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Pathways and Impacts of Farmer-Managed Natural Regeneration Practice on Land Use and Land Cover Changes in Semi-Arid Nyatike, Kenya

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ABSTRACT

This study analysed the spatial and temporal dynamics of the semi-arid region of Nyatike, Kenya. It focused on the influence of Farmer Managed Natural Regeneration (FMNR) practice on land restoration over a decade, 2013-2023. Land use and land cover changes (LULC) are critical indicators of environmental transformation caused by both human and natural factors. The study used Remote Sensing Landsat Data and Geographical Information System (GIS) techniques to identify, classify, and quantify seven major LULC changes in the study area. The findings revealed LULC had undergone significant transformations; Reductions were detected in open trees and shrubs (-0.81%), grassland (-6.67%), dense tree cover/ forests (-1.46%), and wetlands (-0.81%). On the other hand, increases were noted in cropland (+17.42 %), built-up areas (+0.15% and water bodies (+0.02%). The results indicated that most of the land initially under trees, shrubs, grasslands, and forests was converted to cropland as well as built-up areas. This reduction also affected the wetlands, which might have been converted to waterbodies and cropland, too. The study established that FMNR practicein the semi-arid region of Nyatike was adopted in North Kadem and Macalder Kanyarwanda wards, and it has the potential of restoring degraded lands through tree regeneration. A total of 37 tree species were identified, with *Combretum collinum* and *Balanites aegyptiana* being more dominant. These tree species improved soil nutrients, microclimate, and biodiversity enhancement. FMNR is an affordable, low-cost, and sustainable approach to the restoration of degraded landscapes in semi-arid areas and a solution for food insecurity.

Key Terms: Farmer-managed natural regeneration, land use and land cover change, remote sensing and GIS, land degradation, semi-arid lands.

INTRODUCTION

Land use and land cover (LULC) changes are twin words, but not identical, used in land change science affecting the Earth system. Whereas land cover refers to the physical, biological or chemical description of the surface, for example, forests, grasslands, and built environment, land use describes the purposes the land cover serves, for example, grassland for grazing, farming, pastoralism or urbanisation (Burley, 1961; Lo, 1986; Turner & Meyer, 1994). The land use and land cover matrix is comprised of geophysical and economic processes that have continued to shape the landscape. Globally, climate change has continued to cause problems for each individual on the planet. Even as the causes and impacts seem complex and diverse, most of the world population suffering immensely from land degradation arising from anthropogenic global warming is the rural population (Roy et al., 2018), where more than 33% of the land has degraded (Abhilash, 2021). Land degradation is defined as processes affecting land productivity levels, resulting in society not meeting its needs for survival and development. Unsustainable land use practices, including the clearance of natural vegetation, over-cultivation, overgrazing, poor land husbandry, and excessive forest conversion, are key drivers of land degradation. This has led to consequences such as declining agricultural productivity, reduced food security, water insecurity, and recurrent livestock loss and other socio-economic impacts such as poverty, conflicts, and gender inequality, especially in the rural areas (Akhtar-Schuster et al., 2022).

This is further complicated by the increased world population expected to hit 10.3 billion by the year 2084, an increase of 2.1 billion people from 2024 statistics (Lam, 2025). The question that needs to be answered is how the available land will be utilised to cater for the increased population without destroying the land cover already in place. Terrified by these developments, the world leaders are wondering how degraded lands can be restored, how policies supporting sustainable development and sustainable land management (SLM) can be developed (Fitawek& Hendriks, 2024). Sustainable Land Management is defined as practices employed in the land management systems that allow users to gain maximum benefits while preserving or improving the ecological functions of land resources (TerrAfrica, 2005).

LITERATURE REVIEW

Farmer Managed Natural Regeneration (FMNR) practice is a sustainable land management technology that facilitates the regrowth of trees and shrubs from felled tree stumps, sprouting root systems, or seed banks while cultivating crops. FMNR has been widely promoted as a low-cost and scalable approach in communities embracing the activities aimed at reversing environmental shifts that have resulted in soil deterioration affecting livelihoods (Rinaudo et al., 2019). The FMNR practice is an effective strategy for land restoration. By promoting natural regeneration, it rehabilitates degraded wastelands and improves soil fertility. It also restores soil structure, inhibits erosion and soil moisture evaporation, rehabilitates springs and the water table and contributes to biodiversity recovery (Rinaudo, 2023). In addition, specific tree species play a critical role in soil nutrient recycling through nitrogen fixation.

Over 29 countries are practising FMNR, restoring landscapes through reforestation, resulting in strengthened communities. This has restored millions of hectares of degraded lands across Asia, Latin America and Africa (Walker et al., 2024). FMNR encourages farmers to practice agriculture while also regenerating trees and shrubs, restoring degraded land sustainably at a relatively low cost (Rinaudo, 2007).

