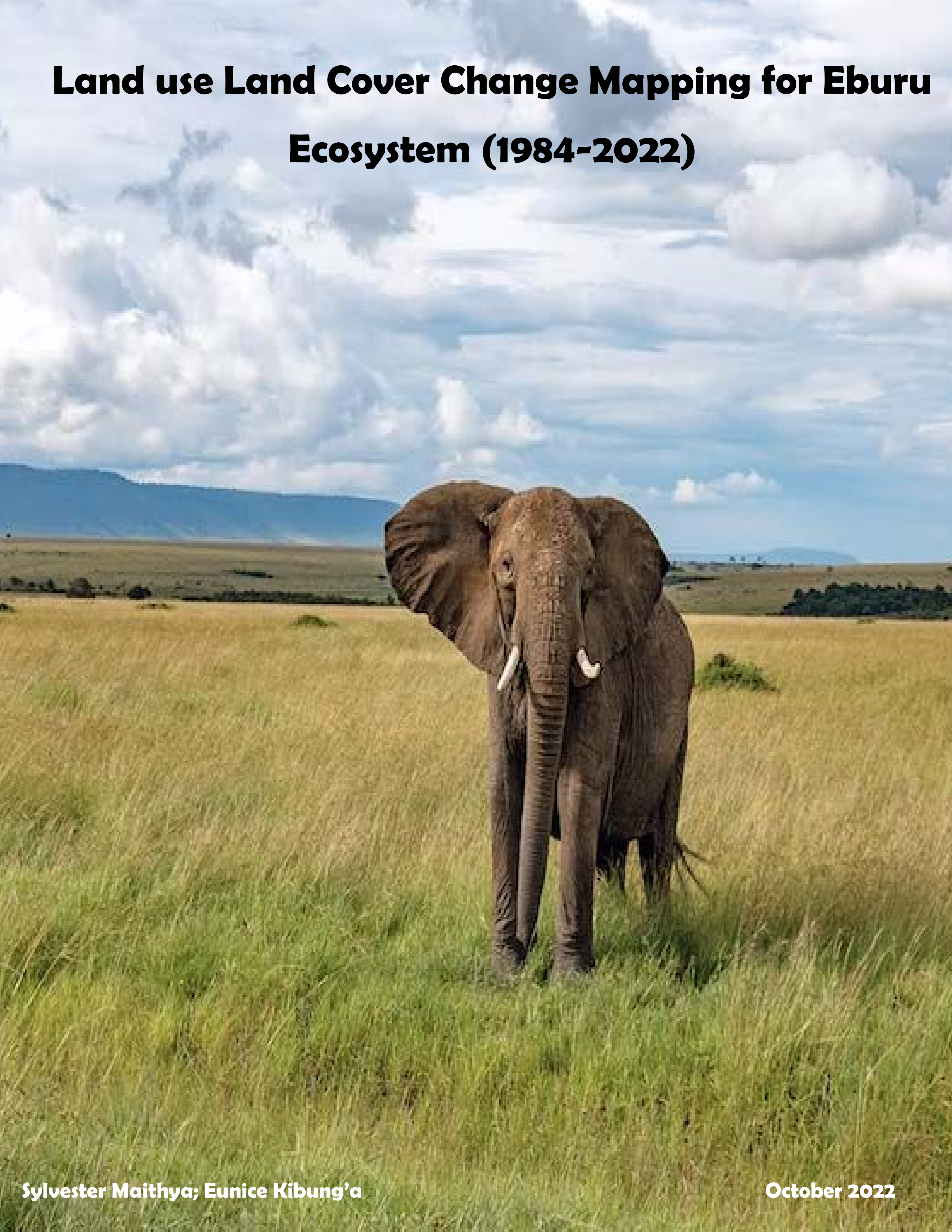
Land use Land Cover Change Mapping for Eburu Ecosystem (1984-2022)



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1.0 Introduction

In spite of some progress made toward the Millennium Development Goals, hunger, poverty and food insecurity persist, while the key ecosystems that underpin and service the natural resource base continues to be depleted and degraded. These development challenges and the related pressures on the natural resource base are now recognised at the global level and as a global issue (Prasuhn et al. 2013). While driven primarily by population and economic growth, the pressures are exacerbated by a rapidly changing environmental context that includes, inter alia, land degradation, climate change, loss of biodiversity, water scarcity, liberalised trade regimes and demands for bio-energy production (Obuya et al. 2022). These factors, furthermore, are linked and often self-reinforcing

The terms land use and land cover are often used interchangeably, but each term has its own unique meaning. Land cover refers to the surface cover on the ground like vegetation, urban infrastructure, water, bare soil, etc. Identification of land cover establishes the baseline information for activities like thematic mapping and change detection analysis. Land use refers to the purpose the land serves, for example, recreation, wildlife habitat, or agriculture. When used together with the phrase Land Use / Land Cover (LULC) generally refers to the categorization or classification of human activities and natural elements on the landscape within a specific time frame based on established scientific and statistical methods of analysis of appropriate source materials. Land cover is the physical material at the surface of the earth. Land use is the description of how people utilize the land for socio-economic activities.

The Eburu Ecosystem Land Cover Change Mapping (LCC) Program aims to create a sustainable and technically rigorous process for providing land cover and change information required for Land Degradation and Restoration by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) to inform the BESNet Solution Fund interventions on the ecosystem.

The focus of this is on providing the ecosystem`s, time series consistent, land cover maps for Kenya in the years 1984, 2000, 2010, 2015 and 2022. The maps will allow for analysis of land cover and cover change through time. In addition, the maps and statistics produced will serve as official documents for informing land use planning, tracking deforestation, and landscape restoration.

On the forest factor in the Eburu Ecosystem; Kenya’s economy is strongly dependent on natural resources including forestry. The Forest sector is the backbone of Kenya’s

Tourism since forests provide habitats for wild animals, offer dry season grazing grounds and protect catchments that provide water downstream. Forests maintain water catchments (defined as water towers) which support agriculture, industry, horticulture, and energy sectors contribute more than 3.6 per cent of GDP. In some rural areas, forests contribute over 75% of the cash income and provide virtually all of household's energy requirements. It is estimated that economic benefits of forest ecosystem services exceed the short-term gains of deforestation and forest degradation and therefore justify the need to conserve the forests.

Inspite of these important functions, deforestation and forest degradation have continued to pose challenges driven by among others pressure for conversion to agriculture, urbanization and other developments, unsustainable utilization of forest resources, inadequate forest governance and forest fires. The country is exploring a wide range of options, including policy reforms and investments, to protect the existing forests and to substantially restore forest ecosystems across the country.

Forests in Kenya are managed under three tenure systems: public, community and private. The Eburu forest ecosystem is under the public forests are managed by Kenya Forest Service charged with the responsibility and mandate to ensure the forest is sustainably managed.

2.0 Materials & Methods

2.1 Description of the Study Area

The study area is located in central part of Nakuru County and extents from longitude 36.023795o to 36.394130o and Latitude -0.314437o to -0.771384o and is generally called the Eburu Ecosystem (Figure 1). Administratively, it covers Gilgil, Kiambogo and Ndabibi locations and covers an area of about 971.39704 Km2 and its within it where we have the Eburu forest. The area has a population of 34, 516 Male and 32,600 female (KNBS 2020).

