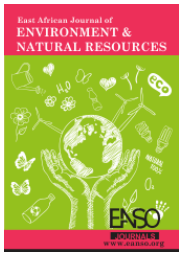
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*Original Article*

# Land Use and Land Cover Change Impacts: A Google Earth Engine–Based Analysis of Kiambu County, Kenya

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**Keywords**:

*LULCC-Land Use Land Cover Changes, GEE- Google Earth Engine, LU-Land Use, GDP-Gross Domestic Product, UHI- Urban Heat Island, LST- Land Surface Temperature, and USGS- United States Geological Survey.*

## ABSTRACT

Land Use Land Cover Change is an exercise practised globally with massive benefits. Though done via acceptable procedures, the exercise leads to several impacts, such as climate change, flooding, diseases, and variations in rainfall and temperature patterns. This study, therefore, sought to investigate the trends in land use and land cover changes and the impacts accrued. The study utilised Landsat imagery for the years 2004,2014 and 2024 and Google Earth Engine (GEE) to come up with the trends in land use changes. The study also utilised questionnaires and interview schedules to come up with the impacts of Land Use Change. The results showed that between the years 2004 – 2024, vegetation declined by 18.40%, cultivated areas went down by 26.98%, water bodies declined by 5.43%, built-up areas went up by 46.36%, and bare lands increased by 3.64%. The study also investigated the impacts of Land Use Land Cover Changes, such as increased rainfall, temperature, flooding, food insecurity, diseases and wildlife habitat interference. The results revealed that all the impacts had a p-value of $< 0.05$, showing that the changes in land use resulted in the impacts accrued. The study results are hoped to be impactful on policies and laws related to Sustainable Land Use Development.

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## INTRODUCTION

The importance of Land Use Land Cover changes (LULCCs) is undeniable globally, economically, the exercise contributes to job creation and Gross Domestic Product (GDP) (Seth, 2021), and socially, the exercise enables citizens to own homes (Rahman *et al.,* 2022). Despite this, the exercise has encountered various impacts. According to Wamalwa *et al,* (2025), the destruction of the planet Earth is highly contributed to by vast changes in land use. In the United States of America (USA), increased urbanisation has resulted in LULCCs in the areas that are of close proximity to urban centres (Rahman *et al.,* 2022). The result of this is increased LST (Njoku & Tenenbaum, 2022; Rahman *et al.,* 2022; Omar *et al.,* 2017), which is resulting in negative impacts on natural landscapes, people's livelihoods, and ecological functioning. Moreso, the concentration of atmospheric heat in regions on the Earth's surface has resulted in an Urban Heat Island (UHI) (Rahman *et al.,* 2022). Similarly, in China, land use land cover change has led to various impacts such as environmental degradation, ecological deterioration, and economic development degradation (Su *et al.,* 2011). In Sub-Saharan Countries, Land Use Changes are practised on a large scale due to population increase. According to Mohammed (2022), LULCCs in Nigeria have led to loss of biodiversity, soil degradation, wetland degradation, and water pollution. This has resulted in an increase in temperatures in the region, flooding, and changes in rainfall patterns. Due to changes in land use, Ghana has witnessed changes in hydrological cycles, climatic variability, food insecurity, and livelihood changes, leading to an increase in poverty levels (Li & Elumalai, 2025). Drastic changes in Land Use in Uganda have led to food insecurity, fish deaths in lakes, increased soil erosion, and small land ownership among the citizens (Environmental Change and African Societies 2019). In Kenya, LULCCs are done on a large scale. The impacts of these are visible, for example, the sizes of family lands have reduced, leading to an increased vicious cycle of poverty among the citizens, loss of biodiversity, animal and human conflicts, and environmental and soil degradation. Many studies in Kenya have been done on Land Use Land Cover Changes, for instance, LULCCs and their implications on human-wildlife conflicts in the semi-arid rangelands of southern Kenya (Judith, 2013). Richard (2024) researched LULCCs and their implications for degraded land in the Elgeyo escarpment, Kenya. Mugambi *et al.* (2025) researched Mapping LULCCs in Eastern Slopes of Mount Kenya; Case of Tharaka Nithi County. Faith *et al.* (2025) did a study on Assessment of LULCC Dynamics and Drivers in Mbagathi River Catchment in Kajiado County, Kenya. Harison *et al.* (2024) researched land use/land cover dynamics in arid and semi-arid landscapes: A 24-year analysis of Baringo County, Kenya (2000–2024). Anne *et al. (*2024) researched on Spatio-temporal patterns of land use and land cover change in Kibwezi West, Eastern Kenya. These studies were done in different parts of Kenya, using different objectives and methodologies. Therefore, this study was conducted in Kenya, in Kiambu County. The study utilised Landsat imagery and GEE in its effort to analyse LULCCs, their impacts, and solutions.

