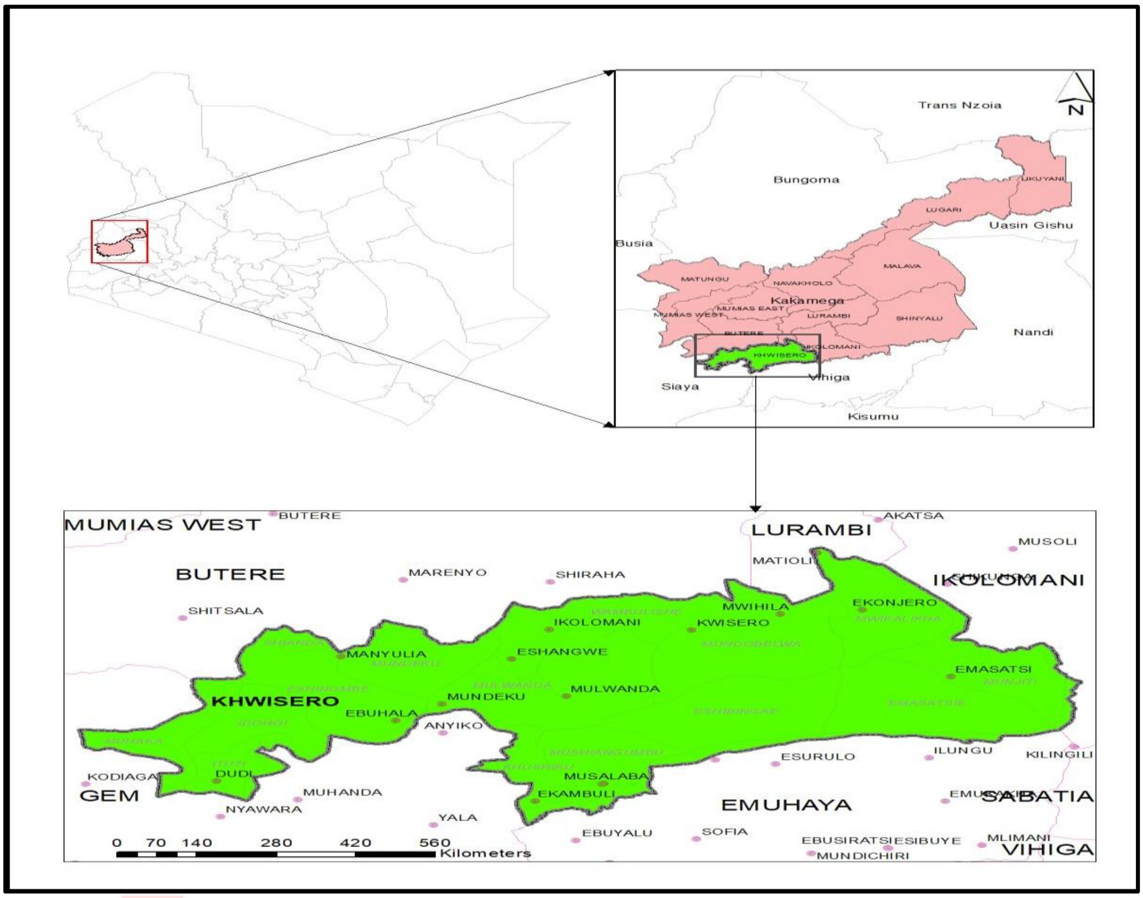
Table 1: Administrative Units and Area by Wards

Ward	Area (Km^2)	No of village units	No of community areas
Kisa Central	53.5	4	9
Kisa West	28.7	3	6
Kisa East	31.9	2	5
Kisa North	31.5	2	5
Total	**145.6**	**11**	**25**

Source: Kakamega County Development Plan, (2018-2022)



Legend Kakamega County
Khwisero Sub County

Figure 2: Khwisero Sub County Administrative Boundaries by Ward
Source: Kakamega County Development Plan, (2018-2022)

The sub county is divided into two divisions. This are Khwisero East and Khwisero West. Khwisero East has three sub-locations namely; Kisa East, Kisa North and Kisa South. Khwisero West has four locations namely; Eshirombe, Kisa central, Kisa West and Mulwanda. This is shown in Table 2 below.