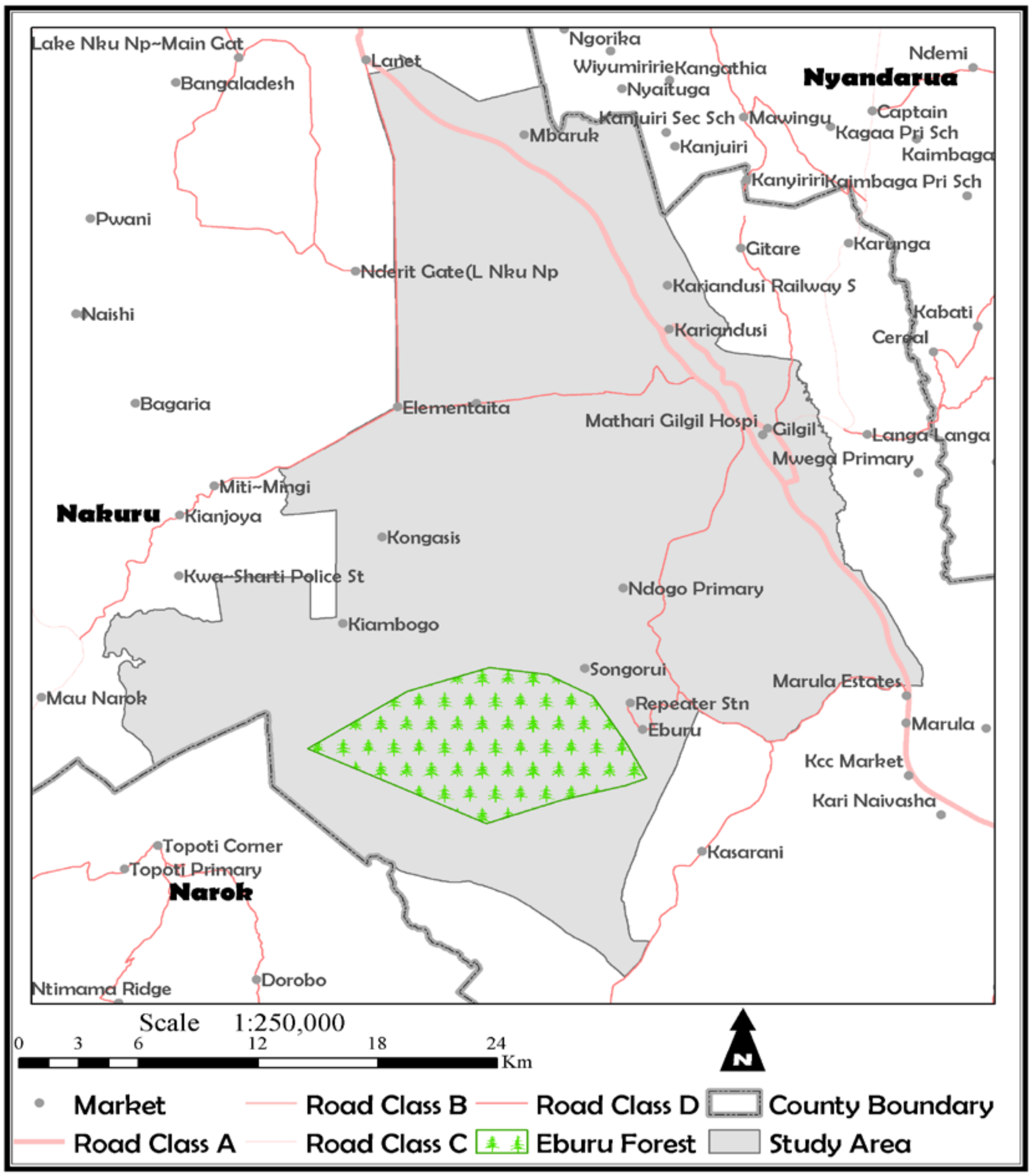

Figure 1: Study Area Map

2.2 Geographic Projection and Map sheet Units

Kenya is located in eastern coast of Africa, straddling the equator and bordering the Indian Ocean between Tanzania and Somalia. It has an area approximately of 592,152 km sq. On Landsat's generic UTM, WGS84 projection, Kenya is divided into four UTM Zones (Figure 2). For purposes of harmonization to the country's projection system, the Universal Transverse Mercator (UTM) used by the Kenyan Government for national mapping is adopted. The Arc 1960 Datum for Kenya allows for more accurate placement of features on their specific position on the ground. In the case of the area of study, it sits on the path 162, row 60. Then from this the study area was extracted, Eburu Ecosystem had three administrative wards covering it. Therefore, this was used as the study area. Projection Type: - Universal Transverse Mercator (UTM)

Spheroid Name: - Clarke 1880
Datum Name: - Arc 1960
UTM Zone: - 36 South of Equator
Scale Factor at the central meridian: - 0.999600
False easting: - 500000.00m
False northing: - 1000000.00m

2.3 Software Requirements

The software required to support data processing were chosen on the basis of functionality. They include:

- Image processing software; ERDAS IMAGINE 2015 (64 bit), ENVI Classic (64 bit) and ENVI 5.2.1 (64 bit)- For Image Analysis;
- GIS software: Arc Map 10.5 For GIS Analysis; Change Maps generation.
- Statistical Software: The R Statistics package was used for specialist statistical routines- For Image Processing;
- Excel sheets for statistical data dbfs plotting, graphs.

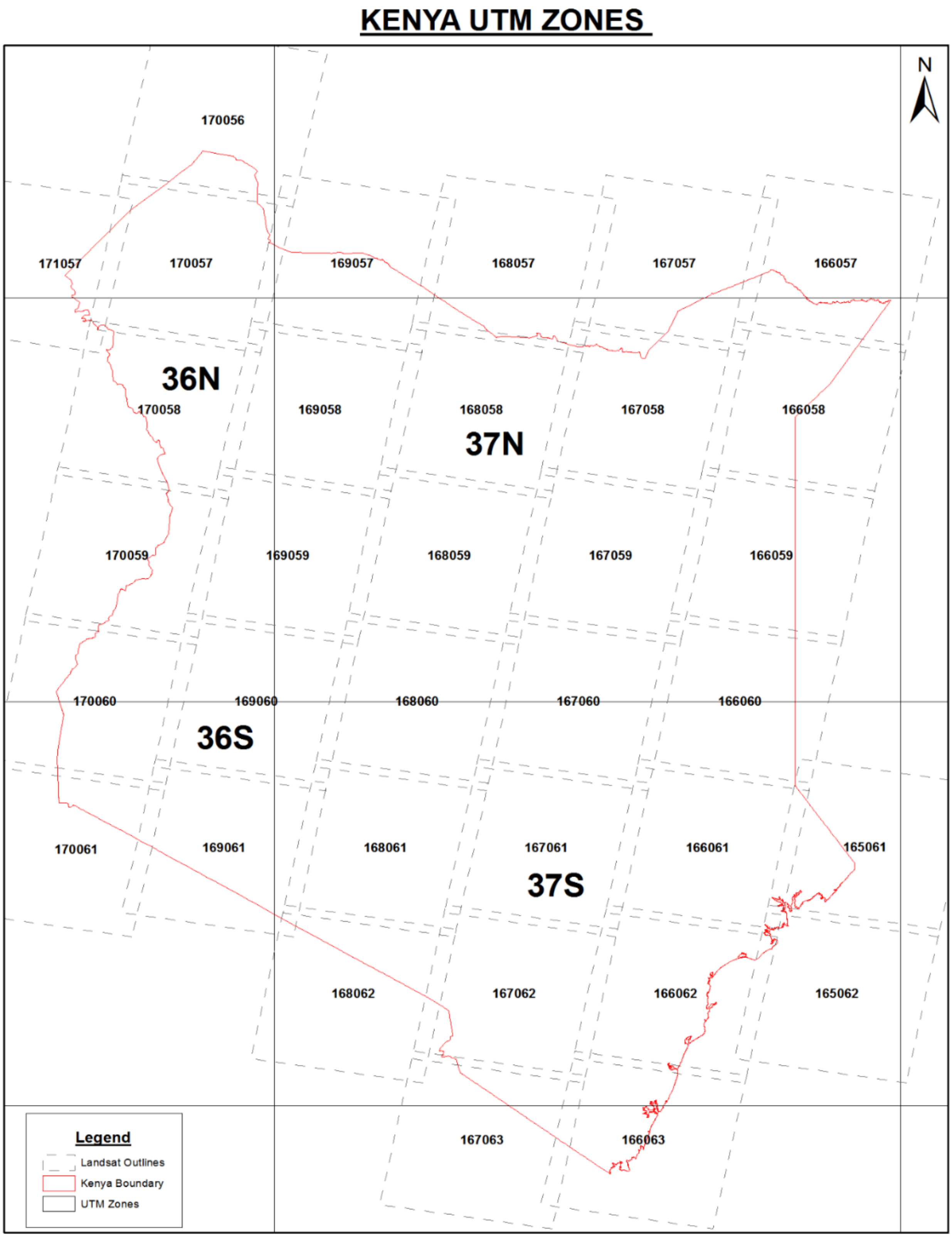

Figure 2: UTM zones of Kenya

2.4 Land Cover Classes for LCC Mapping

The final land cover categorization was based on local definitions of land cover e.g., the definition of forest lands, country needs for land cover information and simplicity of the land cover mapping system. The categories mapped were suitable for Land cover and forest classes' generation and marrying together with the Land degradation areas and, importantly, capable of being mapped using available image data at study area scale. They also took into account the requirements set out in the 2006 IPCC Guidelines.

Satellite remote sensing was able to detect land cover. The 2006 IPCC guidelines list 6 broad land use classes under the UNFCCC.

- Forestland
- Cropland
- Grassland (Grass and Shrubs)
- Wetland (Waters and marshy areas)
- Settlement
- Other land (Rock, bare land)

The study area derived classes of the following schema; Forestland, Wooded grassland, Grassland, Cropland, Waterbody, Settlements.

The project focused on;

- Deforestation
- Forest degradation
- Adjust land degradation
- Unsustainable management of forests and the adjacent land uses.

2.5 Data Requirements and Data Sources

The LCC produced land cover maps of the study area 1984,2000,2010,2015 and 2022 at a spatial resolution of 30m using 0.5ha as the Minimal Mapping Unit (MMU). The US Landsat series and Landsat image archive is the only data source which meets the historical requirements. Other ancillary datasets and references are the agro ecological zones, the goggle earth engine and the validation exercise.

2.6 Land Cover Classification

Classification here refers to 'image classification' - the process of assigning a land cover class (or class probability) to each image pixel from a Landsat image. Numerous mathematical methods exist for classifying digital image data. Standard image processing packages offer several options for classification. The classification method used is known as random forests (RF ™) (Brieman, 2001). The RF method was chosen after a comprehensive pilot study to compare various methods. Random Forests does calculate and store measure of class confidence for each pixel.

The criterion above was most important in view of the time series monitoring objectives of the LCC, and the multi-date change detection processing which followed image classifications. The following sections described the LCC classification process and essential elements of the RF method. The operating work unit for image classification was a Landsat scene. The RF classification process is applied to each stratification 'zone' in the image.