On the other hand, a lot of work on FMNR has been done in the Sahel, and the results are the same in all the parts of the world where it has been done. FMNR is a practice with the potential to provide a solution to climate change while positively impacting the welfare of communities. The technique involves farmers prioritising systematic growth and management of tree species that support crops while carrying out agricultural activities in the farms (World Vision Kenya, 2021). Previous studies have shown that the farmer-driven adoption of this technology in Africa has enabled the restoration of degraded ecosystem services, thus strengthening resilience to extreme weather events and supporting climate adaptation. In turn, the restored lands have contributed to increased agricultural productivity and improved food security

(Haglund et al., 2011). Additionally, studies conducted in countries such as Burkina Faso, Niger, Senegal and Mali have reported the regeneration of trees on farms, providing a safety net to farmers by generating cash income, crop supplements, and improving caloric intake and diet in areas prone to drought The FMNR practice in Niger has seen restoration of over five (5) million hectares of degraded land regrowing about two hundred (200) million trees, hence improving food security for over 2.5 million people and increasing land cover (Reij et al., 2009). In Ethiopia, the practice in Tigray and Amhara has reduced erosion and restored community watershed, providing more water for domestic and agricultural use (World Vision Kenya, 2021).

Land degradation in Kenya is widespread, affecting over 30 per cent of the land, with 80 per cent classified as arid or semi-arid (World Vision Kenya, 2021). This, in turn, reduces land cover and limits land use, consequently reducing the food crop productivity potential of the country, resulting in hunger and a lack of dietary diversity. This has led to malnutrition of about 26 per cent of children under the age of five (Wanjira et al., 2020). Hence, appropriate techniques to increase land cover by restoring degraded land so as to improve food security and provide income security through various land uses are needed. On the realisation that Kenya's forest cover had declined from 10 per cent to 6.6 per cent in 2008 (MENR, 2016), Kenya positioned itself to increase land cover through its initiative of forest cover expansion to more than 10 percent and targeted to restore 5.1 million hectares of land that had experienced degradation in the recent past by 2030 (MENR, 2016). This was revised to achieve a forest cover of at least 14 per cent, in line with the Kenya Forestry Research Institute's target of planting 500 million tree seedlings by 2022 (Wanjira et al., 2020).

As one of the strategies to achieve this, Kenya adopted the FMNR practice, which is also crucial in achieving Kenya Vision 2030, supporting the National Climate Change Action Plan, and will help achieve targets set in relation to the restoration of degraded lands under the United Nations Convention to Combat Desertification, to which Kenya is a signatory (Government of Kenya, 2019). World Vision Kenya, in collaboration with CIFOR-ICRAF through the Regreening Africa project, introduced FMNR practice in Nyatike, Kenya, in 2013, to restore degraded land (Odhiambo, 2024).

Since LULC assessment is integral to the diverse aspects of the natural environment, LULC changes in the semi-arid areas of Nyatike, Migori County, Kenya, have not been addressed, and the changes have not been reported. Knowledge of LULC changes in this region is scarce. This study attempts to map and quantify the LULC changes in the semi-arid Nyatike, Kenya, using multi-temporal remote sensing satellite data, and also describes the tree species adopted by farmers practising FMNR in an effort to improve land use and increase land cover.

METHODOLOGY

The study was carried out in Nyatike Sub-County, Migori County, Kenya, as shown in Figure 1. The Sub-County covers an area of approximately 676.9 km^2, and had a population of 176,162 according to the 2019 census. Projections show that by the year 2025, the population will reach 203,865 persons. It is dividedinto seven wards, namely: Kachieng', Kanyasa, North Kadem, Macalder /Kanyarwanda, Kaler, Got Kachola and Muhuru. The region is characterised by unreliable and poorly distributed rainfall, with annual totals ranging between 700mm and 1,800 mm (Migori County Government, 2023). The target population for the study was the 2,727 farmers practising FMNR in Nyatike, Migori County, as per the database from World Vision that spearheaded the project of Regreening Africa in the Migori County offices.

The study adopted a quantitative field survey research design. Farmers who were practising farmer-managed natural regeneration technology and planted maise were included in the study. In each selected farm, tree species adopted and utilised by farmers in their farms were selected for the study. A botanist helped in the identification of the species using both local and botanical names.

The sampling technique used was the Land Degradation Surveillance Framework (LDSF). This technique is effective in assessing the processes of land degradation and restoration over time (Vågen et al., 2013), hence, its choice for the study.

A hierarchical sampling design comprising three levels of randomisation was used. Since the area covers 676.9 km^2, the area was divided into seven (7) blocks (sites) of approximately 10 km by 10 km in size. For purposes of this study, the seven blocks were the wards within the Sub-County: Kachieng', Kanyasa, North Kadem, Macalder /Kanyarwanda, Kaler, Got Kachola, and Muhuru.