Table 2: Administrative Units and Area by Location

Location	Area (km^2)	Sub-locations
Kisa East	16.9	3
Kisa North	26.2	2
Kisa South	20.1	3
Eshirombe	10.5	2
Kisa central	25.1	3
Kisa West	17.7	3
Mulwanda	29.2	4
Total	**145.6**	**20**

Source: Kenya National Bureau of Statistics, (2019)

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Topography and Hydrology

Khwisero Sub County is situated on the Eastern edges of the Rift Valley in the Southern part of Kakamega County. Its altitude ranges between 1240 metres and 2000 meters above mean sea level. Being in the southern piece of Kakamega County, it is bumpy and is comprised of granite rocks. The sub area has undulating slopes and valleys with streams moving from Northeast to Southwest and flowing into Lake Victoria. River Yala is the major river in Khwisero Sub County which experiences high riverine erosion.

Climate

Khwisero Sub County encounters tropical monsoon climate with reasonably circulated precipitation all through the year with a typical yearly precipitation that ranges from1400 mm to 2000 mm. Temperatures range between 18℃ to 29℃. This climate upholds a wide assortment of harvests like tea, maize, sugarcane, horticultural yields and raising of domesticated animals.

Geology

The geological formation of the sub county is made out of significantly the Kavirondian system with few parts with the Nyanzian System rocks notable ones include; granite extension from Mumias and Maragoli granite, mudrock, greywacke, rhyolite/agglomerate, conglomerate, basalt/andesite, grits among others. These rocks have high potential for utilization as building materials and minerals.

Soils and Land Use

The sub county has two principal ecological zones to be specific; upper medium and lower medium. The most predominant ecological zone is the lower medium. The lower medium zone has primarily the red loamy sand soils gotten from sediments and absent rocks. The vitally economic activity is sugarcane production with certain farmers planting maize, yams, tea, groundnuts, cassava and sorghum on a small scale.

Study Population

Khwisero Sub County has a populace of 113,476 as at 2019 census, with Khwisero West Division leading with a population of 70,765 while Khwisero East Division has 42,711 persons. Mulwanda Location occupies the largest area of 29.2 km^2 and thus the leading location in population of 25,186. The highest concentration of population density of 1032 persons per km^2 is found in Eshriombe Location which occupies the smallest population of 105km^2 with the least population of 10,874 amongst all the locations.

Sampling Procedure and Sample Size

The sampling area was Khwisero Sub County. The study employed purposive for the study area and key informant and random sampling procedures for households and soil samples. The study area was selected purposively because it is part of Kakamega County which encounters a wide range of environmental issues like land resource exhaustion, deforestation, pollution, water catchment areas destruction and loss of biodiversity (C.G.K, 2018-2022). In addition, KIPPRA (2021) and KNBS (2020) reports shows that Kakamega County is leading in poverty index across the members of the population with 65% of its household lack food stock followed by Homabay at 55%, then Turkana at 52% while counties like Kisii are at 11%, Bungoma 8% and Vihiga is at 4%. This could be mitigated by Khwisero Sub County which is approximately 33 kilometers from Kakamega Town where a lot of subsistence farming take place thus assist in the problem of food security within the county as it is well documented that Kakamega County is not food sufficient (C.G.K, 2018-2022). In addition, SOFDI (2021) cited that Misango Hills in Khwisero Sub County is a geographical feature that has been deforested over long time thus affecting food production potential because of depleted soils caused by erosion and thus making the study necessary.

According to Kenya Population and Housing Census (2019), Khwisero Sub County has a population of 113476 persons. According to Fisher et al (Mugenda and Mugenda 1999), a sample population greater than 10,000 sample size is 384. Therefore, Mugenda and Mugenda recommend the formula;

NF=n/1+(n/N)
to be used to calculate the sample size.
According to the above formula,
NF = the desired sample size when the population is less than 10,000
n = the desired sample when the population is more than 10,000
N = the estimate of the population size
Using the above formula, the sample size will be
Thus, NF = 384/1+(384/113476) = 384

Therefore, sample size of 384 was divided proportionately amongst the locations depending on their percentage of area population as shown in the table 3 below.

Table 3: Sample Size Calculation per Location

LOCATION	TOTAL POPULATION	SAMPLE FORMULA	SAMPLE SIZE
Mulwanda	2.5,186	25186 x n / 113476	85
Kisa Central	22,291	22291x n / 113476	75
Kisa North	18608	18608 x n / 113476	63
Kisa East	12,665	12665x n / 113476	43
Kisa West	12,414	12414x n / 113476	42
Kisa South	11,438	11438x n / 113476	39
Eshirombe	10,874	10874x n / 113476	37
Total	**113,476**	**$(1.96)^2$x 0.5 x (1-05) / $(0.05)^2$**	**384**

Source: Researcher, (2024)

Simple random sampling on the other hand was used to select the households, where each household was given an equal chance. But because of the different population sizes in the locations, the sample population was distributed according to the percentage they contribute to the study area population. The area with the most noteworthy populace created the biggest number of samples. The respondents were distributed as shown in table 3 per location. The research keyed in the names provided by village elders; the names of households were entered into excel then used RANDBETWEEN formula to generate random numbers from the excel.

