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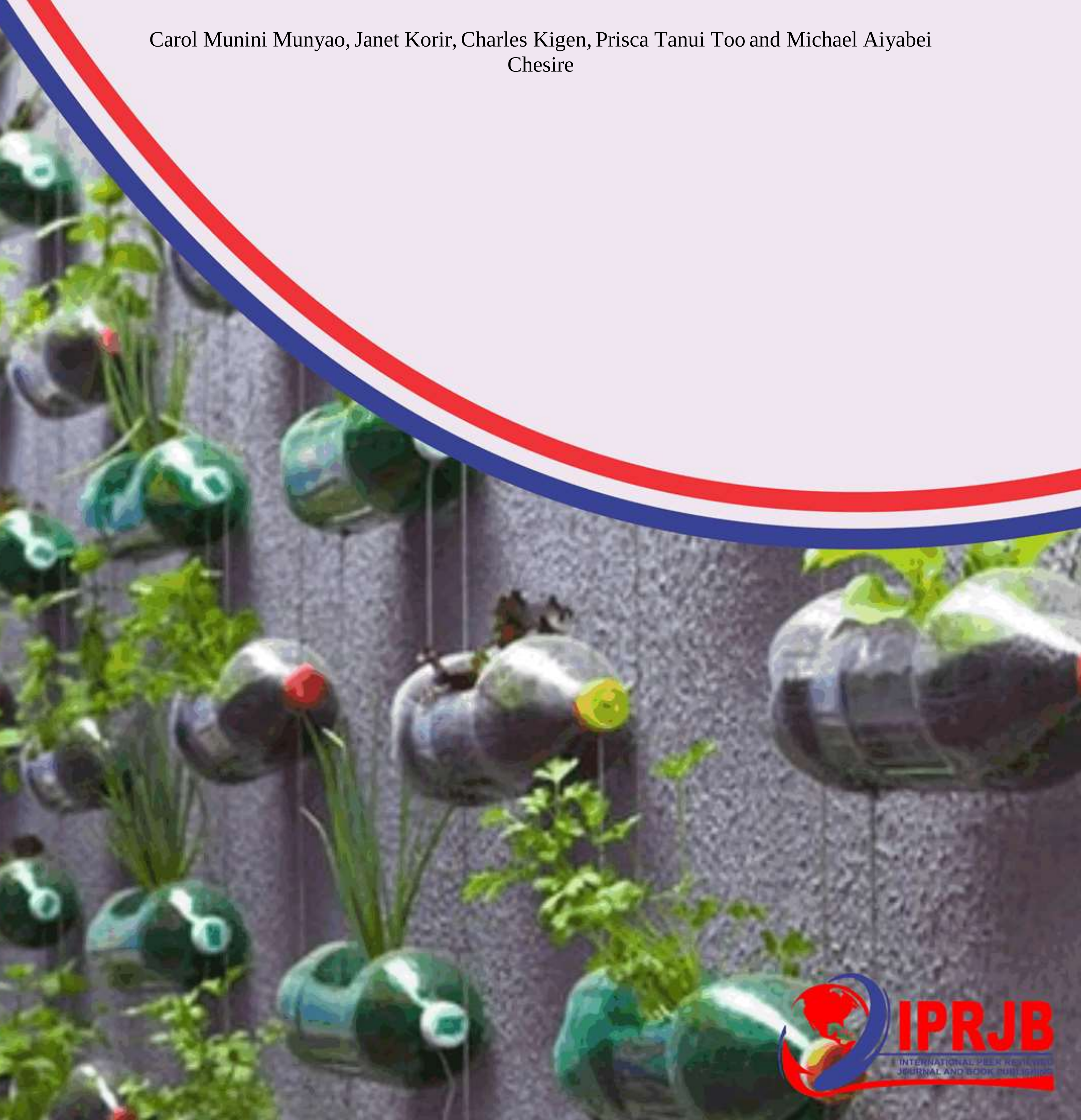

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Enhancement of Vegetation Cover through Farmer Managed Natural Regeneration in the Central Rift, Kenya

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Abstract

Purpose: This paper discusses the contribution of Kenya Central Rift Farmer-Managed Natural Regeneration Scale-up project (CRIFSUP) to enhanced vegetation cover through promotion of Farmer Managed Natural Regeneration concept among farmers in central rift region, Kenya. The project ran between July 2017 and June 2021, when it transitioned to a further five-year phase. The goal of this paper is to assess and compare changes in vegetation cover and species composition through FMNR and other evergreen agricultural practices in CRIPSUP and outside project areas in Central Rift Kenya.