### Statement of the Problem

Land Use and Land Cover Change (LULCC) is a driver that is significantly transforming natural landscapes, leading to weighty effects on the functioning of ecosystems, climate, and the wellbeing of human beings. In Kiambu County, increased population growth, urban sprawl, and increased anthropogenic activities have increased the conversion of natural lands into built-up lands. Despite these transformations, a comprehensive geospatial analysis that can quantify the temporal and spatial dynamics of LULCC remains limited.

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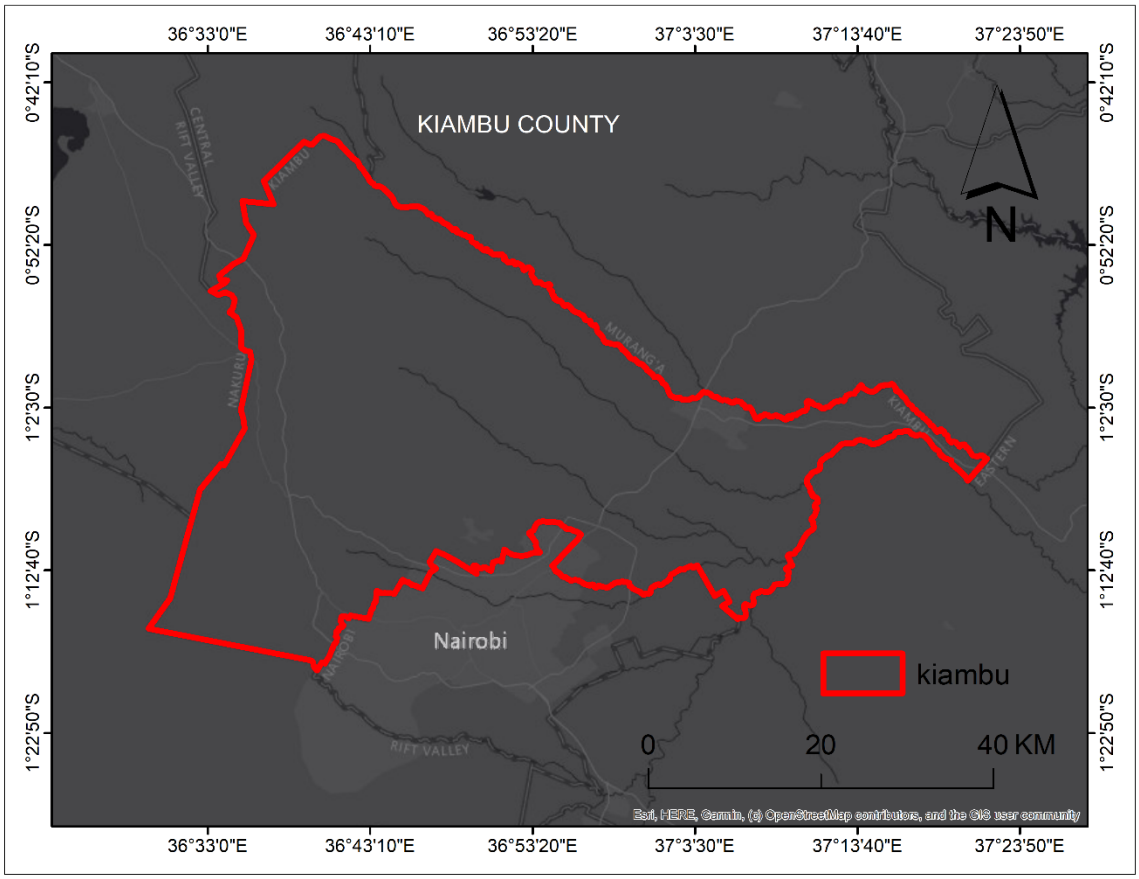
Moreover, the extent to which high-resolution satellite imagery and studies based on cloud geospatial platforms, particularly the utilisation of GEE in monitoring and evaluation of land use changes, is inadequately documented. This paucity of robust, spatially explicit information constrains evidence-based decision-making on land use planning that contributes to environmental management and the formulation of sustainable development policies. To address the gap, the study employed a Google Earth Engine-based geospatial analysis to observe the changes in spatial and temporal patterns in Kiambu County over the period 2004 – 2024. The study examined environmental and socio-economic impacts linked to these changes to boost the understanding of the relationships between LU dynamics and changes in landscapes. The aim of this study was to analyse the effects of LU and LUC using a Google Earth Engine-based analytical framework in Kiambu County. The study sought to test the ($H_0$): there is no substantial relationship between LULCCs and the associated impacts in Kiambu County.