Purposive sampling was used to select the Key Informants for vegetation types cover data and drivers for LULCC data. The study used 7 agricultural officers; one from each location, the Forestry Officer within the sub county and the Chief Sub County Environmental Officer.

Data Collection

The study used both primary and secondary data collection so as to achieve the objectives of the study.

Questionnaires

Driving forces data and vegetation types cover data was collected through questionnaires that were administered to the household heads. Questionnaires were also administered to the Key Informant (Sub County Environmental Officer and forest officers) for data on driving forces and vegetation types cover. The questionnaire contained both open ended and closed questions which required responses from the households and Key Informant.

Interviews

Scheduled interviews were conducted with the household and Key Informant on driving forces, vegetation types cover and soil data.

Field Observation

Driving forces data, soil data and vegetation types cover data was collected through personal field observation.

Photography

Photographs were taken in the field on vegetation types cover and the physical and the geomorphology of the soils within the study area.

Satellite Images

The study was based on agriculture, forest land together with built up land use land cover categories. In addition, the study was based on a 20 years' duration thus the study used Landsat 7, Landsat 8 and Landsat 9. Landsat 7 and 8 were launched on 15th April1999 and 11th February 2013 respectively which are still operational while Landsat 9 which is the most current was launched on 27th September 2021 (USGS, 2018). The study used a 30-metre multispectral scanner. Landsat 7, Landsat 8 and Landsat 9 satellite images was classified via supervised classification of images processed then employed the post-classification comparison change detection technique in ArcGIS to measure LULCC. This was the most appropriate method because it compensated for variations in atmospheric conditions, sensor and environmental differences between the date since each classification was produced independently (Serra *et al.*, 2003). Furthermore, Mamdouh (2016) noted that, post-classification comparison change detection doesn't just give the size and distribution of changed areas (either negative or positive) however it additionally gives the percentages of other land cover classes that share in the adjustment of each land cover class separately. The study further used overlay procedure which is a GIS operation that allowed an input of 2002 images, 2012 images then 2023 images so as to give an output that showed the percentage change.

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Data acquisition and image preprocessing in Remote Sensing

The satellite imagery used in this study is from United States Geological Survey (USGS) earth explorer (https://earthexplorer.usgs.gov.) The study area is covered by path 170 and row 60 of the Worldwide Reference System (WRS). Landsat images of 2002, 2012 and 2023 were used for spectral indices data for the study of land use land cover changes effects on land quality in Khwisero Sub County which was accessed on 8th July 2023. The satellite imagery used comprised of Landsat Enhanced Thematic Mapper Plus (ETM+) and Operational Land Imager /Thermal Infrared Sensor (OLI-TIR). All the images used in this study have a 30m spatial resolution and below 2% cloud cover. The study focused on the images from Landsat 7, Landsat 8 and Landsat 9 retrospectively from 2023 backwards to 2002and used a 10-year periods through the indices provided in the images which provided both spatial and temporal data. The study used pre-processed remotely sensed data which has already undergone atmospheric, geometric and radiometric corrections. Remotely sensed data for vegetation was collected from decadal NDVI which normally range from 0.1 to 0.6 where values that are high represent more greenness of plant canopy and density (EOS Data Analytics, 2019 and GIS Geography, 2022). The study used the following formula (Engdawork *et al.*, 2018);

NDVI = NIR - Red / NIR + Red (Eqn… 6)

Where;

NIR = Near Infrared Light

Red = Visible Red Light

Table 4: List of Satellite Imagery used in this Study

Year	Sensor Name	Date Of Acquisition	Number Of Multispectral Bands	Path Row	Spatial Resolution	Cloud Cover
2002	LANDSAT 7 ETM+	4/9/2002	1,2,3,4,5,61,62,7 & 8	170 60	30	Less than 2%
2012	LANDSAT 8 OLI – TRIS	21/9/2013	1,2,3,4,5,6,7,8 & 9	170 60	30	Less than 2%
2023	LANDSAT 9 OLI – TRIS	27/9/2022	1,2,3,4,5,6,7,8,9,10 & 11	170 60	30	Less than 2%

Source: Researcher, (2024)

RESULTS AND DISCUSSION

The current study aimed at investigating the effects of land use land cover areal changes on vegetation types cover in Khwisero Sub County between 2002 to 2023. The data collected on effects of land use land cover areal changes on vegetation types cover between 2002 to 2023 focused on; uses of vegetation types cover in Khwisero sub county, the extent of vegetation types coverage in the study area, the effects of various LULCCs on the vegetation types covers in the study area and remote sensing data of NDVI indices analysis of the period between 2002 and 2023. Field data indicated that cropland was the largest in Khwisero Sub County followed by forests, then grasslands and shrubs while others covered the smallest area as shown in Table 5 below.