Methodology: The study was undertaken in three counties that included; Elgeyo-Marakwet, Nakuru and Baringo. The Study sites were Ndabibi sub-County in Nakuru County, Marigat sub-County in Baringo County, and sub-County Ng'oswet in Elgeyo Marakwet. This study employed cross-sectional study design where there was evaluation of changes in tree density and tree species composition before and after the Intervention of CRIFSUP project in Central Rift, Kenya. Both qualitative and quantitative data were used to investigate and analyse the critical study findings. The data collection methods included surveys, focus group discussions, key informant interviews, and observations. Multi-stage sampling was applied in this study. In total, 402 households out of a sample size 426 participated in the household survey in the study.

Findings: The total acreage of land under FMNR managed in the project area increased from 500 acres at inception in 2017 to 4,588 acres in 2019 then to 6,938 acres in project year 2021. This was attributed to farmers recognising benefits of FMNR such as increased pasture, firewood, honey, milk production and training to replicating farmers. The average number of trees per hectare in areas practising FMNR was 115.9; significantly higher compared to areas where there was no FMNR practice such as community land allocated to individual households where average number of trees per hectare was 69.89. Farm boundaries recorded the lowest number of tree populations at 12.47 trees/ha and 14.5 trees/ha before and after project intervention, respectively. There was however, no significant difference in tree densities along the boundaries and among the control farmers before and after project intervention ($p = 0.08$). To the contrary, tree densities for farmlands, communal land and overall, in the area of project operation were significantly higher after intervention of CRIFSUP project ($p = 0.02$). This was attributed to increased knowledge on FMNR practices as where 45.0 % (n =181) of farmers indicated knowledge on natural regeneration of trees, while 27.9% (n = 112) displayed knowledge on protection of naturally regenerated trees and seedlings. In conclusion, FMNR and other evergreen methods were found to enhance vegetation cover and through enhanced tree densities and tree diversity in the three regions.

Unique Contribution to Theory, Practice and Policy: The study recommends expanding FMNR training to raise awareness and adoption among farmers. Efforts should be made to overcome challenges affecting tree densities on farm boundaries. Additionally, scaling up FMNR practices to other regions and monitoring long-term impacts on biodiversity and ecosystem services are suggested.

Keywords: *Land Degradation, Natural Regeneration, Vegetation Cover, Resilience, FMNR*

INTRODUCTION

The world has experienced severe land degradation due to deforestation, climate change, drought, desertification and unsustainable land uses. Consequently, the productivity and health of farmlands, grazing lands and forests is damaged, which in turn harms the individuals and communities who depend on these resources for their food supply, health and income (Rinaudo et. al, 2019). It is estimated that up to 65% of productive land in Africa is degraded, exacerbating poverty, food and nutrition insecurity, loss of biodiversity, conflicts and insecurity (UNCCD, 2013; ELD-UNEP, 2015). In sub-Saharan Africa, smallholder agriculture is a key driver of deforestation (FAO, 2020). Farmers continue to expand agricultural land and are increasingly cropping marginal areas to increase their production. They are also abandoning traditional practices particularly fallowing and enclosure that formerly allowed farmland to rejuvenate (Crossland et al., 2018). Recent estimates indicate 132 million hectares of degraded cropland in Africa (Cai et al., 2011). This underpins why large-scale restoration methods and practices are being advocated for and deployed. There is evidence that natural regeneration on agricultural and pastoral land has great potential to restore biomass (Poorter et al., 2016), soil organic carbon (Bayala et al., 2019), biodiversity (Rozendaal et al., 2019) as well as other essential ecosystem functions (Lohbeck et al., 2015). Land restoration has the potential to increase food and nutritional security, sequester carbon, recharge groundwater and reverse biodiversity loss (UNCCD, 2013; Nkonya et al., 2016). The United Nations General Assembly declared 2021–2030 the decade of ecosystem restoration (UN, 2019).

In Kenya, all the 47 counties are exposed to land degradation of varying magnitudes (GoK, 2016). The country is an agricultural nation, with over 12 million people residing in areas with degraded lands. Unfortunately, the food crop productivity growth in the country has failed to exceed the population growth (Mulinge et al., 2016). According to the 2016 "Land Degradation Assessment in Kenya" report by the Ministry of Environment and Natural Resources (MENR), approximately 61% of Kenya's total land area is affected by moderate degradation, while acute degradation impacts about 27%. There have been rapid land use and massive land cover change in Kenya since early 2000s such as deforestation, especially in the Rift valley; mainly encroachment of water towers like Mau forest/escarpment (Baker and Miller 2013; Kiage et al. 2007) and human movement and settlement in arid ASAL areas (low lands) as population pressure mounts in the high potential highlands (Kameri-Mbote 2007).