RF is a supervised classification approach which began with operators selecting training samples from the image. The procedure fits a large number of separate trees, each to a randomly selected subset of the training data. Each pixel was given a class label from each tree, and the relative frequencies of a pixel's class allocations from the multiple trees can be used as measures of classification confidence. Typically, map results were displayed using only the 'most common' class label for each pixel. The confidence measures become important in the subsequent multi-temporal classification processing. The RF procedure also produces summaries as indicators of classification accuracy derived from the training data. RF is implemented in a program script in the statistical language 'R'

2.7 Stratification – spectral stratification zones

Land use and land cover varied tremendously across the study area. Land cover ranges from the dense forests to vast dry wooded grassland areas. Climate, soil variations, and altitude are the main drivers for differences in natural cover. They also affect agricultural land cover and land use. A single image classifier would not accurately classify all these different land cover types simultaneously. Instead, the approach adopted in LCC was to subdivide or stratify the area into smaller zones related to the mix of land covers, and to their spectral signals. Stratification was a technique used to divide a set of data into groups (strata) which are similar in some way.

The classification process was trained and applied separately within zones. The rationale for stratification is that, within a more localized area, the land cover types were more similar in terms of type and spectral response, than in a larger area or across the study area. The results were a more accurate classification of land cover types within each zone, and thus for the study area.

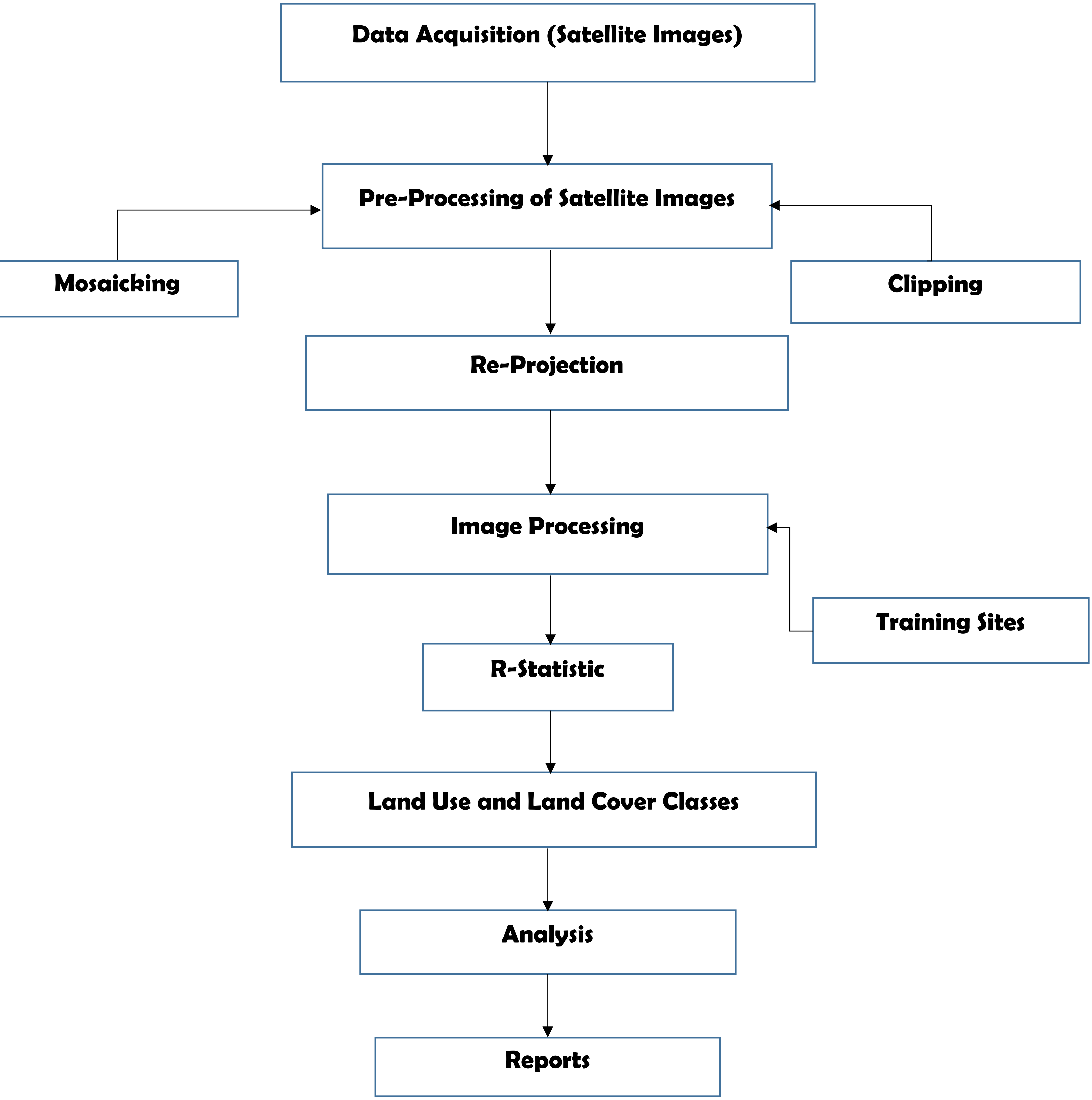

Figure 3: Methodology Diagram

3.0 Results, Analysis & Discussions

3.1 Results: Land Use Landcover Maps and Analysis.

3.1.1 Land Cover 2022 analysis

The land use land cover classification for the year 2022 was done and the results are as shown Figure 4 and graphical analysis of the acreage of the various classes are as shown in Figure 5.