Table 5: The Extent of Vegetation Types Covers in Khwisero Sub County

Vegetation Types Cover	Extent of vegetation types Cover Area (Frequency/percentages)					Statistics (n = 384)	
	Largest	Larger	Large	Small	Smallest	Mean	St. Dev.
Forests	90(23%)	158(41%)	72(19%)	12(3%)	52(14%)	2.76	1.171
Shrubs	69(18%)	132(34%)	66(17%)	56(15%)	61(16%)	2.42	1.262
Grassland	49(13%)	130(34%)	110(29%)	53(14%)	42(11%)	2.76	1.338
Cropland	229((60%)	109(28%)	42(11%)	4(1%)	0(0%)	4.54	1.142
Others	18(5%)	28(7%)	10(3%)	0(0%)	328(85%)	1.53	0.729

Source: Researcher, (2024)

The findings of the current study from the responses of the households shown in Table 5 reveal that the largest coverage area of vegetation type cover was occupied by cropland at 60%, forest at 41% and shrubs and grasslands at 34%. These results are similar to the land use land cover activities coverage output performed in remote sensing which showed agricultural land occupied the largest portion with an average of 62% followed by forests at an average of 21% for the period between 2002 – 2023. Further, results from the KIIs revealed that LULCCs affect various vegetation types covers by 89%agreeing while11% of the respondents acknowledged that they did not witness any LULCCs effect on vegetation types cover. Other studies highlighted the vegetation coverage in various part of the globe. A study in Ethiopia by Tufa *et al.* (2015) supports these findings where their study noted that agricultural land covered the largest part of the study area. This study is also supported by Tatek *et al.* (2022) found out that the Guna Mountain vegetation was dominated by cropland vegetation as Khwisero Sub County. Other studies noted that grassland was the dominant vegetation (Adhiambo,

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2018 & Njagi *et al.*, 2022). Others noted forests were the dominant vegetation (Belay, 2018 & Mainuri, 2018). Karaja *et al.* (2021) and Muriuki *et al.* (2023) studies noted that shrubs were dominant vegetation.

The Effects of LULCCS on Vegetation Types Cover

The current research aimed at establishing the effects of LULCCs on vegetation types cove in Khwisero Sub County. But it was necessary to determine the uses of these vegetation types cover thus leading to the effects experienced in the study area. The study found out that the people of Khwisero Sub County used vegetation types cover in various ways like crop farming in cropland vegetation for food particularly for humans and livestock, building and construction materials from forests, grasslands and shrubs, medical uses from forests and shrubs, timber sale from logging in forests and traditional rituals particularly circumsion within the forested areas. Forest vegetation cover is affected by land use land cover changes in Khwisero Sub County. The Table 6 below shows how LULCCs affect forest cover.

Table 6: LULCCs affecting Forest Cover

LULCC	Frequency	Percent	Valid Percent	Cumulative Percent
Agricultural expansion	232	60.4	60.4	60.4
Built-up expansion	34	8.9	8.9	69.3
Road construction	41	10.7	10.7	79.9
Deforestation	69	18.0	18.0	97.9
Natural fires	4	1.0	1.0	99.0
Others	4	1.0	1.0	100.0
Total	**384**	**100.0**	**100.0**	

Source: Researcher, (2024)