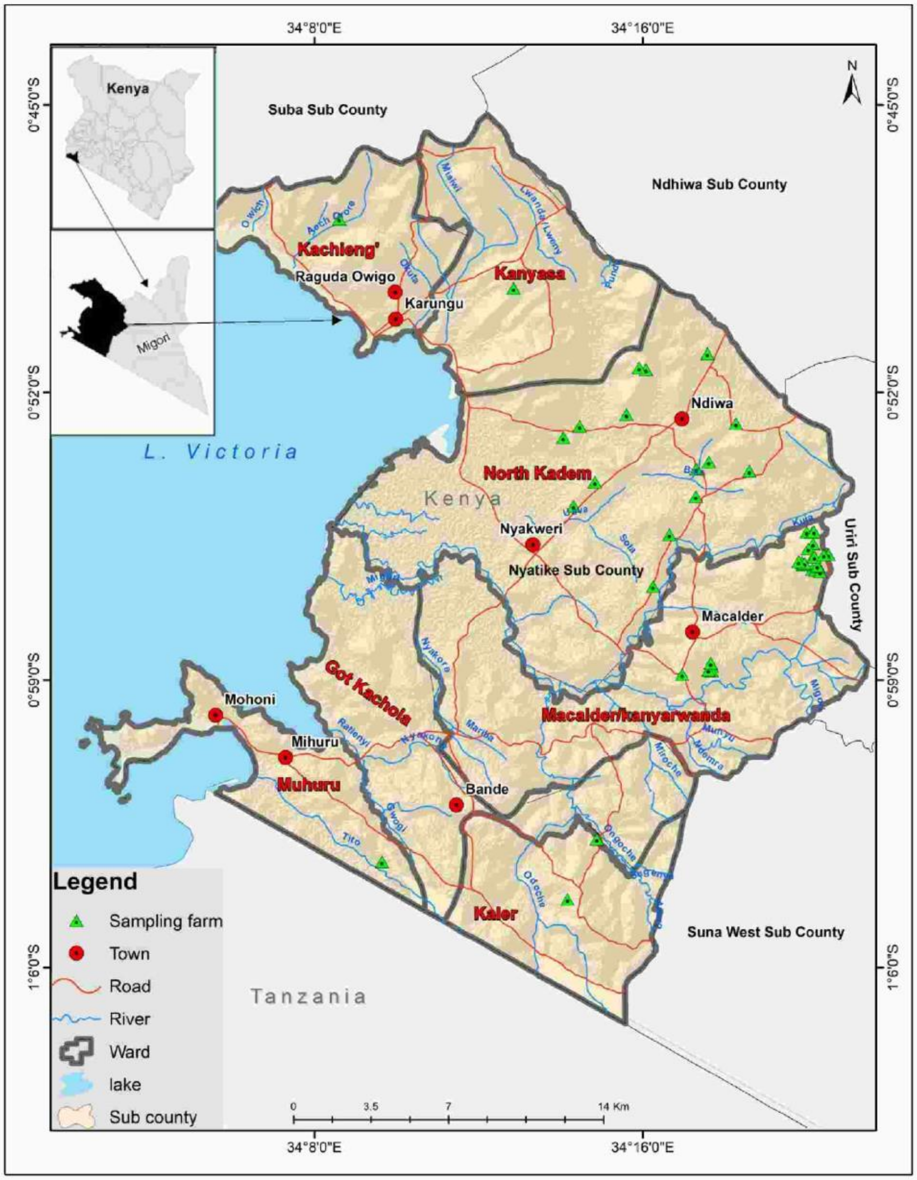

Figure 1: Map of Nyatike Sub-County Showing Study Site and Sampling Plots

With a target population of less than 10,000, a sample size of between 10 per cent and 30 per cent was a good representation of the target population (Mugenda & Mugenda, 2003). This study adopted 12 per cent of the farmers as the target population. This resulted in 332 farmers. Further, systematic sampling of the 332 farmers was carried out, where every eighth farmer was selected for the study. This is because the farmers were assumed to have homogeneous characteristics and shared the same climatic conditions. Forty-five (45) farmers were randomly selected to participate in the study, as shown in Table1 below.

Table 1: Blocks, Sample Size and Treatment Plots

Blocks	Number of farmers	12% of the target population (Sample size)	Systematic sampling of samples (8th farmer)
North Kadem	1068	129	16
Macalder/ Kanyarwanda	1577	190	24
Kaler	18	3	1
Muhuru	21	3	1
Got Kachola	09	2	1
Kanyasa	15	2	1
Kachieng'	19	3	1
TOTAL	**2727**	**332**	**45**

In each plot, tree species adopted by farmers to support maise farming were selected for the study. Their canopy size was also measured.

A cloudless scene of Landsat TM images for 2024 was downloaded from the U.S. Geological Survey (USGS); the image was a subset for the study area. The land-cover map was classified.

Authorisation to conduct the research was obtained from the National Council for Science and Technology and Innovation. An introductory letter endorsed by the researcher's institution of learning was distributed to the selected FMNR farmers in the study area. The letter outlined the purpose of the study, the nature of the information to be collected and the expected level of participant involvement. Further, the researcher also arranged, through pre-visits with research assistants, to meet with the farmers. The researcher also trained the research assistants, who in turn helped with the data collection process.

To establish the species diversity on the farmlands under the FMNR in Nyatike Sub-County, a frequency table capturing the various tree species and the count of each tree species was provided. Measurements of canopy radius and tree height were taken at 1.3 metres above ground using a tape measure. In total, 45 sample farms were established and evaluated across the seven blocks (wards). A cross-tabulation analysis involving canopy size, tree species, and blocks (wards) was also conducted to observe the species distribution across the wards and canopy sizes.