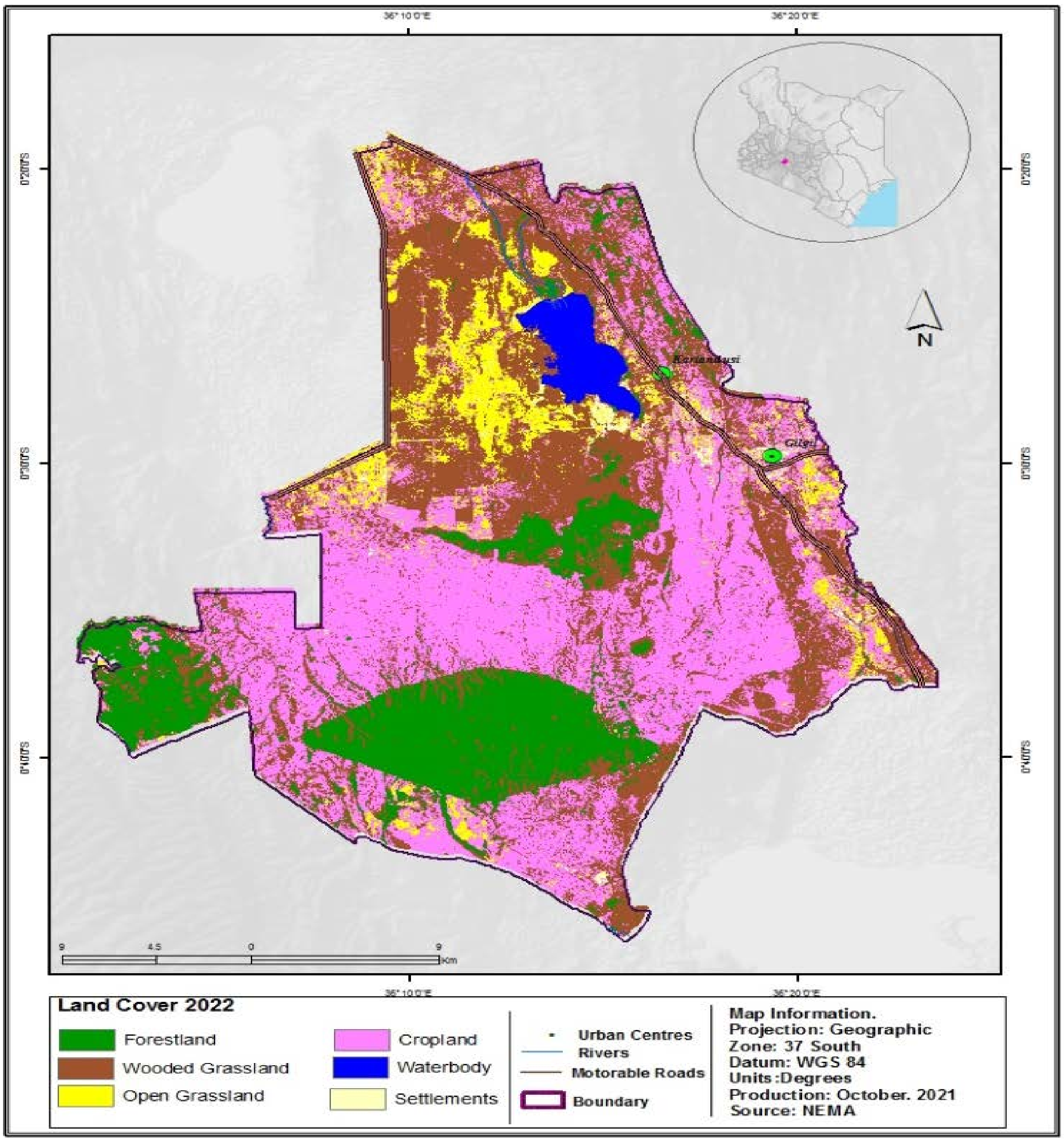

Figure 4: Land cover map 2022

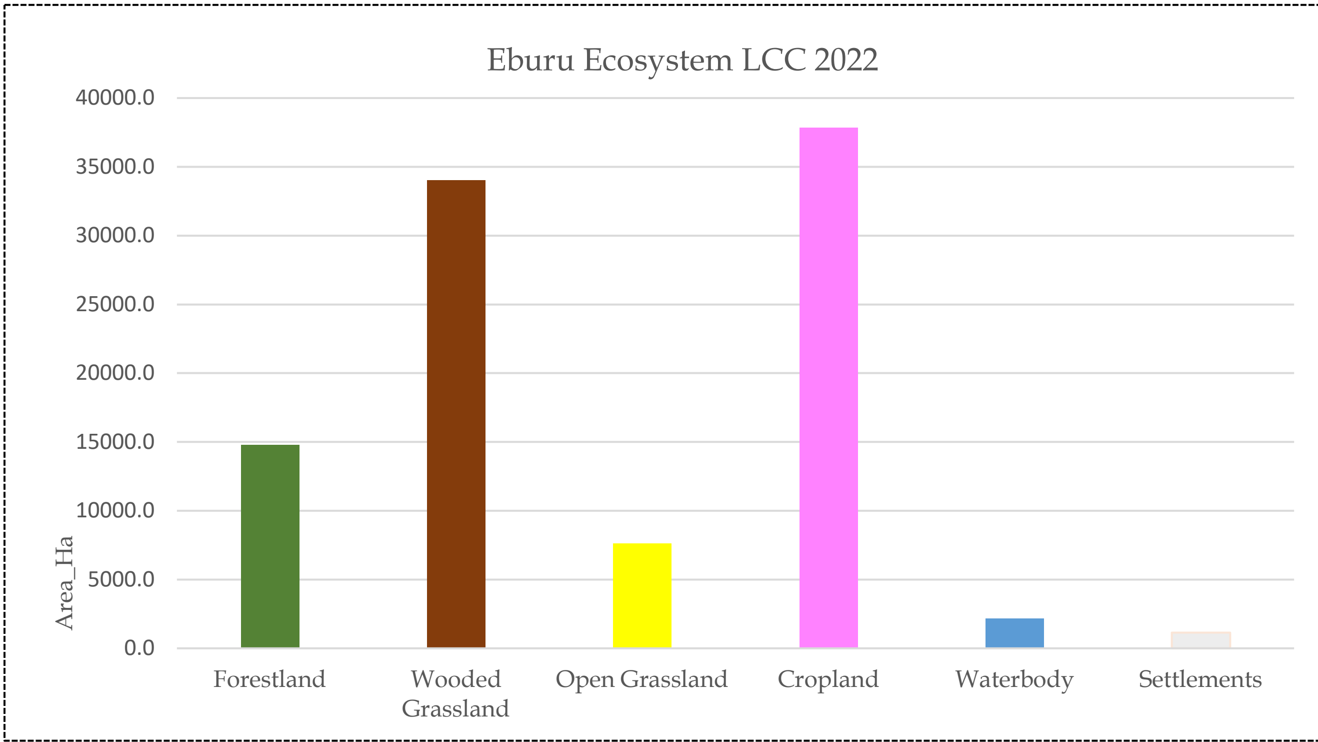

Figure 5: Land cover statistics 2022

Figure 5 shows the classes distribution in the ecosystem. Cropland was the highest in hectares coverage, followed by wooded grasslands and the forested area.

3.1.2 Land Cover 2015 analysis

The land use land cover classification for the year 2015 was done and the results are as shown Figure 6 and graphical analysis of the acreage of the various classes are as shown in Figure 7 .

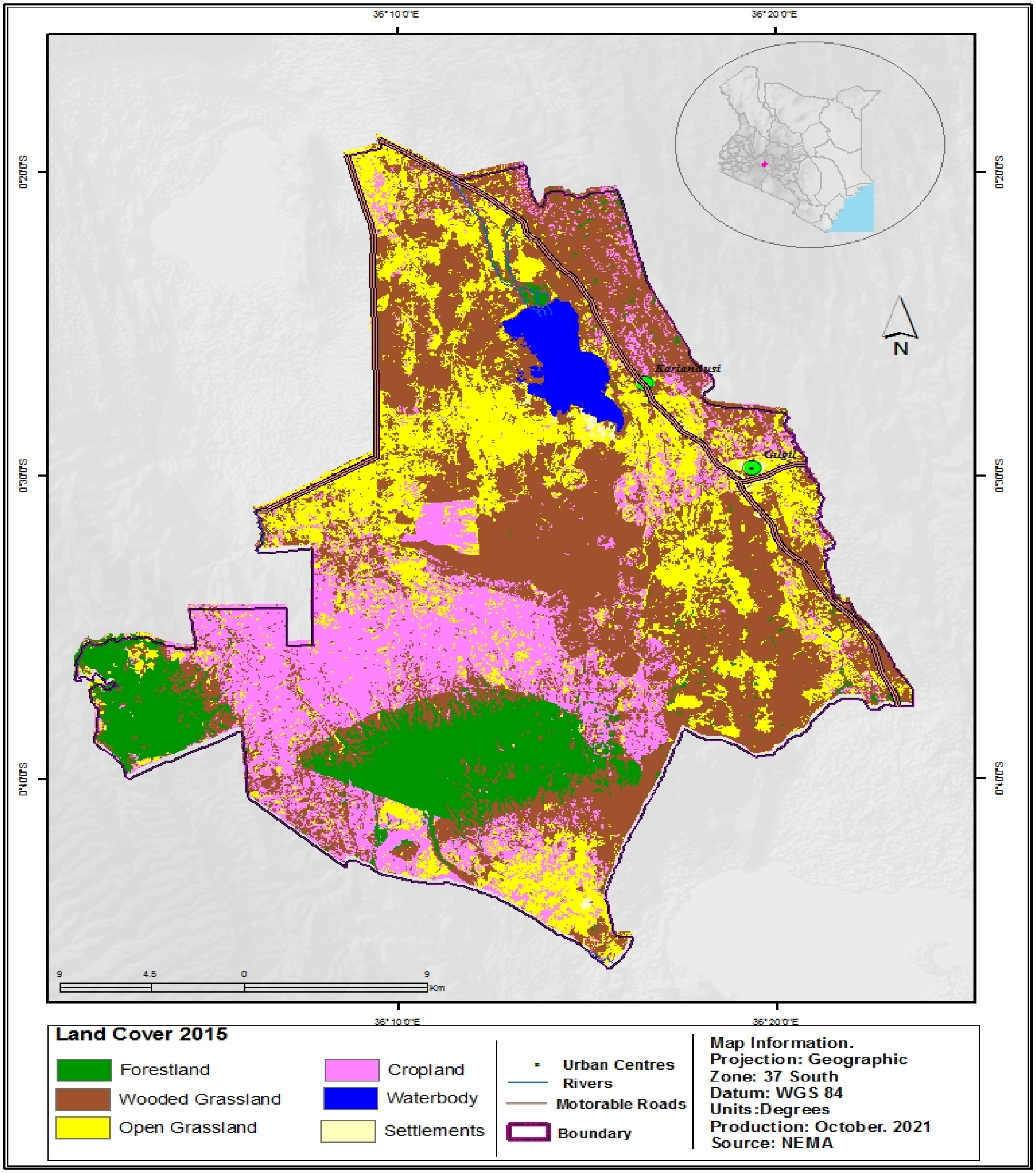

Figure 6:Land cover map 2015

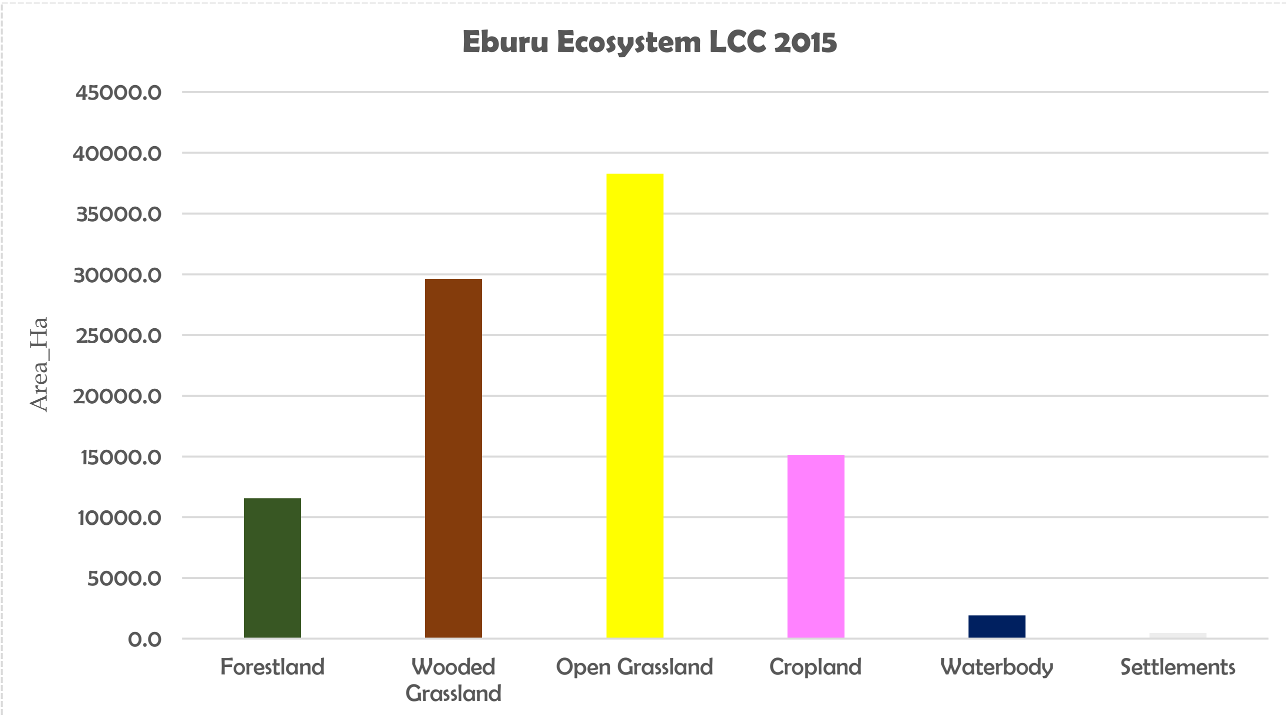

Figure 7: Land cover statistics 2015

In 2015, the map indicates that the grasslands were thriving. The forest cover had risen from the previous 2010 statistics. This could be attributed to the tree growing initiative drive from the 2010 constitution to raise the country's tree cover to 10%.