Table 6 reveal that agricultural expansion affected forest cover the most at 60.4% whereas built-up expansion and deforestation affected forest cover averagely at 8.9% and 18% respectively. This can be linked to remote sensing statistics in Khwisero Sub County in 2012 where forest reduced by 17.5%. The study further revealed that these LULCCs reduced forest cover, diminished wildlife habitats, fragmented the forest, reduced forest fertility and diminished traditional / aesthetic value (CGK, 2018-2022). These results are similar to studies across the globe. Efrymson *et al.* (2005) noted that USA reduced forest cover thus destructing wildlife habitat. These findings of reduced forest cover due to LULCCs is supported by Schenker (2000) and Ganasri & Ramesh (2016). Westbrooks (1998) found out that loss of forests led to spread of invasive species particularly plants. This is supported by Jihad Engineering Services Company (2001) who found out that loss of forests led to endangering unique species. Deforestation occurred due to growth of urban centres led to loss of ecosystem unique species. Deforestation due to growth of urban centres led to loss of ecosystem function as and biodiversity (Zhihui *et al.*, 2014; FAO, 2010; Gumidoga *et al.*, 2014; Lambin & Geist, 2008; Verburge, 2006). Twesigye et al (2011) noted that forested areas reduced in size. Tatek *et al.* (2022) insisted on road construction being a major cause of reduction in size of the forested areas. Chepkwony (2009) found out that forests in Trans Nzoia dropped from 11236 Ha to 1143 Ha to create land for agriculture making it to increase by 57% making agricultural encroachment the leading LULCC in Trans Nzoia by use of Landsat images. Anne (2022) study using Land images of between 1986 to 2019 found out that forested areas reduced from 45% to 23% between 1986 and 2019 creating settlement and farmland which increased from 25.2% to 40.6%. Similarly, using satellite images in Mt Elgon, planted forests, natural forest and bamboo forests decreased by 15.6%, 18% and 15.19% respectively to create land for mixed farming, fallow land and tea plantation which increased by 29%, 10% and 0.13% respectively (Masayi *et al.*, 2021). Peterson *et al.* (2021) study in West Pokot highlighted that cultivated area increased from 0.18% to 1.33% between years 1985 to 2015, dense shrubs and trees also increased in area from 15% in 1980s to 30% in 2010s. This use satellite images of between 2015 and 2021 further noted that mixed vegetation of shrubs, trees, grass and herbs reduced from 60% in 1985 to 40% in 2015 (Peterson *et al.*, 2021).

River Lumi catchment area in Taita Taveta has experienced decrease in forests, grazing land and riverine vegetation between 1987 to 2019 by 52.7%, 3.0% and 36.6% respectively whereas farmlands, settlement and water body increased between 1987 to 2019 by 20.5%, 112.1% and 2.3% respectively due to increased LULCCs within the area (Ndalilo *et al.*, 2021). This study made use satellite images pf between 1987 and 2019. Forested areas in Cherenganyi have been decreasing for the past 35 years from 14.1% to 0.4% annually as seen on the Landsat images creating land for crops and grass which increased to 8.1% (Rotich and Ojwang, 2021). In Bungoma, the forests reduced to create land for grass while annual cropland reduced to create settlement which increased from 6.25% in 2000- 2006 to 12.267% in 2006-2010 (Machuma *et al.*, 2021). Masayi (2021) carried out a study in Malava forest and found out that natural forests reduced from 8.77% to 2.37% creating land for agriculture which increased from 40.91% to 77.92% as seen in satellite images of between the years 2013 to 2021. The shrubs cover within the study area are affected by the land use land cover changes practiced within the study area as shown in Table 7 below.

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Table 7: LULCCs affecting Shrub Cover

LULCCs	Frequency	Percent	Valid Percent	Cumulative Percent
Agricultural expansion	97	25.3	25.3	25.3
Built-up expansion	122	31.8	31.8	57.0
Road construction	58	15.1	15.1	72.1
Deforestation	95	24.7	24.7	96.9
Natural fires	4	1.0	1.0	97.9
Others	8	2.1	2.1	100.0
Total	**384**	**100.0**	**100.0**	

Source: Researcher, (2024)

Table 7 reveal that shrubs cover within the study area is mostly affected by built up expansion at 31.8% as shown. This could be linked to remote sensing statistics of land use land cover change detection in Khwisero Sub County where built up areas have been increasing in size from 2002-2023 from 4.96 km^2 in 2002 to 8.86 km^2 in 2023. The respondents revealed that the LULCCs reduce shrubs species, extinct medicinal species and reduced immunity to disease and pests. These results are supported by Belay (2018) who noted that LULCCs in shrub lands reduced medicines in Ethiopia. Increased encroachment in shrub lands led to reduction in size of the shrubs land thus leading to degradation (Muriuki *et al.*, 2023). In Uganda, increased agricultural activities reduce the shrub land in size and species composition (Kilama *et al.*, 2021). Land use land cover changes affect grassland vegetation cover in Khwisero Sub County as shown in Table 8 below.