## MATERIALS AND METHODS

### Study Area

The study was conducted in Kiambu County. The County is a pre-urban region located in the central part of Kenya. Its neighbours include: Nakuru, Kajiado, Murang'a, Machakos and Nyandarua. The county is characterised by red volcanic soils and cool and wet climatic conditions that support various agricultural activities. The county is densely populated with approximately 2.41 million people. The county is rich economically with various activities like industrial development, agricultural activities, trade, and real estate.

**Figure 1: Study Area Map**




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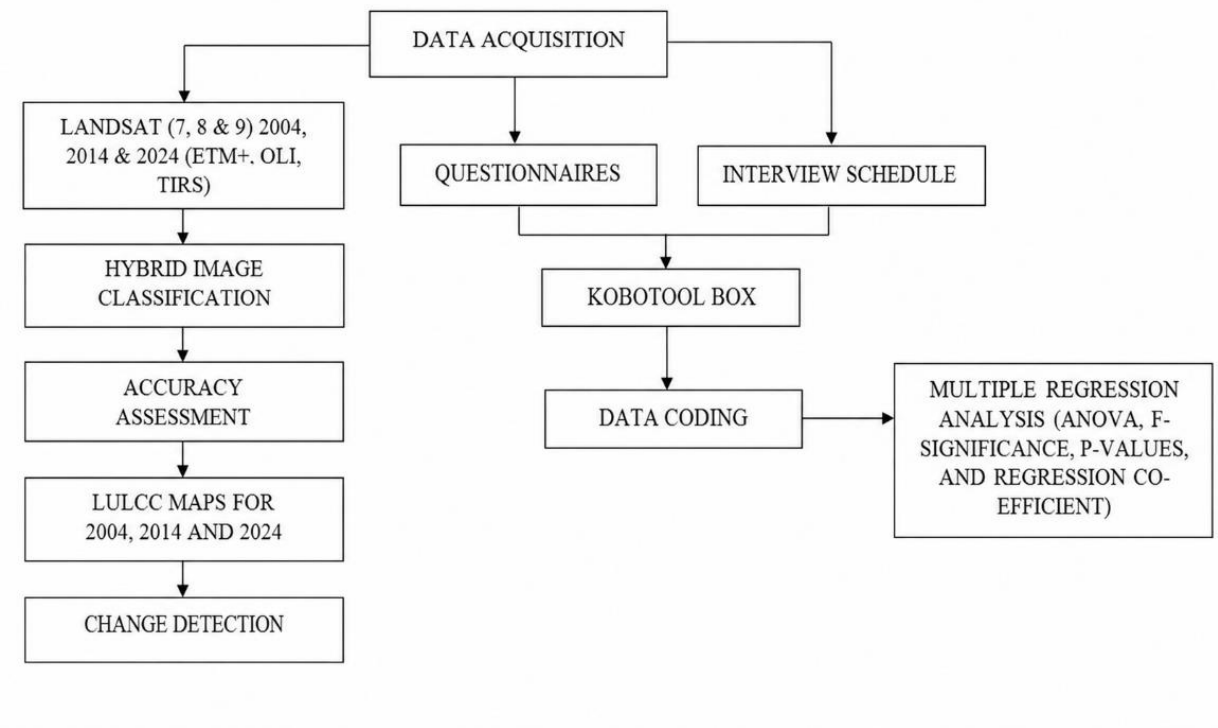
**Data Acquisition and Methodological Flowchart**

The study adopted a mixed-methods approach by integrating primary and secondary data sources. Primary data were collected through interview schedules administered to six purposively selected key informants comprising the County Planning Officer, County Agriculture Officer, County Water Officer, County Environment Officer, County Mining Officer, and the Chief of Kiambu Sub-County. The selection of the officials was based on the level of expertise and those who are involved directly in land use land cover changes, environmental conservation and natural resource management.

The study administered 397 structured questionnaires to the household heads in Kiambu County who were selected using a simple random sampling technique. The main aim of using this technique was to ensure that every household has an equal probability of being selected within the target population. The sample size was determined using Yamane's (1967) sample size determination formula, $n= N/1+N*e^2$ based on a target population of 2,417,735 persons as reported by the Kenya National Bureau of Statistics (KNBS, 2019).

Secondary data comprised Landsat satellite imagery acquired for the years 2004 and 2024. Prior to image classification and analysis, the satellite data underwent comprehensive geometric and radiometric corrections to minimise positional and spectral distortions, thereby enhancing the accuracy and reliability of the Land Use and Land Cover Change (LULCC) analysis.