3.1.3 Land Cover 2010 analysis

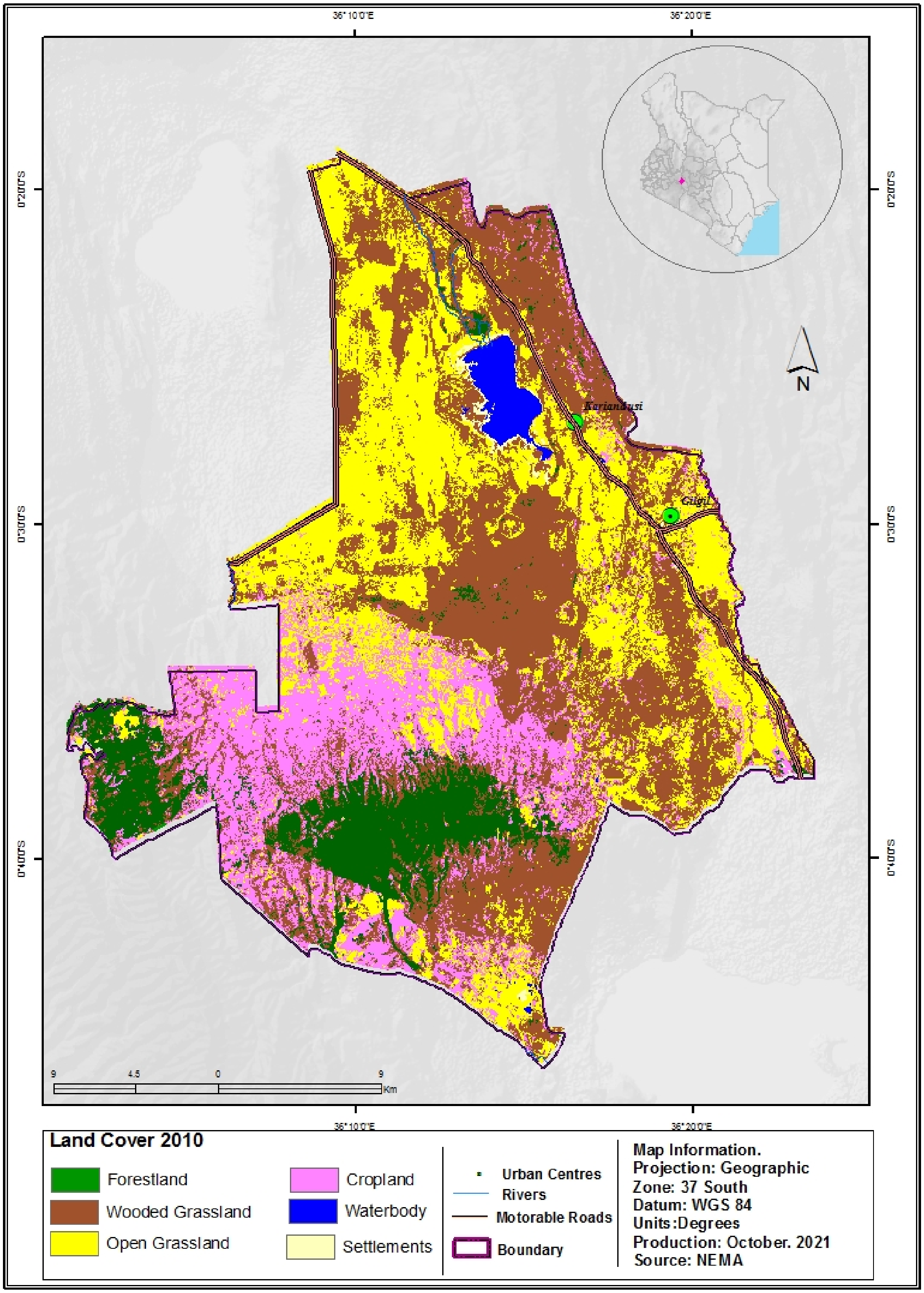

Figure 8:Land cover maps 2010

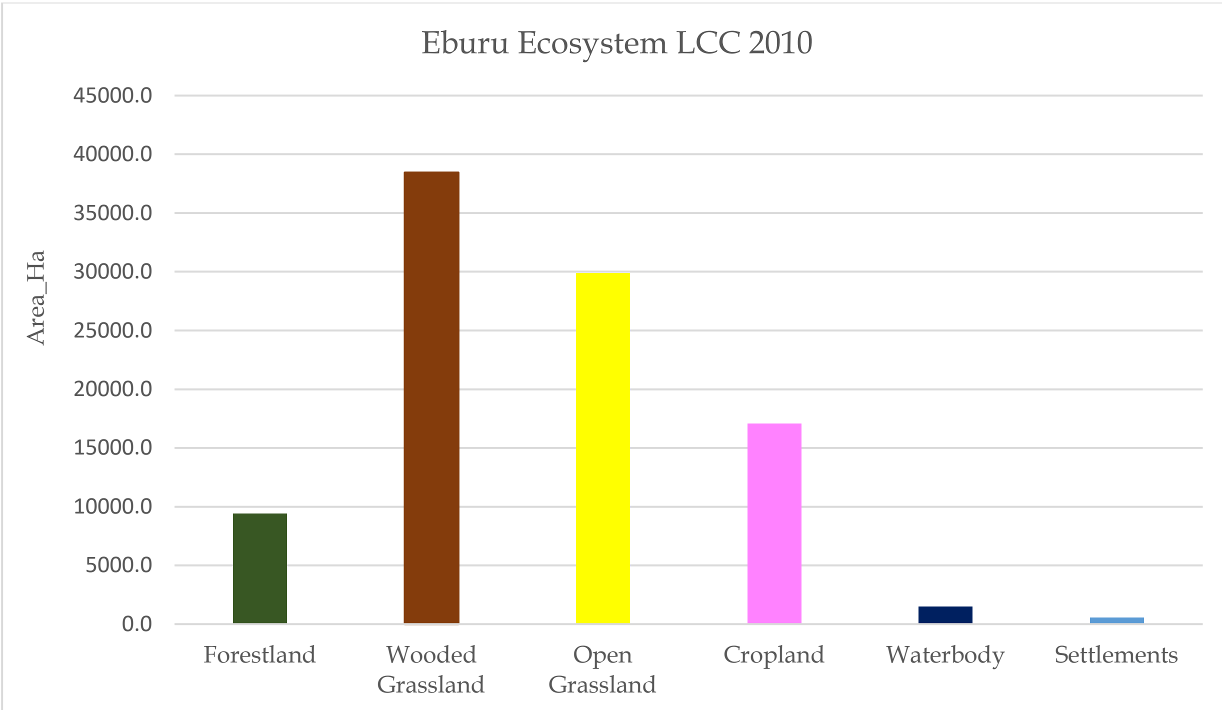

Figure 9: Land cover statistics 2010

The above statistics analysis explains the status of the ecosystem`s landcover in 2010.