Table 8: LULCCs affecting Grassland Cover

LULCCs	Frequency	Percent	Valid Percent	Cumulative Percent
Agricultural expansion	71	18.5	18.5	18.5
Built up expansion	82	21.4	21.4	39.8
Road construction	114	29.7	29.7	69.5
Deforestation	105	27.3	27.3	96.9
Natural fires	8	2.1	2.1	99.0
Others	4	1.0	1.0	100.0
Total	**384**	**100.0**	**100.0**	

Source: Researcher, (2024)

Tables 8 indicate that deforestation and road construction were found to affect grassland vegetation cover at 27.3% and 29.7% respectively. The respondents noted that the LULCCs affected grasslands by reducing or causing scanty growth reducing grassland species, changing the colour of grassland from green to brown and causing the grass within the grassland to become hard which turned out not to be good for livestock. Grasslands that were changed to cropland experienced exposure to soil erosion (Jayakumar & Arockiasay, 2003). This is supported by Twesigye *et al.* (2011) and Negese (2021) who noted deteriorating health of ecosystems, genetic loss and annual soil loss. Verburge (2006) acknowledged the reduction in size of grasslands. Tatek *et al.* (2022) supported this finding because their study noted that grasslands was changed to cropland leading to loss of ecological services, decrease in raw materials causing policy implication balancing food security and ecological services. Cropland vegetation cover is affected by LULCCs in the study area as shown in Table 9 below

Table 9: LULCCs affecting Cropland Cover

LULCCs	Frequency	Percent	Valid Percent	Cumulative Percent
Agricultural expansion	154	40.1	40.1	40.1
Built-up expansion	53	13.8	13.8	53.9
Road construction	40	10.4	10.4	64.3
Deforestation	125	32.6	32.6	96.9
Natural fires	12	3.1	3.1	100.0
Total	384	100.0	100.0	

Source: Researcher (2024)

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Table 9 shows that agricultural expansion affected cropland the most at 40.1% while clearing / deforestation affected cropland at 32.6%. This could explain the reason for increase in bare land / fallow land in 2012 due to clearing of cropland area from 8.04 km^2 to 30.10 km^2. Agricultural expansion could not be used to explain the drastic drop in bare land in 2023 because agricultural land use has been dropping from 2002-20023. Therefore the 13.8% of build-up and afforestation can be used to explain this coverage. The respondents confirmed that LULCCs affected croplands by reducing farm yields, increased fragmentation, increased invasion of pests &diseases and reduction in the size of land as shown in Plate 1 and 2 below.

Plate 1: Kitchen Garden
Source: Researcher, (2024)

Plate 2: Kitchen Garden
Source: Researcher, (2024)

Plate 1 and 2 indicate the reduced size of land for growing crops, thus the only space allocated for a kitchen garden unlike previous years before the fragmentation of land so as to inherit ancestral land. This study is supported by Ellis and Pontius (2007) who noted that cropland expansion without adequate land management results in loss of ecological values. Most studies concentrated on forests, shrubs, grasslands and savannah (Tahiru *et al.*, 2020). Farm land and agricultural land were adversely affected by build-up expansion and road expansion causing loss of ecological services (Tatek *et al.*, 2022 & Tufa *et al.*,2015). Land use land cover changes affected cropland vegetation cover the most as shown in Table 10 below.

Table 10: Levels of effect of LULCCs on Vegetation Types Cover

Vegetation Types Cover	Levels of effect of LULCCs on Vegetation types cover (Frequency/percentages)					Statistics (n = 384)	
	Most	**More**	**Averagely**	**Less**	**least**	**Mean**	**St. Dev.**
Forests	103(27%)	131(34%)	94(25%)	31(8%)	25(7%)	2.17	1.112
Shrubs	67(17%)	183(48%)	69(18%)	28(7%)	37(10%)	1.41	0.863
Grassland	120(31%)	147(38%)	66(17%)	32(8%)	19(5%)	2.33	1.146
Cropland	286(75%)	62(16%)	24(6%)	0(0%)	12(3%)	2.44	1.150

Source: Researcher, (2024)

Table 10 findings revealed that the most affected vegetation types cover was cropland, whereas forests, shrubs and grassland were affected more. These findings can be linked to the decreasing of agricultural land and bare land. In other studies, the dominant vegetation cover that was affected in Kajiado is wooded grassland and open grasslands that were affected the most (Adhiambo, 2018). Forest in Njoro Kenya and Ethiopia were affected the most (Mainuri, 2018 & Belay, 2018). In Wajir, Njemps shrubs were affected the most (Muriuki *et al.*, 2023 & Karanja *et al.*, 2021) because they were the most dominant vegetation.