The arid and semi-arid Counties including Baringo and parts of Elgeyo Marakwet among others are more prone to land degradation due to highly erodible soils and deforestation, combined with high intensity storms that create conditions for excessive run-off and soil erosion (Plate 1).

Plate 1: Degraded Lands in Baringo

Source: WVK, 2022

In the Central Rift, Elgeyo-Marakwet County has experienced significant environmental degradation mainly on the escarpment and the Kerio Valley evident from the unpredictable rainfall patterns, massive soil erosion, landslides and prolonged drought (GoK, 2017). Baringo County is among the most marginalized counties in Kenya with a poverty rate of 52.2% against 45.2% nationally (Baringo CIDP 2018-2022). It has lost most of its forest cover due to unsustainable land management practices including hilltops denuded of trees and vegetation cover (Plate 2), overgrazing, steep hillsides cultivated across contour lines and weak bunds.

Plate 2: Hilltops Denuded of Vegetation

Source: WVK, 2022

In Nakuru County, environmental degradation is mainly a result of inappropriate farming methods, poor solid and liquid waste disposal, soil erosion and extensive tree felling for charcoal production (Plate 3).

Plate 3: Charcoal Production

Source: WVK, 2022

There is evidence that natural regeneration on agricultural and pastoral land has great potential to restore biomass (Poorter et al., 2016), soil organic carbon (Bayala et al., 2019), biodiversity (Rozendaal et al., 2019) as well as other essential ecosystem functions (Lohbeck et al., 2015). However, most knowledge about natural regeneration comes from successional studies where agricultural lands are abandoned, or regeneration is happening in natural forests or expanding forest buffer zones (Chazdon and Guariguata, 2016; Chazdon et al., 2020). Regeneration on agricultural land that is still being farmed requires farmers to actively manage the regeneration process, which is increasingly being done using a practice known as Farmer Managed Natural Regeneration (hereafter, "FMNR").

FMNR is defined as an agroforestry practice that involves the deliberate protection and management of naturally regenerating woody vegetation by farmers on agricultural land. Agricultural land may be used for growing crops or livestock grazing or both, as often occurs in agro-pastoral landscapes where livestock roam across crop fields in the off-season (Chomba et al., 2020). Management principally includes selecting, protecting and pruning regenerating plants arising from re-sprouting rootstock or from seeds. It does not include exclosures, where agriculture is excluded from an area of land to allow regeneration (Mekuria et al., 2017). FMNR is a promising climate-smart agricultural practice that represents an affordable means of enhancing rural livelihoods as well and soil reduction in addition to conserving biodiversity (CGIAR, 2015). FMNR was used to engage communities in sustainable and profitable land and forestry management as the foundation for the CRIFSUP project. FMNR is both a community mobilisation approach for landscape restoration and a specific technique to regenerate trees. Living tree stumps and self-sown seeds are re-grown into usable trees by pruning and protecting them. The regeneration of trees restores and builds natural assets (Bayala et al., 2014, 2019; Mbow et al., 2014) and makes agricultural activities more productive (Bayala et al., 2012, 2015), increasing income (Binam et al., 2015), as well as food and water availability (Dawson et al., 2013). FMNR can be considered in any agricultural, livelihood or development project where tree regeneration will contribute to long-term well-being and where the physical conditions for FMNR exist.

FMNR is also an empowering form of social forestry or agroforestry, giving individuals and communities the responsibility to nurture trees and reap the rewards from the sustainable harvesting of wood and non-timber forest products (Binam et al., 2015). Even before environmental commitments and policies grow, it is clear that regenerating trees provide fodder, shade, and soil nutrients (Dawson et al., 2013). As a natural resource management intervention, FMNR is a rapid, low cost and easily replicated community-led approach to restoring and improving agricultural, forested and pasture lands (Rinaudo et. al, 2019). FMNR is largely being practiced in arid and semi-arid areas, also referred to as dry and sub-humid areas in sub-Saharan Africa. Rainfall is unevenly distributed and ranges between 100 and 950 mm per year (Haglund et al., 2011; Sendzimir et al., 2011; Gonzalez et al., 2012; Binam et al., 2015). FMNR has been used by World Vision Kenya (WVK); a child-focused development non-governmental organization as a sustainable land management practice for around three decades. In Kenya, FMNR was initially introduced to communities in 12 counties including; Migori, Homabay, Nakuru, Baringo, Elgeyo Marakwet, Laikipia, Samburu, Marsabit, Isiolo, Garissa, Kajiado and Narok through the Global Evergreening Alliance and Ark Foundation.