3.1.4 Land Cover 2000 analysis

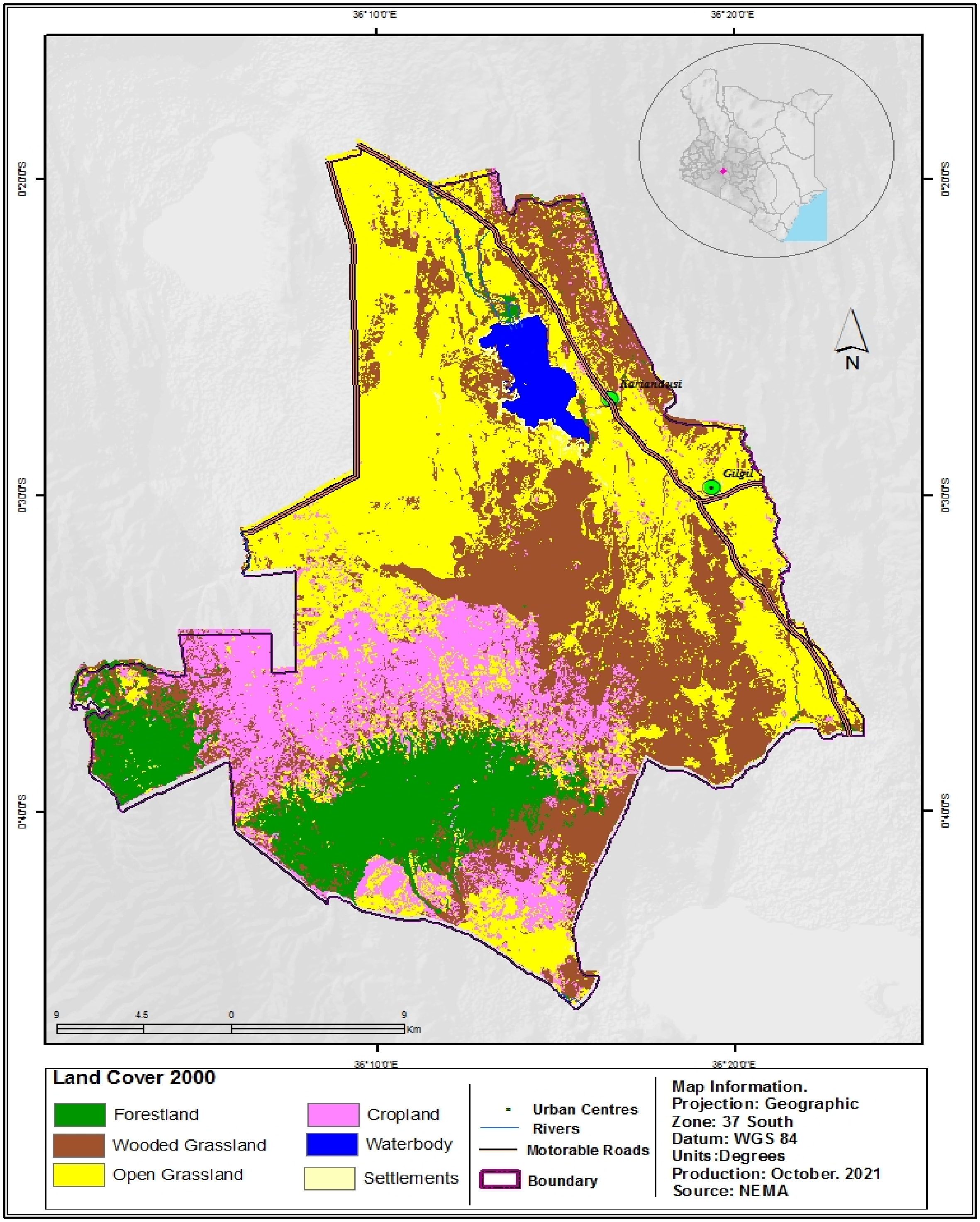

Figure 10:Land cover map 2000

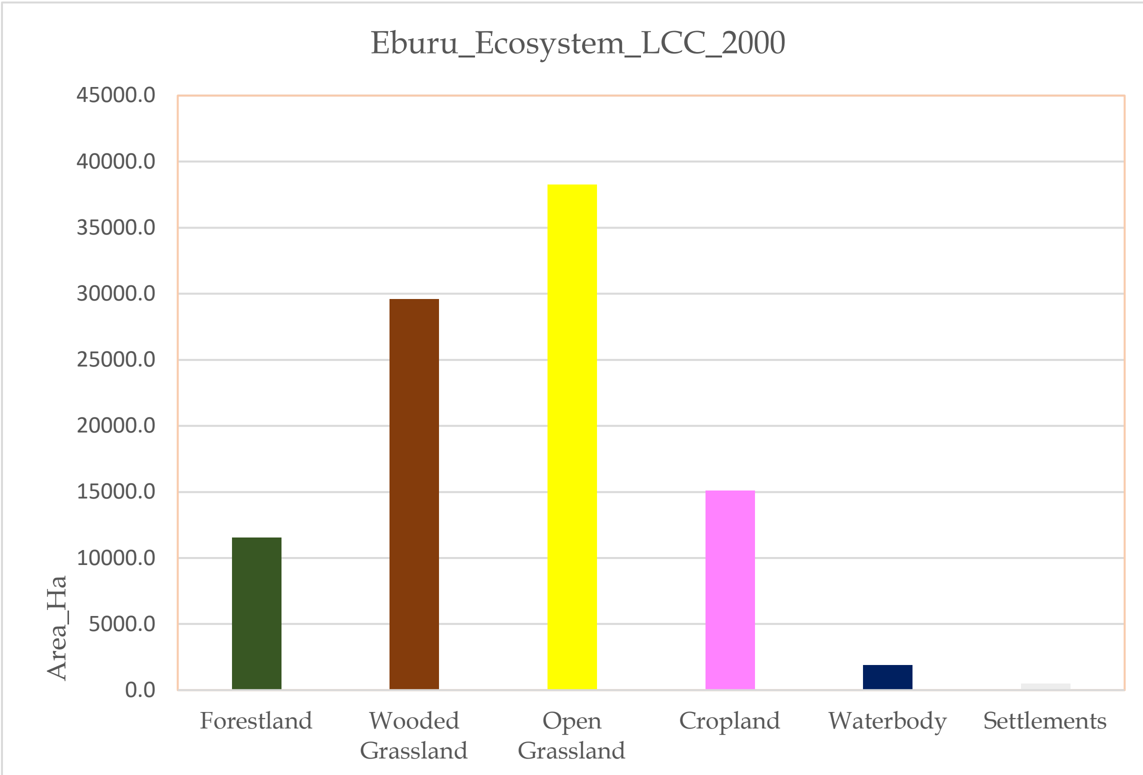

Figure 11: Land cover statistic 2000

In the above analysis, the forest area was actually continuous with the Mau Forest ecosystem. The side bordering Narok County is almost undisturbed. Farmed area was not as it is now. Most areas that are on farms now were wooded grasslands and open grasslands. The forest healthy was of high density in the year 2000.