**Figure 2: Methodological Flowchart**




## RESULTS AND DISCUSSIONS

Remote Sensing data was analysed using Google Earth Engine to generate land use and land cover classification maps and an accuracy assessment. Change detection was carried out, and graphs and tables were generated using ArcMap software. The Kobo Toolbox mobile App data collection was used to collect qualitative and quantitative data in the field for 397 questionnaires and 6 interview schedules. The collected data were cleaned, coded and analysed using descriptive and nonparametric statistics. The study results generate regression coefficients, P-values, ANOVA and F -significance for hypothesis

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testing. Graphs and tables were generated using Python scripts.

### Accuracy Assessment

The study carried out an accuracy assessment on the classified images for 2004, 2014, and 2024. The results were shown in Table 1. In the study results, both the overall accuracy and Kappa Accuracy percentage were above 90%, showing that the land use land cover change classification was of high accuracy. According to Singh (2025), in the accuracy assessment, the result of both the overall accuracy and Kappa Accuracy above 90% indicates that the sample in the assessment was correctly classified.

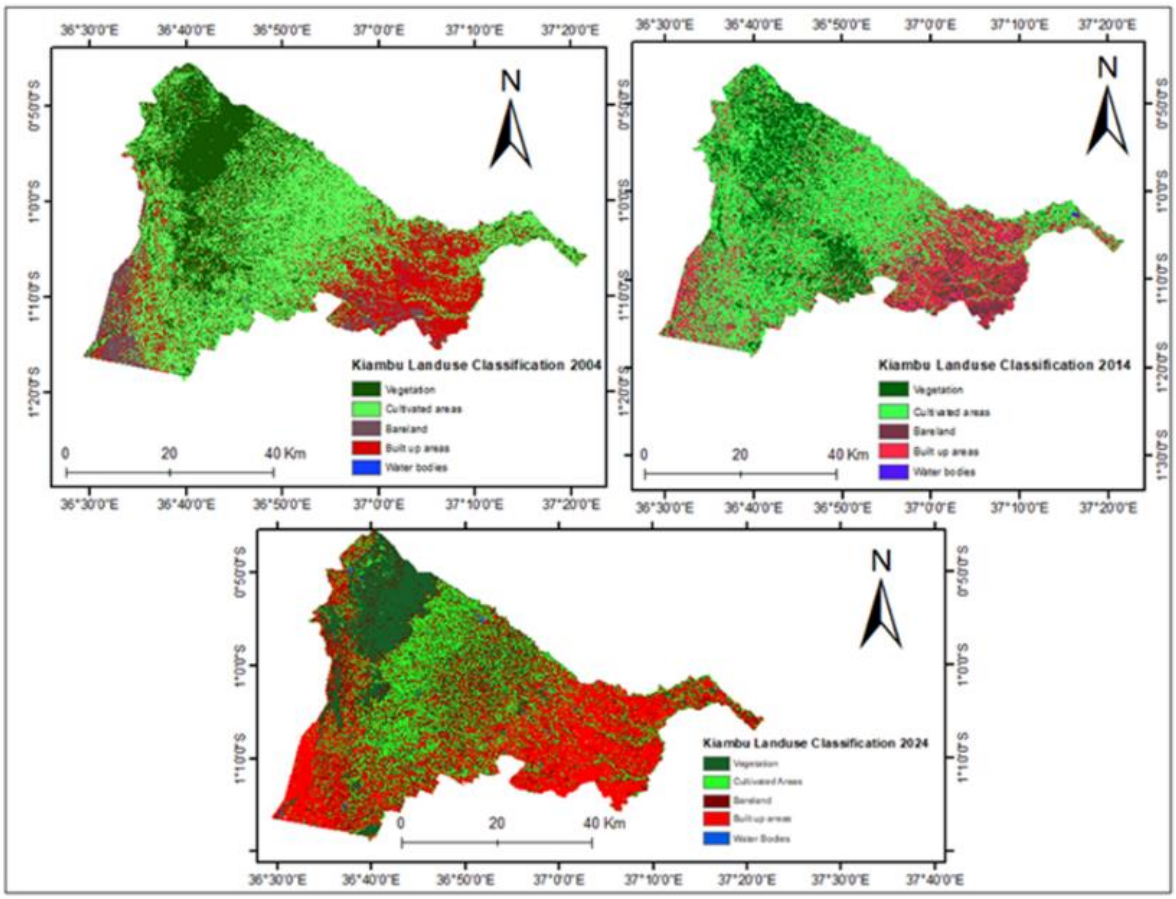
**Table 1: Land Use Land Cover Change Accuracy Assessment**

| Metric | 2004 | 2014 | 2024 | Minimum required |
|---|---|---|---|---|
| **Overall Accuracy (%)** | 94.28 | 95.24 | 92.10 | >90% |
| **Kappa Coefficient** | 0.930 | 0.940 | 0.988 | >0.85 |

### Land Use Land Cover Classification

Figures 3 and 4 reveal various changes in land use in Kiambu County from 2004, 2014, and 2024. The change shows a normal curve with 2004 having a higher percentage in vegetation and cultivated areas, while in 2014 the amount of vegetation cover is on a reduction trend and cultivated areas are increasing. The year 2024 saw an increase in built-up areas due to increased rural-urban migration and the expansion of the Nairobi city population. Moreso, from 2004 to 2014, the land use land cover changes were minimal, and this may be attributed to the fact that there was minimal rural-urban migration. Logging increased in 2014 with a high margin due to drastic changes in land subdivision and deforestation.