In addition, the respondents noted that there are other factors affecting vegetation types cover apart from LULCCs by 92% which included; climate change, droughts, floods, pests, charcoal burning, brick making, mechanization, population pressure, political decisions, poor land tenure systems and hailstones. Sang *et al.* (2023) supports this finding because a study conducted in Isiolo also noted climate change, population pressure and economic growth affected vegetation type covers. Salomon and Arona (2022) noted that apart from LULCCs, climate change affects vegetation types cover together with population growth thus supporting these findings. In Pakistan, Saadia *et al.* (2023) noted that climate change is a severe problem around the world thus affecting vegetation types cover apart from anthropogenic activities.

NDVI Indices Analysis

The current study aimed finding the NDVI indices values from Landsat 7, 8 and 9 images so as to validate the data from the field. The study accessed remote sensing data on vegetation through NDVI. Remote Sensing Phenology (2018) outlined the NDVI ranges as 1.0 to -1.0 giving the following prescriptions; 0.1 or less is equated to barren rock, sand, snow and bare land; 0.1 to 0.5 is equated to sparse vegetation; shrubs, grasslands or sensing crops while 0.6 to 0.9 is equated dense vegetation. NDVI shows the density and health of the vegetation cover (Remote sensing phenology, 2018). Although NDVI has some few limitations for example it is affected by water, clouds, limited bands, depend on sunlight, may be affected by soil moisture and sometimes atmospheric conditions it still give reliable data about vegetation cover types (Remote sensing phenology, 2018). NDVI can also categorize vegetation covers as thriving under stress or changes in vegetation covers (Remote Sensing Phenology, 2018). The negative values indicate loss of vegetation or contamination while positive values indicate healthy and dense vegetation.

The NDVI indices of Khwisero Sub County between the study period of 2002 to 2023 were accessed on Landsat 7, 8 and 9 images as shown in Figure 3 and further summarized in Table 11.

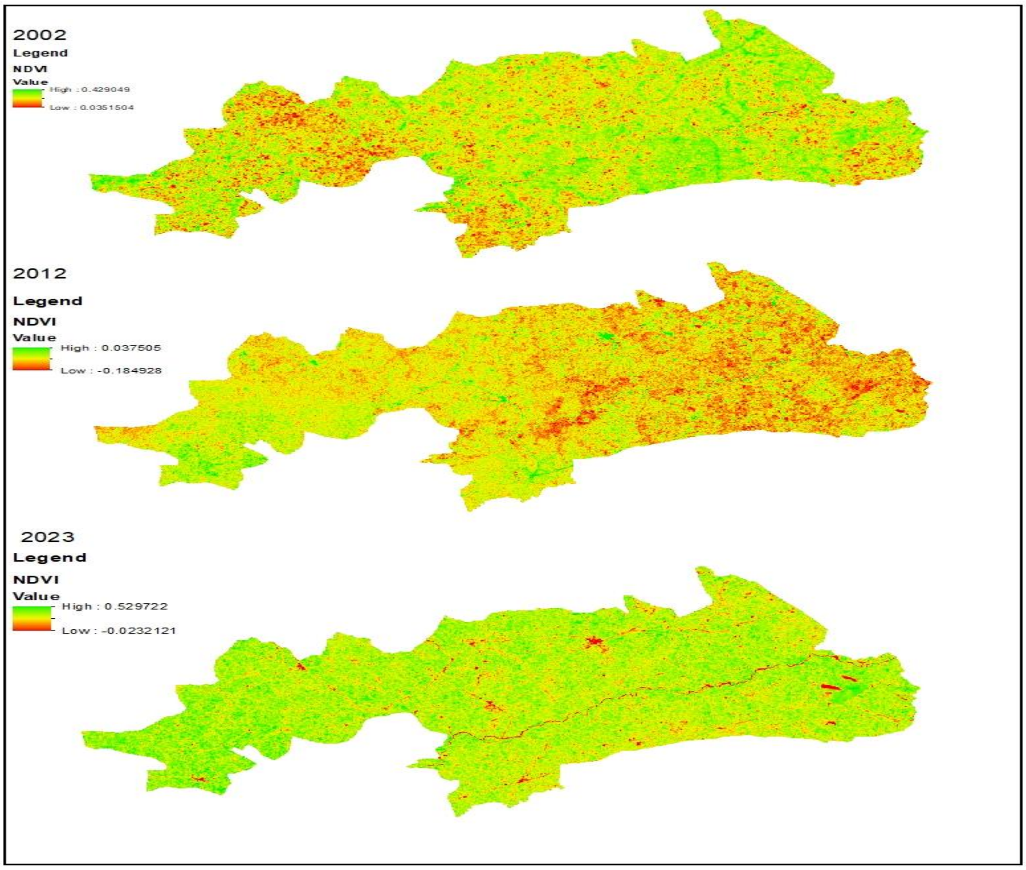

Figure 3: NDVI values for Khwisero Sub County between 2002 and 2023
Source: Researcher, (2024)