3.1.5 Land Cover 1984 analysis

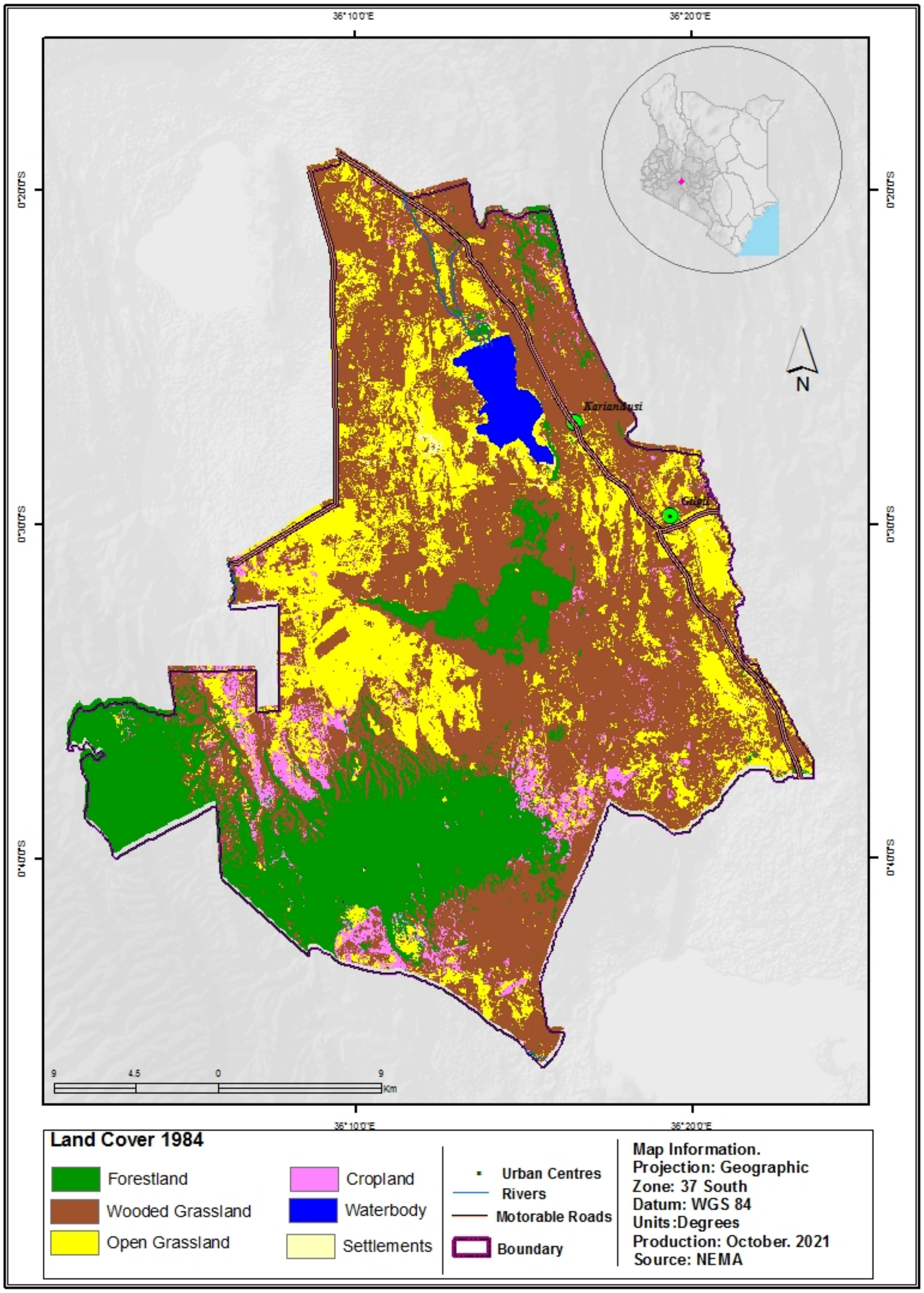

Figure 12: Landcover map 1984

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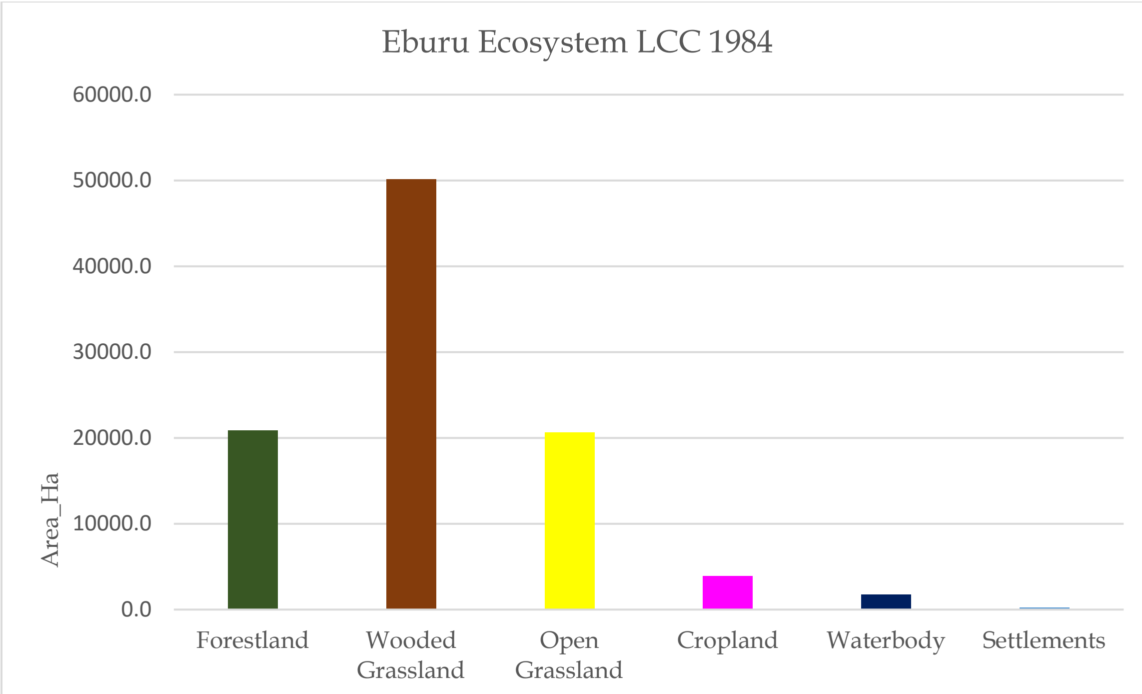

Figure 13: Land cover statistic 1984

From the historical data and indigenous knowledge, in the year 1984, the area was not inhabited. The population was very small and sparse. The farming activity was very minimal. The forest area not disturbed at all. The wooded grassland was also thriving in these years.

3.1.6 Forest cover trend curve between 1984, 2000, 2010, 2015 and 2022.

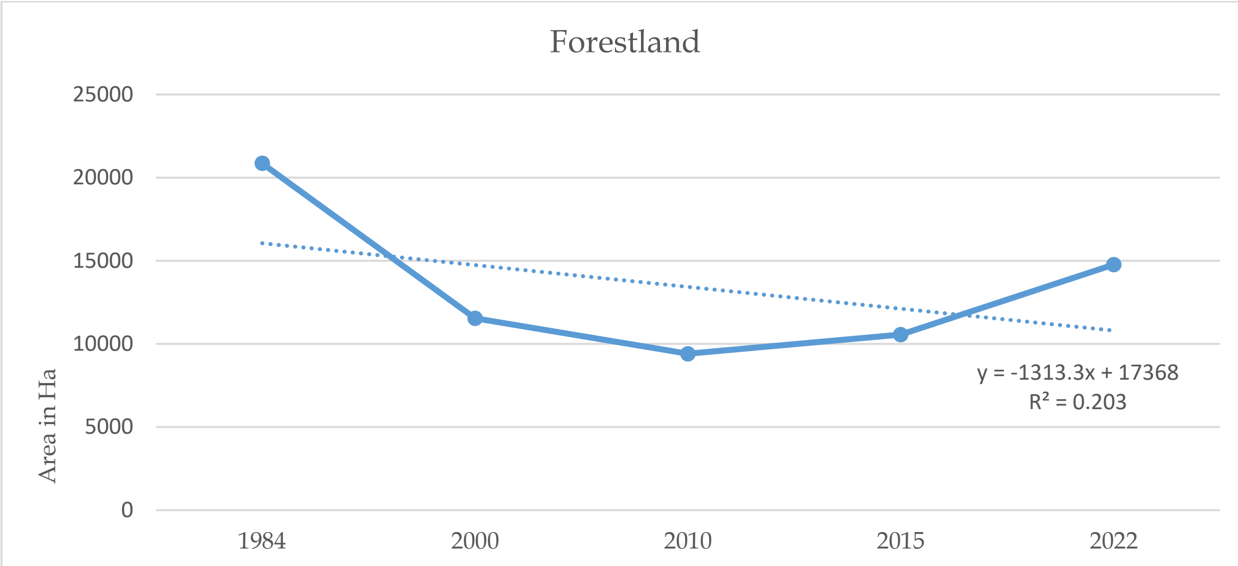

Figure 14: Forestland trend curve

As depicted above and in the time, series maps, the forest was at its highest in 1984, dropped in 2000 all through 2010, the rise started happening in 2010, albeit slow, the forest has been regaining heath. Factors attributed to the 2010 constitution on forest cover increase to realize the 10% tree cover. Also, the positive initiatives employed by Kenya Forest Services and its partners.

3.1.7 Cropland trend curve between 1984, 2000, 2010, 2015 and 2022.

In the figure below, the reverse of the above forest trends is a true depiction of the croplands. Most of the forestland, wooded grasslands, grasslands have been cleared to give more land for subsistence farming.

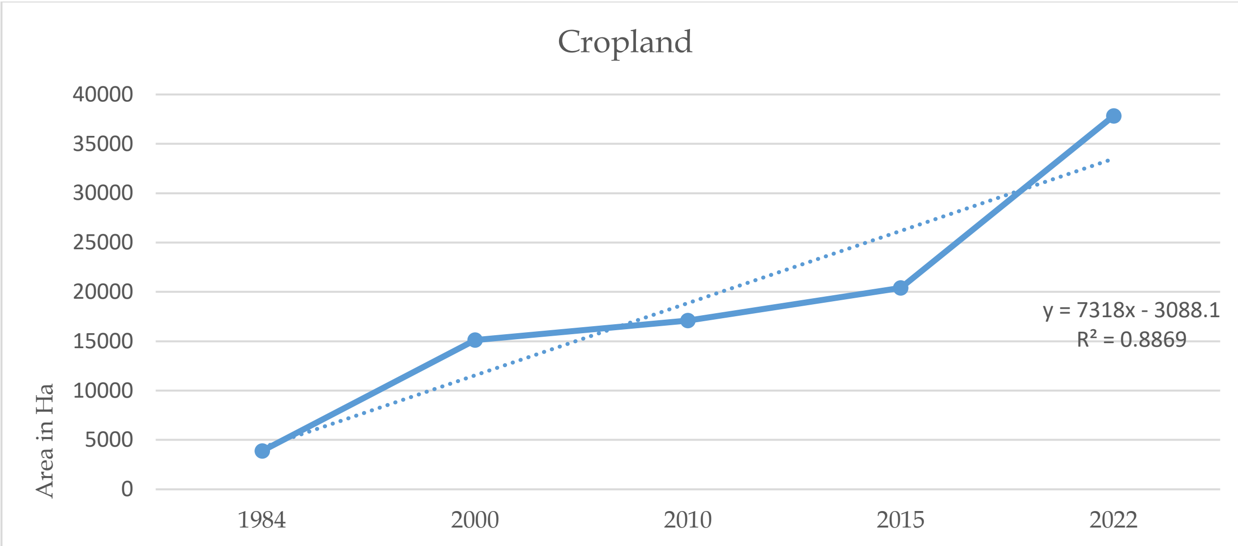

Figure 15: Cropland trend curve

In the year 2022 as depicted in Figure 15, the human activities i.e., farming has highly increased tremendously in the study area. The main one being subsistence farming of maize, potatoes, beans, wheat and pyrethrum in small scale. This had seen the clearing of previous grasslands and some woodlands to give more land for subsistence farming.

In Figure 14, the forest area in 2022 had increased gradually from 2010. A factor that can be attributed to the forest being fenced off from any human activities and a station at the forest entrance. The patrols were made regularly to safeguard the forest.

Evidently, there has been an increase of forest cover mainly attributed from the Kenya Forest Service fencing off the forest area in collaboration with Rhino Arc and the Mpesa Foundation.