**Figure 3: Kiambu County Land Use Classification Map for 2004, 2014 and 2024**

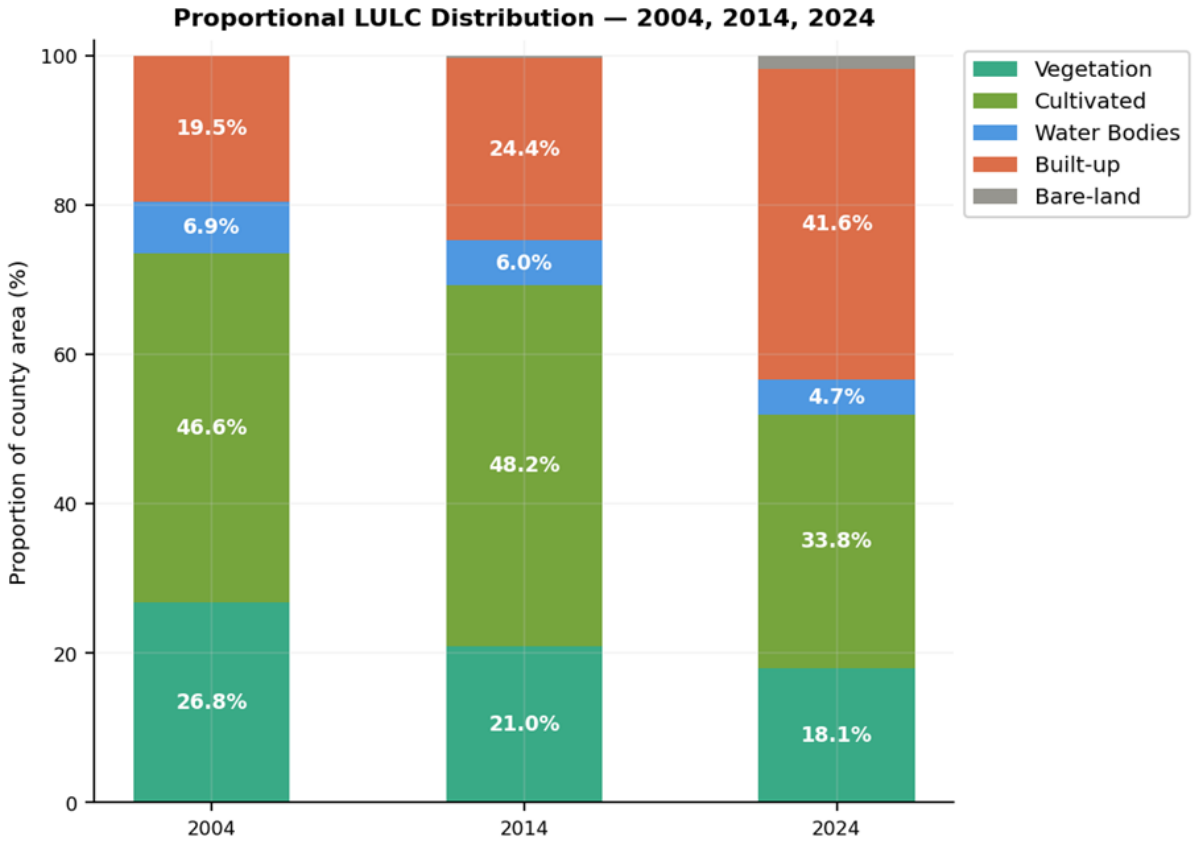



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The study derived annual rates of LULC change (20-year period 2004–2024). The study findings showed built-up area more than doubled over 20 years, from 19.5% to 41.6%. Critically, the rate of urban growth was 3.46 times faster in 2014–2024 than in 2004–2014.