Integration of remote sensing and Geographical Information Systems (GIS), combined with existing spatial data, was used to analyse land use/land cover change. Landsat scenes, raster data for Nyatike Sub-County in 2013 and 2023, were derived from the U.S. Geological Survey (USGS) website, Earth Explorer. The study area administrative boundaries vector datasets overlaid on the images were obtained from DIVA GIS. Identification and change detection of the land cover were based on Landsat image analysis.

The satellite images were radiometrically corrected by applying the top of the atmosphere (TOA) process to make comparisons among the images from different dates. Atmospheric and topographic corrections were also conducted to ensure spatial and temporal comparability of the datasets. All the images were geo-processed by clipping to extract the study area extent. The Raster Composite tool in the ArcMap was used to perform Image Classification by executing a band combination. Thereafter, supervised classification in ArcGIS 10.8 to find the maximum likelihood for each of the Landsat images collected was carried out. The training site selection was donein agreement with the Landsat Image, Google Earth, and Google Maps.

To ensure accuracy in the assessment, classifications were taken from the compositions of false colour images, and through the application of the Kappa coefficient, at control points for each year, validation was carried out. Reference data was used to verify measurements of categories of classification. This resulted in the creation of 60 points (locations) of classified images in the seven blocks.

To ensure reliability, remote sensing outputs must be validated. Accuracy assessment helps to determine whether classified images reflect real ground conditions. This involves comparing classified pixels with actual land cover, thus showing how well the classification represents reality (Nicolau et al., 2023). Other measures of accuracy include a producer's accuracy measure that estimates the errors of omission. This is the measure of classifying real-world land cover types. The errors of commission are measured using the user's accuracy, which finds out the likelihood of a classified pixel matching the land cover type. While image classification accuracy is measured using the kappa coefficient.

The overall classification accuracy = No. of correct points/total number of points

The confusion matrix is comprised of rows and columns. The columns are used to represent the ground-truth classes of the pixels, while the rows show the classes of the image pixels classification. The diagonal shows correct pixel classification, and those not assigned to the right class do not appear in the diagonal.

The Kappa analysis is commonly applied in remote sensing to measure the level of agreement between classified images and reference data. It yields a Khat statistic which is computed as:

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}\left(x_i + Xx_{+1}\right)}{N^2 - \sum_{i=1}^{r}\left(x_{ii} Xx_{+1}\right)}$$

Where:

r = number of rows and columns in error matrix, N = total number of observations (pixels)

X_{ii} = observation in row i and column i,

Xi+ = marginal total of row i, and X+i = marginal total of column i

There is perfect agreement when the Kappa coefficient is equal to 1. The value that is close to zero shows the agreement is not better than a chance would provide.

The results from the accuracy assessment depicted an overall accuracy as measured from the random sampling process for the 2013 and 2023 images of 85.6 per cent and 85 per cent, respectively, and a Kappa coefficient of 0.838 and 0.82, respectively, was realised. This results in a rating of the Kappa coefficient as substantial, and hence the classified image is found to be fit for further research.

The land cover classes for the respective dates of interest were then converted to vectors, where their areas were computed to assess the changes.

Ethical Considerations

Authorisation to conduct the research was obtained from the National Council for Science and Technology and Innovation. An introductory letter endorsed by the researcher's institution of learning was distributed to the selected FMNR farmers in the study area. The letter outlined the purpose of the study, the nature of the information to be collected and the expected level of participant involvement. Further, the researcher also arranged, through pre-visits with research assistants, to meet with the farmers. The researcher also trained the research assistants, who in turn helped with the data collection process.

FINDINGS AND DISCUSSION

Results of Remote Sensing and GIS

Table 2 presents the remote sensing and GIS results for Nyatike Sub-County, Migori County. The data captured represents the land use and land cover scenarios of 2013 and 2023. This is also shown in Figure 2. The study shows that some areas have reduced significantly over the past decade. In terms of percentage change, open trees and shrubs (8.68%), grassland (6.67%), dense trees/forest (1.46%) and wetland (0.81%) have decreased by the percentages shown. At the same time, the area under cropland (17.42%), built-up area (0.15 %) and water body (0.02 %) has increased proportionally to the percentages shown. This shows that most of the land that was under open trees and shrubs, and grassland, has been converted to crop land through deforestation. The trees and vegetation that were cleared could have been used for charcoal and firewood. Part of the trees and shrubs, and the grassland, might have been cleared for settlement. The wetlands might have also been reduced due to increased human activities, such as agriculture, due to increased cropland and settlements. Drought experience due to the impact of climate change might have also contributed to the reduction of the wetland. This is also clearly seen from the Landsat images as provided in Figure 1.3 and Figure 1.4, where most of the dense trees/forests and shrublands that existed in 2013 have disappeared in 2023. This means that a lot of deforestation has taken place to pave the way for agricultural productivity.