Figure 3 reveal that the greener the colour the higher the NDVI indices while the browner the colour the lower the NDVI indices. The NDVI indices map clearly shows that 2002 and 2023 which is greener compared to 2012 which is browner; meaning 2002 and 2023 experienced higher NDVI indices unlike 2012 which experienced lower NDVI indices. The mean NDVI indices for 2002 and 2023 are 0.232 and 0.276 respectively while 2012 recorded a low NDVI index of – 0.0735 as shown in Table 12.

Table 12: NDVI Values of Khwisero Sub County Extracted from NDVI Map 2002 – 2023

Value	2002	2012	2023
Lowest	0.035	-0.184	0.023
Highest	0.429	0.037	0.529
Mean	0.232	-0.0735	0.276

Source: Researcher, (2024)

Figure 3 and Table 12 indicate that 2002 the NDVI values were 0.035 (lowest) 0.429 (highest) then dropped in 2012 to -0.184 (lowest) and 0.037 (highest) then increased again in 2023 to 0.023 (lowest) 0.529 (highest). In 2012 the bare land increased by 274%, same to built-up which increased by 76.4% therefore leading to reduced NDVI. The increase in 2023 of NDVI could be attributed to decreased bare land by 91.2% and increased forestation by 193.1%. Due to the nature of vegetation type covers differences caused by differences in latitudes, altitudes, soil types among study areas, studies found varying results. In Ethiopia, Worku et al (2019) found out that in 2000 NDVI values were -0.56 (lowest) and 0.67 (highest) while in 2010 NDVI values were -0.53 (lowest) and 0.63 (highest). In 1985 Mara region registered -0.070 (lowest) and 0.690 (highest) while in 2010 NDVI values were 0.239 (lowest) and 0.719 (highest) (Nduati et al, 2013). Bosommi *et al.* (2015) noted in 1991, Ghana registered 0.48 (highest) and -0.3 (lowest) while 2014 was 0.11 (highest) and -0.08 (lowest) NDVI values. Hu *et al.* (2023) noted Pakistan registered a mean of 0.2 (lowest) and 0.79 (highest) between 2002 – 2021. In the same period Nepal registered 0.11 – 0.51 in 2000 and 0.37 – 0.58 (Naunyal *et al.*, 2023). Yagoub *et al.* (2017) noted that Sudan registered NDVI values of 0.3 (lowest) and 0.8 (highest) between 2001 and 2013. Finally, Shoukat (2022) attributed 0.547 & 0.601 NDVI value to high vegetation canopy while -0.29 to increase in water body and barren land between 2013 and 2020.

Summary

This study aimed at determining the effects of Land use land cover changes on the vegetation cover types in Khwisero Sub County between 2002 and 2023. The results from the field indicated that the vegetation cover types were cropland at 60%, forest at 23% shrubs and grassland at 31%. These vegetation cover types were affected by the LULCCs within the sub county; forests lost to agricultural expansion and other land uses at 60.4%, shrubs lost to built up at 31.8% while grasslands lost to road construction at 29.7%. Grassland and forests were affected the most at 31% and 27% respectively. The study found out that the most common uses of vegetation cover types were food and materials for building and construction. From remotely sensed data cropland occupied the highest area but cost up to 8 km^2 between 2002 and 2023, forests occupied the second highest area loosing between 2002 and 2012 but gained the most between 2012 and 2023 to attain 52 km^2 in Khwisero Sub County. The NDVI indices from the remotely sensed data for 2002 were – 0.035 to -0.429, 2012 -0.184 to 0.037 while 2023 was 0.023 to 0.529.

CONCLUSION

Land use land cover changes affected vegetation cover types in Khwisero Sub County between 2002 to 2023. Forests including shrubs and grassland lost to built up land and agricultural extension land while agricultural land lost to built up land, bare land and forested land. Later on, due to government policies the forested areas gained from shrubs, grassland, bare land and agricultural land. However, majority of the residents were not aware of the long-term effect of LULCCs on vegetation cover types despite the fact that they depended so much on vegetation cover types for their well-being and livelihoods.

RECOMMENDATION

The residents of Khwisero Sub-County to be made aware of the vegetation covers types and sustainable uses so as to support their well-being. Sustainable usage can be achieved through chief barazas, creating sub-county days specifically for planting trees and other vegetation covers. Furthermore, the activities should be community based so that they own their projects.

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