**Figure 4: Proportional LULC Distribution (%) Stacked Bar 2004, 2014, 2024**



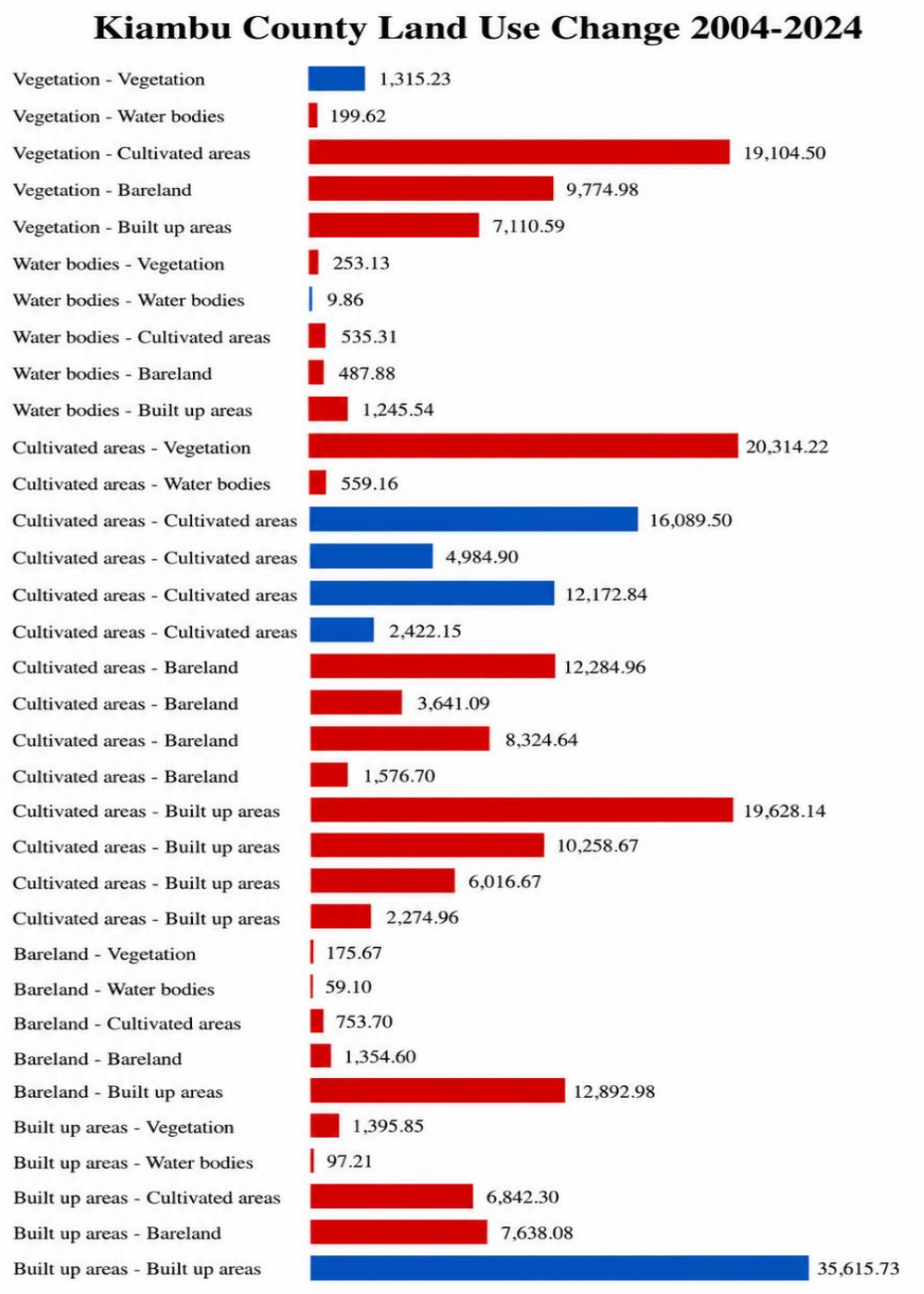

**Land Use Land Cover Change Detection in Kiambu County**

Changes in land use is obtaining the acreage that the land has changed to other utilisation over a period of time. The study deployed the formula Change detection = [LULC 2004] + " - " + [LULC 2024] (Rouse *et al.,* 1974). The study utilised post-classification comparison methods to come up with a change detection win and loss chart for the years 2004 to 2024. The greatest change was seen in cropland to built-up, and the least change was in waterbodies and bare lands. The results correlate with the research by Jamila *et al.* (2021) that revealed a change detection in various land uses at the Wami–Ruvu Basin in Tanzania. The results showed that for the past three years, wetland areas decreased by 0.3%, forested areas by 15.4%, and grassland by 6.7%, while agricultural, bushland, bare soil, and built-up areas have increased by 11.6%, 8.2%, 1.6%, and 0.8%, respectively. This study provides a reference for water resources sustainability for other countries with basins threatened by land use and land cover changes. In Figure 5, the red colour shows a reduction in land use land cover change, and the blue shows an increase.