Table 2: Land Use Land Cover of Nyatike Sub-County (2013 And 2023)

LULC	2013 Area (ha)	Percentage	Area Change	% Change	2023 Area (ha)	Percentage
Built-up area	454.85	0.378	184.58	0.15	639.43	0.531
Cropland	20839.23	17.321	20962.65	17.42	41801.88	34.745
Dense trees/forest	2114.17	1.757	-1751.38	-1.46	362.79	0.302
Grassland	22627.07	18.807	-8027.38	-6.67	14599.69	12.135
Open trees and shrubs	18333.22	15.238	-10437.25	-8.68	7895.97	6.563
Water body	51343.66	42.676	33.32	0.02	51376.98	42.704
Wetland	2585.01	2.149	-974.53	-0.81	1610.48	1.339
Total	120310.22	100			120310.22	100

A closer look at the seven blocks (wards) of Muhuru, Got Kachola, Kachieng', Kaler, Kanyasa, Macalder/Kanyarwanda and North Kadem shows that cropland increased significantly in all the wards (see Figure 2). At the same time, despite the farmers having been practising FMNR, the dense tree/forest cover was reduced, with North Kadem ward registering the highest reduction of 854.33 ha. Grassland also reduced across all the wards, with Macalder/Kanyarwanda registering the greatest loss of 1,935.78 ha. Open trees and shrubs experienced the greatest reduction across the land cover, with a huge loss of 4,722.18 ha experienced in North Kadem ward. This is the same ward that experienced the highest loss of trees/forest cover and the highest increase in crop land of 7,695.53 ha. This study reveals that most of the land cover loss from dense trees/forest, grassland, and open trees and shrubs was converted to crop land use. Since most farmers grow maize as a staple food, it is possible that the grassland, shrubs, trees, and forests were cleared for growing maize. The reduction in land cover is further depicted.