3.1.8 Landcover (all classes) trend curve between 1984, 2000, 2010, 2015 and 2022.

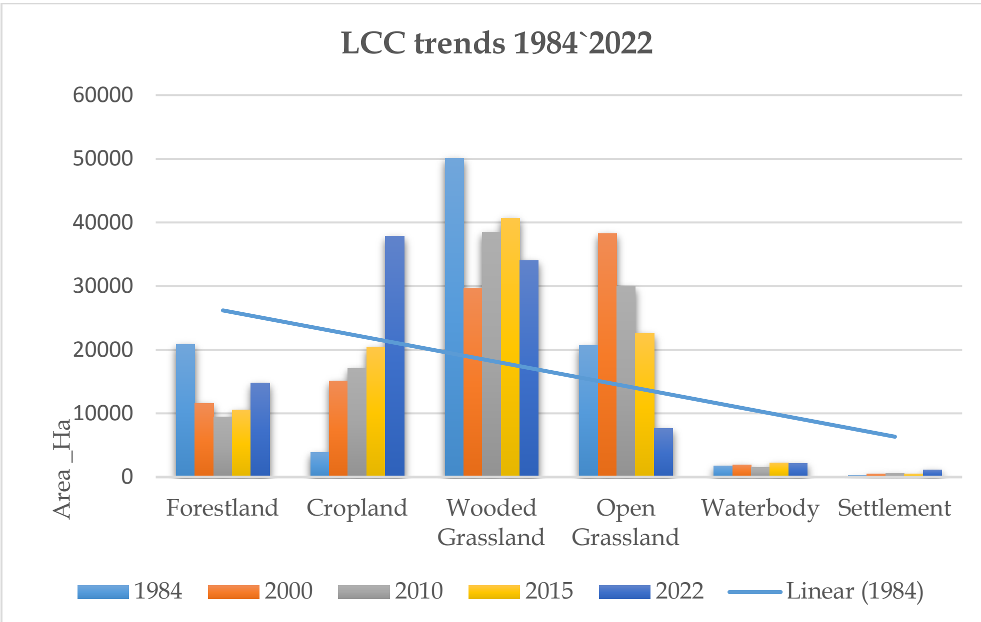

Figure 16: Land cover, land use trend, 1984 to 2022

In figure 16, this shows the interactions with all the classes spreading over the study time in the study area. The loses and gains in different classes.

3.2: Change Maps

3.2.1: Land cover change between 1984 to 2022.

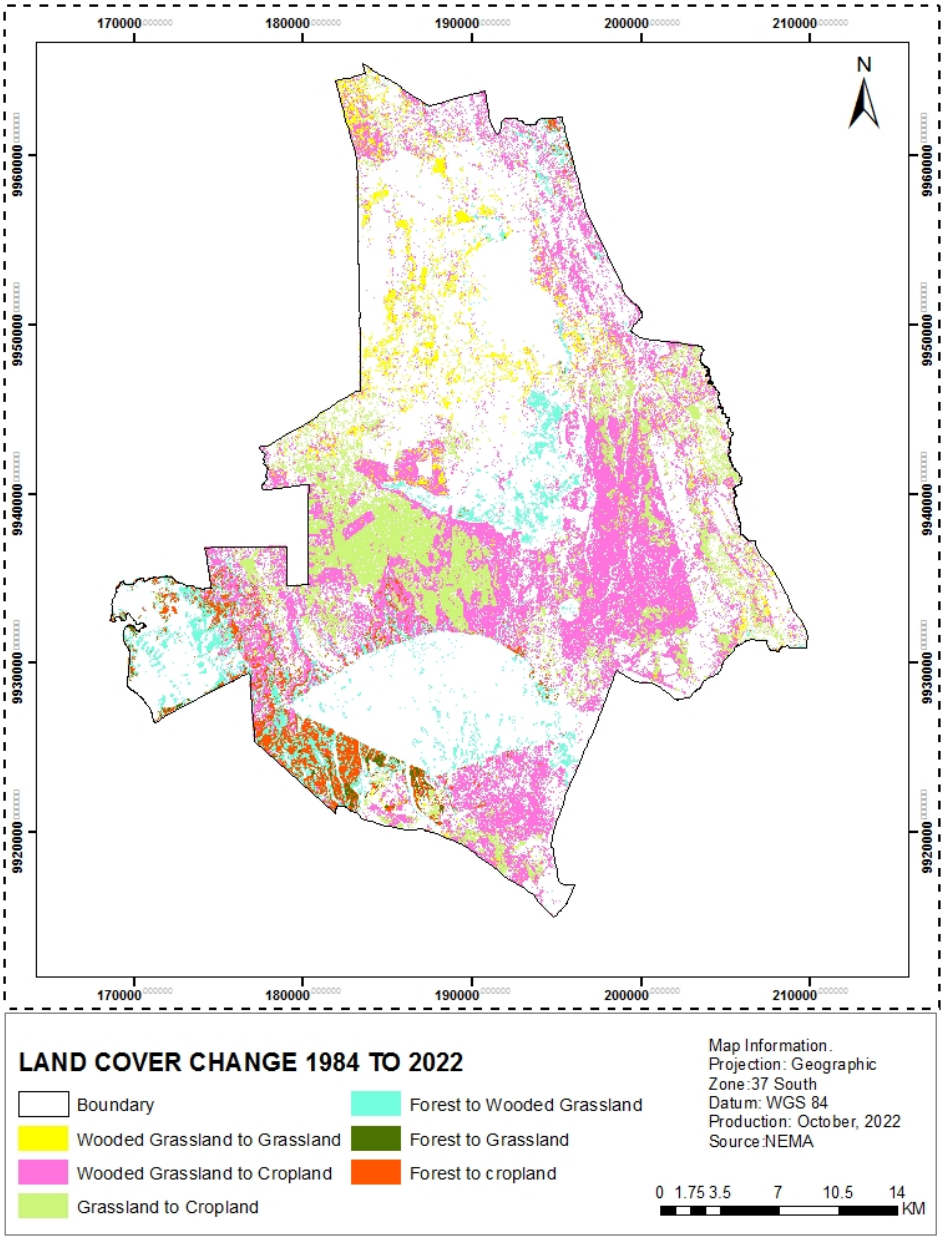

Figure 17: Land cover change map

The above map explains the losses that the Eburu ecosystem has witnessed within the years from 1984 to 2022 between the six classes.

3.2.2: Forest loss between 1984 and 2022.

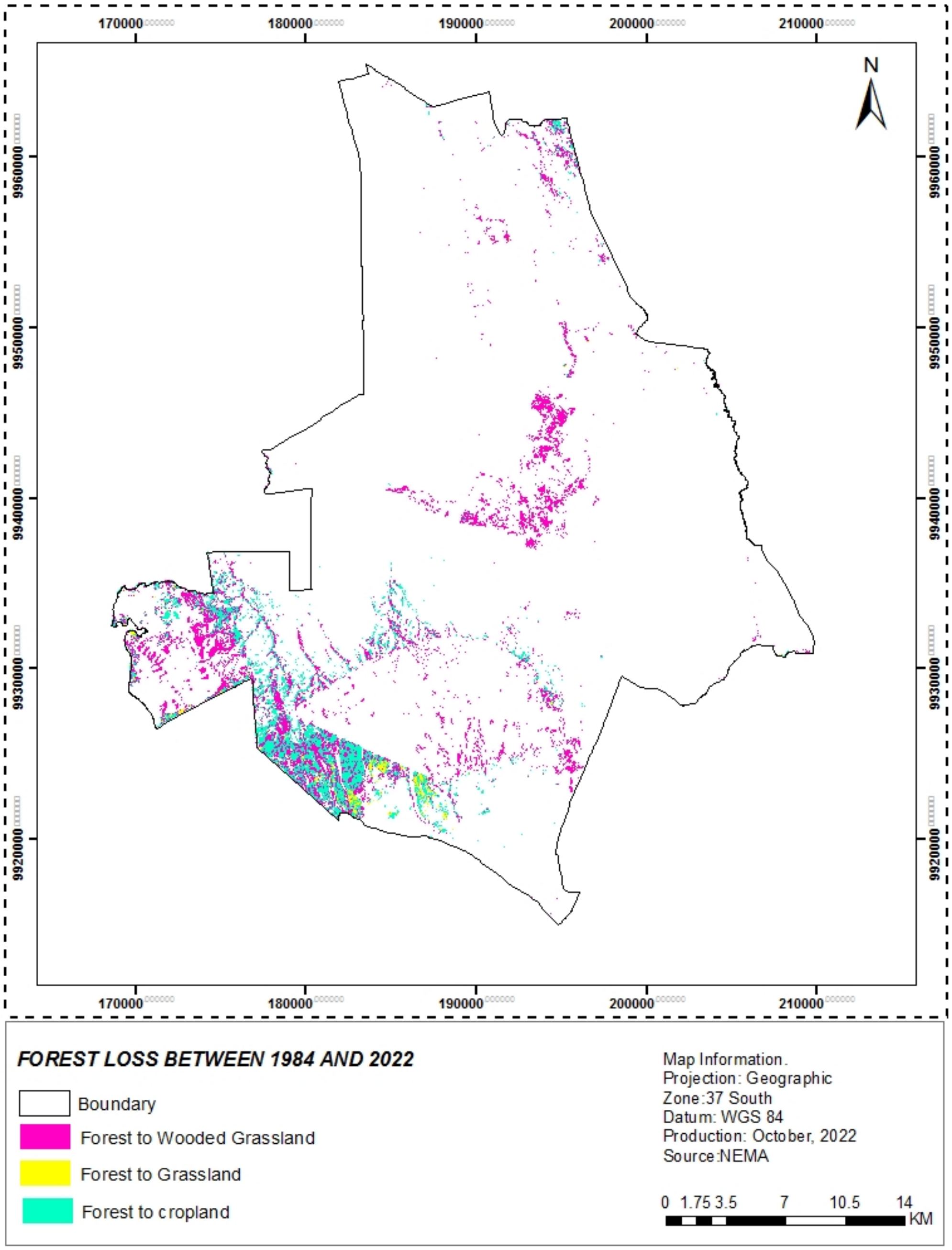

Figure 18: Forest loss between 1984 and 2022

The map above explains it further on the losses the forest cover suffered from and the class beneficiaries of the losses. The cropland was the highest gain of the forest loss.

3.3: Conclusion

In conclusion, the ecosystem has suffered more loss than gain over the study period. These could be attributed to many factors, but majorly to;

- Human disturbance through farming activities and settlement.
- Climate change to some small extent.

4.0 References

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