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**Figure 5: Kiambu County Land Use Change Detection 2004 -2024**



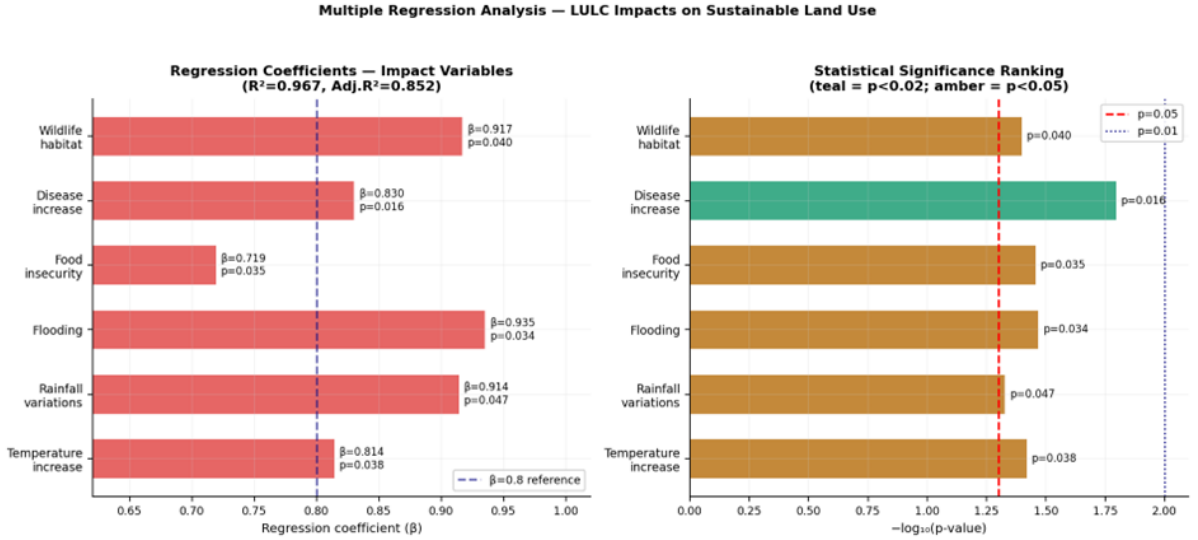

**Impacts of Land Use Change**

Further, the study used questionnaires for 397 Kiambu County households and an interview schedule for 6 officials. The study utilised a multiple regression analysis model (MRA) of $Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + ... + \beta_pX_p + \varepsilon$ (Golberg & Cho, 2004) to test the correlation between LULCCs and various variables on the Earth's surface. The dependent parameter was LUCC, and the independent parameters were: Temperature increase, rainfall variations, flooding, food insecurity, disease increase, and wildlife habitat interference. And the results were as follows:

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**Figure 6: LULC Impacts on Sustainable Land Use**




From the study findings, the multiple R and $R^2$ were < 0.9, indicating a strong relationship among the parameters being tested. The P- values, in the regression model, indicated a strong statistical correlation between the independent parameters and the dependent parameters. In this scenario, all the values were $p < 0.05$, which shows that the independent parameters have an impact on the dependent parameter. The significance F in the ANOVA was 0.00016, which was lower than Fisher's test value (F) of 4.59, reflecting a positive correlation between LU and LCC and the impacts accrued.

The study used interviews to collect qualitative data related to land use and land cover changes and their impacts. The officials that were interviewed indicated that land use land cover changes are the legal or illegal conversion of land utilisation from one state to the other that is mainly caused by anthropogenic factors. Concerning the impacts of land use and land cover change in Kiambu County, the respondents agreed that it is responsible for temperature rise at 100%, inadequate water at 70%, airborne diseases at 80%, and lastly, land use conflicts at 100%.

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

In conclusion, the study proposes the integration of geospatial technologies such as Google Earth Engine (GEE), ERDAS IMAGINE, and ArcGIS Pro in Land Use Land Cover Changes to come up with a robust and reliable framework best for analysing, monitoring, and quantifying Land Use Change. The study findings showed the importance of these technologies in coming up with accurate spatial analyses that are evidence-based in sustainable land use planning and policy formulation. The study findings showed substantial landscape changes in Kiambu County, Kenya, from 2004 to 2024. The study findings showed a reduction in cultivated lands by 26.98%, vegetation coverage reduced by 18.40%, and water bodies by 5.43%. However, built-up increased by 46.36% and bare lands increased by 3.64%. The changes reflect that anthropogenic pressures on the landscape are high, causing alteration to ecological integrity.

Statistically, the study findings affirmed that the independent variables had a significant correlation with environmental impacts ($p<0.05$), thus rejecting the null hypothesis that there is no relationship between land use changes with the impacts.