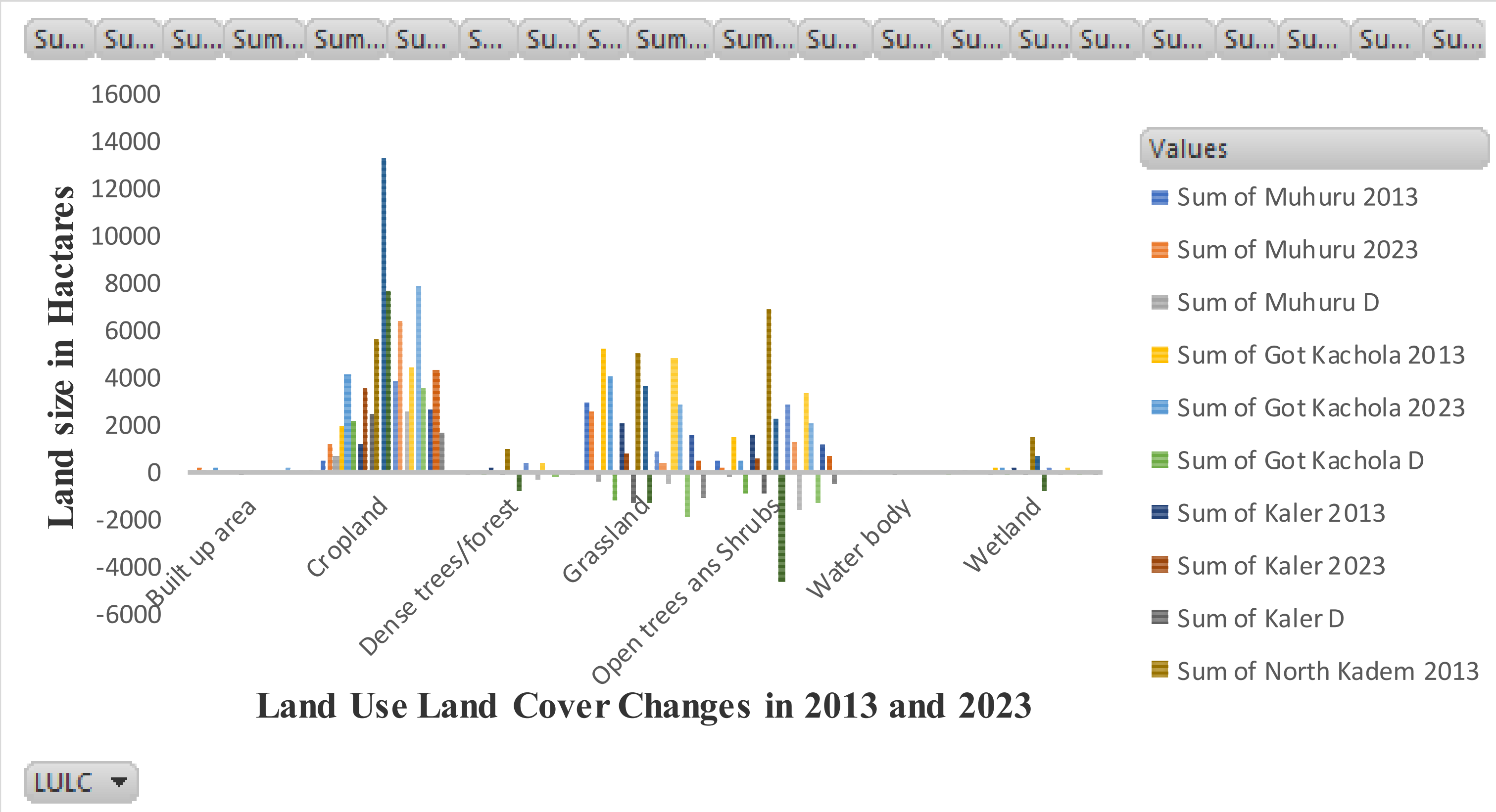

Figure 2: Land Use and Land Cover Changes for 2013 and 2023 and the Difference between the Two Years in the Seven Wards in Nyatike Sub-County

These findings align with a study conducted in Ethiopia that assessed the impact of cultivated land and urban expansion on land use and land cover change, which includes forest destruction and its far-reaching effects on sustainable environment conservation and management. The Landsat images showed that the rate of land conversion from forest and grassland for the cultivation of crops and built-up spaces was on an upward trend (Tilahun et al., 2022). This study also revealed an increase in built-up areas in all wards except Kaler ward, where the built-up area reduced by 11.8%, while crop land significantly increased in all wards within the decade. The increase in crop land is an indication that Nyatike Sub-County is an agricultural area. This is in line with a study showing that agricultural areas in middle-income countries tend to increase (Azadi et al., 2021). The scenario in Nyatike Sub-County is proof that Kenya is a middle-income country.

A study in China showed that forest destruction to pave the way for agricultural activities resulted in the loss of up to 376.04 km². This also led to a 6.08% decrease in natural habitats (Tilahun et al., 2022). With the loss of forests, there is a huge loss of biodiversity and climate change. This is also shown in Figure 3, where the reduction of land use and land cover between 2013 and 2023 is evident. FMNR practices provide a better option for increasing food production while ensuring tree cover is maintained.

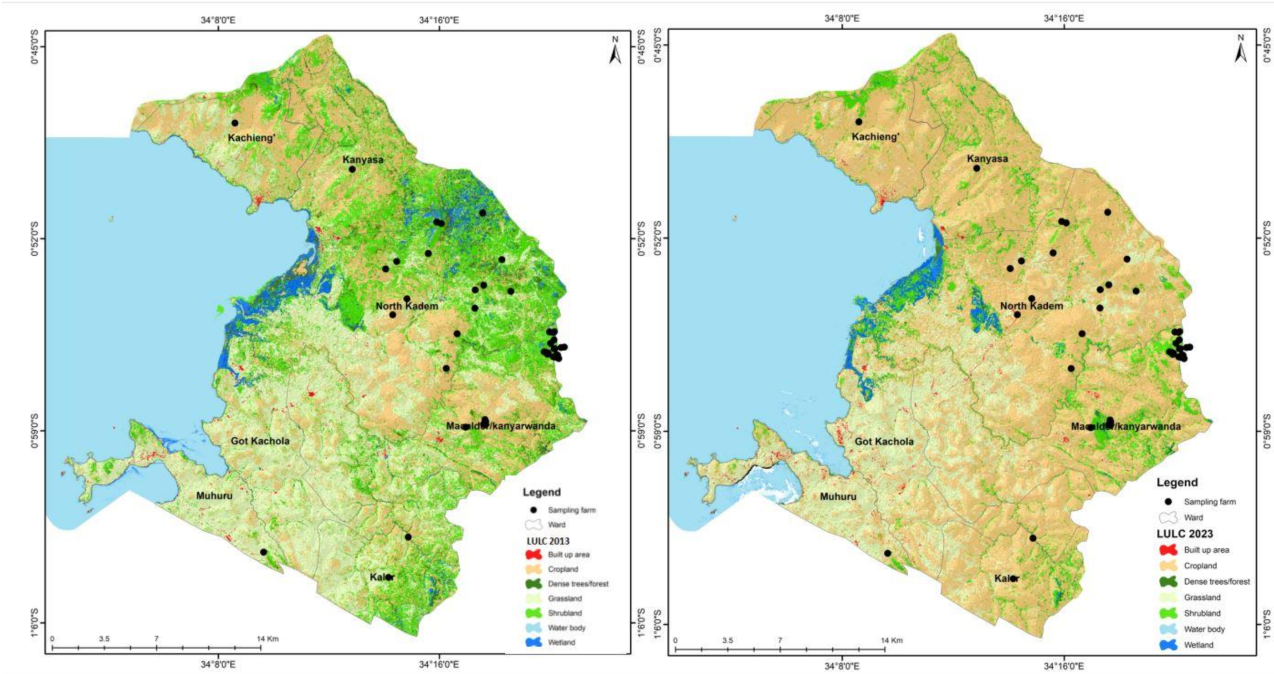

Figure 3: Land Use Land Cover (LULC) Map as at 2013 (on the left) and 2023 (on the right)