FMNR has been widely cited as a key practice within evergreen agriculture, which is a form of agroforestry (Garrity et al., 2010). Some of the evergreen agriculture practices included, organic farming, crop rotation among others. Other practices, models and approaches used to restore degraded land by the WVK through the CRIFSUP project included; Citizen Voice and Action (CVA) which is a local level advocacy methodology that transforms the dialogue between communities and government in order to improve services, which impact the daily lives of children and their families (WVI, 2014). Child participation and school engagement was another approach that enhance the uptake and FMNR practice in the region. FMNR was rolled out in schools and young children were taking up the challenge of conserving the environment and increasing tree cover. The Training of Trainers (ToT) Model was intended to engage master trainers in coaching new trainers that are less experienced with a restoration. In Kenya, Work Vision (WV) through the Kenya Central Rift Farmer-Managed Natural Regeneration Scale-up project (CRIFSUP) which started in 2017 sought to restore ecosystems and farmlands for smallholder farmers and pastoralists, in Central Rift by 2021 through FMNR and other evergreen agricultural practices. WVK through CRIFSUP project gave concrete evidence of the benefits of FMNR technology as a land restoration technique in Kenya's ASAL. However, there has been suggestion that projects promoting FMNR are often characterized by intense long-term external intervention funded by donors, involving training farmers and incentive structures such as cash for- food programs or improved marketing of tree products (Rinaudo, 2007; Larwanou and Saadou, 2011). This makes the sustainability of the practices questionable beyond project period. The goal of this paper is to assess and compare changes in vegetation cover and species composition through FMNR and other evergreen agricultural practices in CRIFSUP and outside project areas in the Central Rift Kenya.

Analytical Framework

The analytical framework was developed to compare 1. Tree densities and 2. The species composition in areas where CRIFSUP project operated and where it did not operate in the region (Figure 1). It compared how adoption of various land restoration practices by farmers in WVK project areas and control areas contributed to significantly different vegetation cover in the Central Rift region Kenya.