Therefore, the study concludes that there is a need to integrate geospatial technologies in planning and environmental monitoring alongside existing land use policies for sustainable land use management. Integrating these efforts with Sustainable Development Goals (SDGs) and Kenya Vision 2030 will promote sustainable

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urban growth, protect natural ecosystems and climate resilience, thus creating sustainable resource utilisation.

**Recommendations**

The study recommends the following:

- The integration of advanced geospatial technologies such as Google Earth Engine, ArcGIS Pro, Qgis, and ERDAS IMAGINE in land use land cover change management by national government, county governments and other relevant stakeholders.
- The geospatial technologies should be integrated into the routine of daily environmental monitoring to be able to detect unsustainable land use changes for timely decision-making that is evidence–based.
- Land use changes, laws and policies should be harmonised with Sustainable Development Goals (SDGs), Kenya Vision 2030 and Bottom-Up Economic Transformation Agenda (BETA) for sustainable land use management.

**Recommendations for Further Research**

The study recommends the following for further research: -

- Temporal and spatial analysis of land use and land cover changes using multi-temporal satellite datasets with higher spatial and temporal resolutions.
- Integration of advanced machine learning and artificial intelligence techniques for accuracy and predictive modelling of future land use and land cover scenarios.
- Investigating socio-economic and ecological consequences of Land Use Land Cover Changes and its effects on biodiversity conservation.

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**REFERENCES**

Anne, J. K., Otieno, P. O., & Mwangi, L. N. (2024). Assessment of land use land cover changes using GIS and remote sensing. *Environmental Monitoring and Assessment, 196*(4), 245–260.

Appiah-Opoku, S. (2020). *Land use change and sustainability*. IntechOpen.

E.A. Njoku, & Tenenbaum, D. E. (2022). Quantitative assessment of the relationship between land use/land cover (LULC), topographic elevation and land surface temperature (LST) in Ilorin, Nigeria. *Remote Sensing Applications: Society and Environment, 27*, Article 100780. https://doi.org/10.1016/j.rsase.2022.100780.

*Environmental Change and African Societies*. (2019). Brill.

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Article DOI: https://doi.org/10.37284/eajenr.9.3.5345

Faith, M., Makokha, M., & Obiero, K. (2025). Assessment of land use and land cover change dynamics and drivers in the Mbagathi River catchment in Kajiado County, Kenya. *Open Access Library Journal, 11*, e11019. https://doi.org/10.4236/oalib.1111019.

Jamila, A., Kim, S., & Patel, R. (2021). Accuracy assessment of land-use/land-cover classification using multi-temporal satellite imagery. *International Journal of Remote Sensing, 42*(6), 1234–1250.

Judith, A. (2013). *Analysis of land use land cover changes in Kiambu County* (Master's thesis). University of Nairobi.

Kenya National Bureau of Statistics. (2019). *2019 Kenya population and housing census. Volume I: Population by county and sub-county*. Kenya National Bureau of Statistics.

Li, P., & Elumalai, V. (2025). *Groundwater quality under agricultural activities: Cases from China and South Africa*. Springer Nature Switzerland.

Mohammed, J. (2022). *Land use/land cover changes, driving forces and their implications on climate variability: The case of Kereba Sub-Catchment of Awash Basin, Eastern Ethiopia*. GRIN Verlag.

Omar, P. J., Gupta, N., Tripathi, R. P., & Shekhar, S. (2017). A study of change in agricultural and forest land in Gwalior city using satellite imagery. *Samriddhi Journal, 9*(2), 109–112. https://doi.org/10.18090/samriddhi.v9i02.10870

Pauline, W., Samson, M., & Charity, C. (2025). Analyzing the effects of land use land cover change on climate variability using remote sensing. *Journal of Land Use Policy and Geospatial Sciences, 8*(8), 2657–2664.

Rouse, J. W., Haas, R. H., Schell, J. A., & Deering, D. W. (1974). Monitoring vegetation systems in the Great Plains with ERTS. In *Proceedings of the Third Earth Resources Technology Satellite-1 Symposium* (Vol. 1, pp. 309–317). NASA Special Publication SP-351. National Aeronautics and Space Administration.

Singh, K. A., Ryu, D., Arora, M., Tiwari, M. K., & Sahoo, B. (2025). Improving the accuracy of remotely sensed TSS and turbidity using quality-enhanced water reflectance by a statistical resampling technique. *International Journal of Applied Earth Observation and Geoinformation, 142*, 104681. https://doi.org/10.1016/j.jag.2025.104681

Su, S., Jiang, Z., Zhang, Q., & Zhang, Y. (2011). Transformation of agricultural landscapes under rapid urbanization: A threat to sustainability in the Hang-Jia-Hu region, China. *Applied Geography, 31*(2), 439–449.

Yamane, T. (1967). *Elementary sampling theory*. Prentice-Hall.

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