Species Diversity on Farmlands under FMNR

The data in Figure 4 shows the frequency with which each of the tree species was encountered across the treatment sites of the seven wards/blocks. A total of 166 trees were identified in the study area. This confirms that FMNR has a large potential for accommodating biodiversity in agricultural landscapes. *Combretum collinum* species was the most frequently encountered species (28 times), followed by *Balanites aegyptiaca* (26 times) and *Grewia bicolour* (mollis) (21 times). Other tree species and their respective numbers according to occurance in the field study included *Ficus sycomorus* (8), *Albizia coriaria* (7), *Acacia polyacantha* (7), *Lannea shweinfurthii* (6), *Combretum mole* (6), *Pappea capensis* (5), *Commiphora africana* (5), *Ormocarpum trichocarpum* (4), *Rhus natalensis* (4), *Vepris nobilis* (3), *Olea europaea* (3), *Lepisanthes senegalensis* (3), *Tamarindus indica* (3), *Lannea welwitschii* (2), *Zanthoxylum usambarense* (2), *Flueggea virosi* (2), *Acacia hockii* (2), *Psidium guajava* (2), *Trichilia emetic* (2), *Capparis decidua* (1), *Cedrela odorata* (1), *Ximenia Americana* (1), *Annona senegalensis* (1), *Dichrostachys cinerea* (1), *Kigelia africana* (1), *Prunus africana* (1), *Acacia seyal* (1), *Erythrina abyssinica* (1), *Piliostigma thonningii* (1), *Vachellia xanthophloea* (1), *Maytenus senegalensis* (1), *Gardenia volkensii* (1), *Boscia salicifolia* (1) and *Cordia monoica* (1).

Many species were encountered only once in the treatment sites. This indicated that some specieswere more commonly incorporated in FMNR practice while others were less commonly grown. Two wards/blocks had greater tree species diversity. North Kadem had 64 trees while Macalder/Kanyarwanda had 96, showing that many farmers in these wards embraced the FMNR practice compared to the other places within the Sub-County. Notably, Muhuru had two tree species, while the rest (Got Kachola, Kachieng', Kaler, and Kanyasa) had only one tree each.

The tree canopies were also measured and recorded. It was found that the tree with the largest canopy size, 9.0 m, was *Ficus sycomorus*. This particular tree is mainly found in Macalder/Kanyarwanda. The data show that only eight such trees were considered for this study, and the general range of canopy size for this species of tree in this setting was 4.0–9.0 m (averaging 4.87 m). The Trees with the smallest canopy sizes, at 1.5 m, were *Combretum collinum* and *Olea europaea*; both tree species were found in Macalder/Kanyarwanda. However, *Combretum collinum* is mainly found at Macalder/Kanyarwanda (27) and Muhuru (1). A total of 28 such tree species were found to be utilised in the FMNR practice in Nyatike Sub-County. It had the highest frequency in the study area. The canopy size range for *Combretum* *collinum* was 1.5–5.5 m (average 2.79 m). The other tree species, *Olea europaea,* is found in Macalder/Kanyarwanda (1) and North Kadem (2). The canopy size range is 1.5–2.3 m (average 1.97 m). A total of 3 such tree species were considered for this study. However, on average, it was observed that the tree with the largest average canopy size is *Cedrela odorata* (6.0 m), and is found in Got Kachola ward. The tree with the smallest average canopy size is *Lepisanthes senegalensis* (1.73 m). All three tree species are found in Macalder/Kanyarwanda. The averages of the tree species are shown in Figure 4.