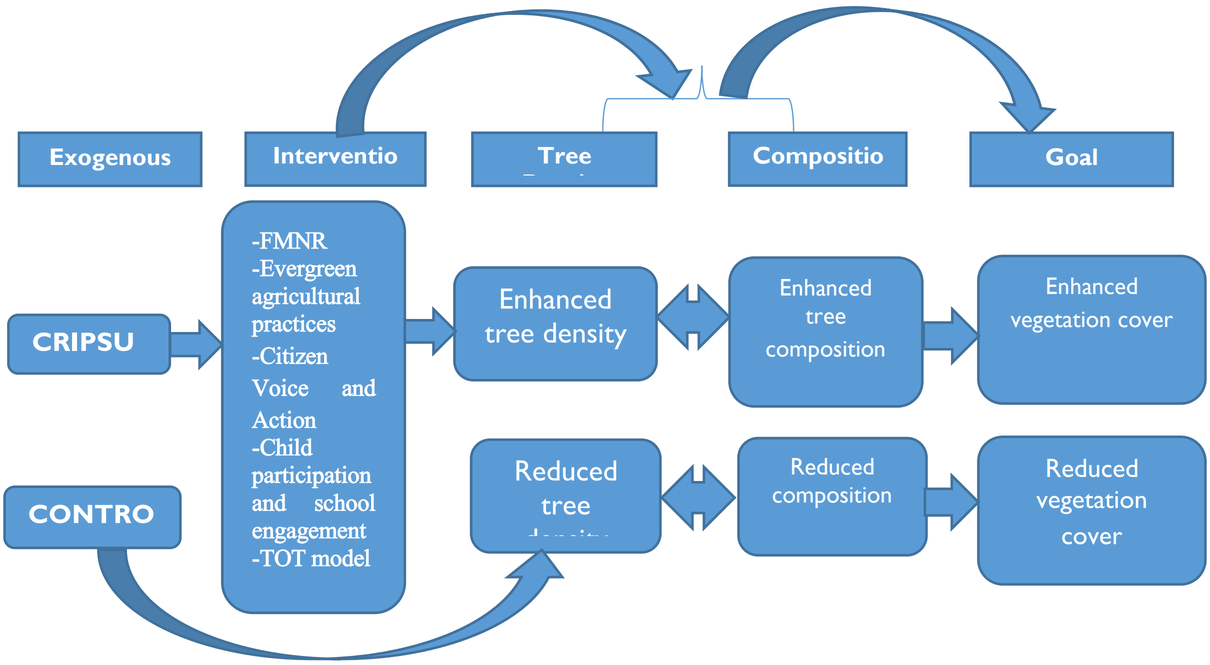

Figure 1: Analytical Framework

Study Sites

The study was undertaken in three counties, including Elgeyo-Marakwet, Nakuru and Baringo. Fieldwork was conducted within Ndabibi sub-County in Nakuru County, Marigat sub-County in Baringo County, and sub-County Ng'oswet in Elgeyo Marakwet (Figure 2).