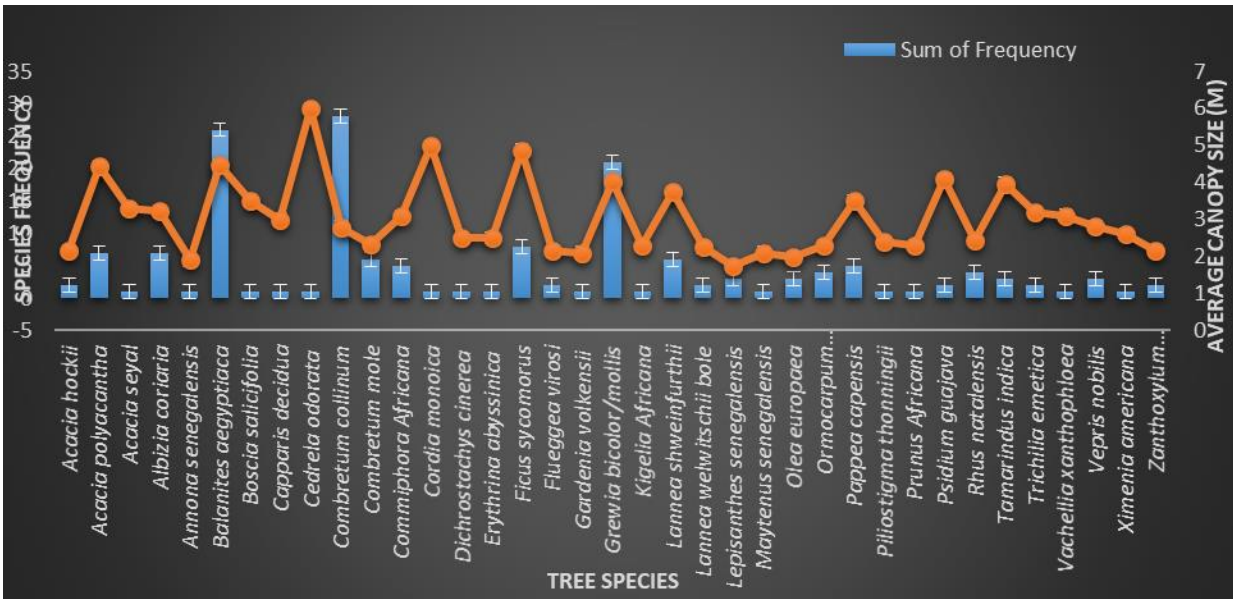

Figure 4: Tree Species and Their Respective Frequencies in the Study Area

The study identified 37 different tree species in the Nyatike Sub-County region that are used in the FMNR practice. Areas with higher tree densities tend to safeguard soil from erosional agents (Rezaei & Miri, 2022). The areas of North Kadem and Macalder/Kanyarwanda with many tree species are expected to experience minimal erosional activities, hence may have rich soil nutrients and microbial composition, resulting in higher production of maise yield.

Tree canopy size plays an important role in providing a cooling effect during periods of high temperatures. The study found that trees that exhibit the strongest cooling capacity have a tree crown diameter (TCD) of 3 m. This is higher than the trees with a TCD of 7 m and 5 m, whereas trees with the weakest cooling capacity had a TCD of 5 m. The results indicate that the trees with a small canopy have a better cooling effect than trees with a large canopy for the same level of coverage (Wang et al., 2023). Trees' canopies play an important role in the nutrient cycle and water conservation. It directly enhances maise yield by modifying microclimate and improving soil nutrients through organic matter, influences the health status of trees, and the rate of carbon sink (Handiso et al., 2024; Zhou et al., 2021). In this study, the majority of the trees had canopy sizes measuring between 2 and 4 m. The canopy size provides a cooling effect, an effect that the maise grown under it can benefit from during the drought, resulting in high yields. This can result in higher maise yield productivity as shown in Figure 5.

Figure 5: Maise Growing Under Pinus Africana

The findings show that among the 37 tree species found in the study area, the tree species *Annona senegalensis, Kigelia africana, Acacia seyal, Erythrina abyssinica, Combretum collinum, Combretum mole, Albizia coriaria, Acacia polyacantha, Tamarindus indica, Rhus natalensis* and *Boscia salicifolia* confirm that the study area belongs to the Agro-ecological zone (AEZ) IV. The presence of the tree species *Vepris nobilis, Balanites aegyptiaca* and *Trichilia emetic* is an indication that the AEZ III characteristics overlap with AEZ IV. Whereas, tree species *Olea europaea* (AEZ I), *Prunus africana* (AEZ II) and *Zanthoxylum usambarense* (AEZ V) were also found in the study area (Wanjira et al., 2020). This is an indication that tree species can flourish in different ecological zones. Additionally, this study has revealed numerous tree species not known for their utilisation in the FMNR practice, yet may have a significant impact on maise growth and productivity. This includes *Capparis decidua, Cedrela odorata, Ximenia Americana, Lannea shweinfurthi/schimperi, Lannea welwitschii bole, Dichrostachys cinerea, Ficus sycomorus, Piliostigma thonningii, Vachellia xanthophloea, Pappea capensis, Flueggea virosa, Acacia hockii, Psidium guajava, Lepisanthes senegalensis, Grewia bicolour/mollis, Ormocarpum trichocarpum, Commiphora africana, Maytenus senegalensis, Gardenia volkensii,* and *Cordia monoica*.

CONCLUSION AND RECOMMENDATIONS

Conclusion: The study findings revealed that Nyatike sub-County has undergone immense land use and land cover transformations over a decade, with a substantial increase in cropland at the expense of grassland, forests, and shrublands. While agricultural expansion has supported food production, it has also accelerated deforestation and ecosystem degradation. The introduction and gradual adoption of Farmer Managed Natural Regeneration (FMNR) practiceshave demonstrated promising results in reversing these trends. Through the adoption of different natural tree species by farmers practising maise farming, FMNR has enhanced soil fertility, improved microclimate,and promoted biodiversity conservation. North Kademand Macalder Kanyarwanda wards have demonstrated significant success in the adoption of FMNR. Therefore, upscaling of FMNR practice in semi-arid regions of Kenya should be prioritised as part of the National strategies for land restoration, climate adaptation, and sustainable livelihoods. Future research should focus on long-term monitoring of FMNR impacts on ecosystem services and socio-economic outcomes at the household and community levels.

Recommendations: There is a need to establish the impact of the tree species adopted by farmers practising FMNR in Nyatike on maize health and maize yield production. This will help farmers select the tree species for FMNR practice that are more beneficial to maize health and yield to increase maize productivity and provide food security.

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