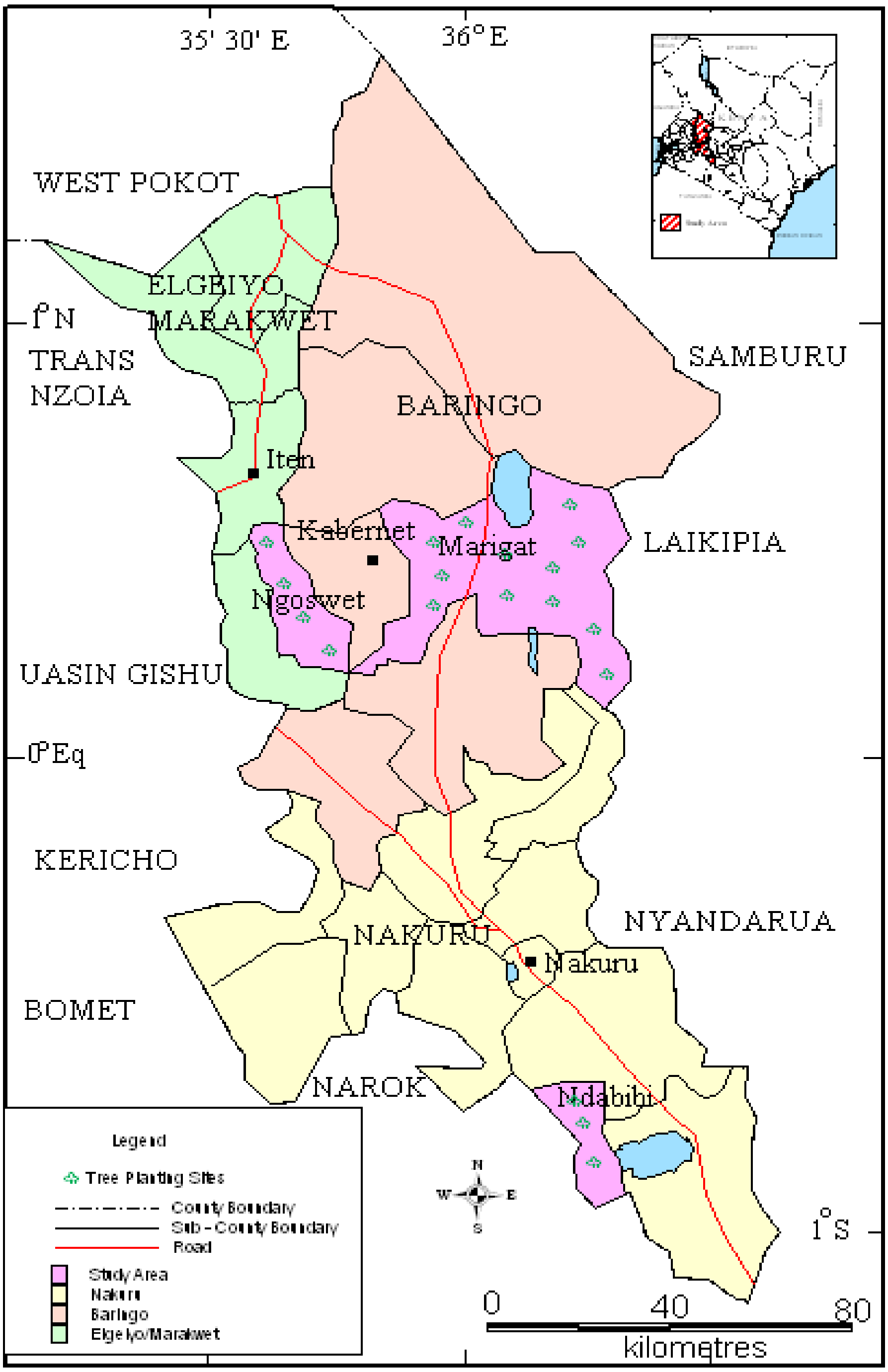

Figure 2: CRIFSUP Phase 1 Project Area

Source: WVK, 2017

POSITION AND LOCATION OF STUDY AREA

Elgeyo Marakwet County covers a total area of 3029.6 km2 which constitutes 0.4 percent of Kenya's total area. It extends from latitude 0o 20″to 1o 30′ to the North and longitude 35o 0′ to 35o 45′ to the East. It borders West Pokot County to the North, Baringo County to the East, Trans Nzoia County to the Northwest and Uasin Gishu County to the West. The county is divided into four sub-counties, namely: Keiyo North, Keiyo South, Marakwet West and

Marakwet East. These are further subdivided into 20 wards with 74 Locations and 212 Sub-locations. The project was located in Ngoswet.

Baringo County is situated in the Rift Valley Region and shares borders with 8 counties namely, West Pokot to the North West, Turkana to the North, Samburu to the North East, Laikipia to the East, Nakuru to the South, Kericho and Uasin-Gishu Counties to the South West, and Elgeyo-Marakwet to the West (Figure 4). The County is divided into 6 Sub-Counties, namely Baringo South, Mogotio, Eldama Ravine, Baringo Central, Baringo North and Tiaty. The project was located at Marigat.

Located in the south eastern part of the Rift Valley Province, Nakuru County borders 7 counties with Baringo to the north, Laikipia to the north east, Nyandarua to the east, Kajiado to the south, Narok to the south west with Bomet and Kericho to the west (Figure 5). Administratively, Nakuru County is subdivided into eleven sub-counties and fifty 55 wards. The project was located in Ndabibi area.

CLIMATIC CONDITIONS

Elgeyo Marakwet County has a relatively cool climate with varied rainfall levels across the County. This is because of the geomorphology/topography that is characterized by three distinct agro-ecological zones namely; the highlands to the west, the escarpment and the lowlands (valley) to the east. The variation in altitude from 100 m above sea level in the Kerio Valley to about 3000 m above sea level in the highlands gives rise to considerable differences in climatic conditions.

Annual mean temperatures on the highland range from 18oc – 22oc while down in the valley, it ranges from 25oc – 28oc.

In Baringo County the rainfall varies from 1,000mm to 1,500mm in the highlands to 600mm per annum in the lowlands. Due to their varied altitudes, the sub-counties receive different levels of rainfall. Koibatek sub-county receives the highest amount of rainfall. The lowland sub-counties of Mogotio, East Pokot and Baringo North receive relatively low amounts. The temperatures range from a minimum of 10°C to a maximum of 35°C in different parts of the county. Average wind speed is 2m/s and the humidity is low. The climate of Baringo varies from humid highlands to arid lowlands while some regions are between these extremes.

It is very much possible for farmers in Nakuru County to have two seasons per years as the county has a bimodal rainfall pattern with a high of 1800mm and a low of 500mm. Nakuru County usually has long rains between March, April, May and June, while short rains occur between October and November.

Research Design

This study employed a cross-sectional study design where there was evaluation of changes in tree density and tree species composition before and after the Intervention of CRIFSUP project in Central Rift, Kenya. Both qualitative and quantitative data were used to investigate and analyse the critical study findings. The data collection methods included surveys, focus group discussions, key informant interviews, and observations. Primary and secondary data were collected from the three area development programmes of Ndabibi in Nakuru County, Marigat in Baringo County, and Ng'oswet in Elgeyo Marakwet. This included both intervention and control communities. There was employment of participatory and consultative process. The WVK evaluation team was involved in all stages of the study and other implementing partners and community representatives we consulted through key informant interviews. The final fieldwork was done in May 2021. The analytical framework of this study was established in order to use findings in a quantitative manner as compared to in a qualitative way to expand the context-related to oriented findings.

Data Collection

Data was collected by trained enumerators using customed forms in KOBO Toolbox. Participatory approaches were used to collecting first-hand information from all stakeholders and farmers who had adopted FMNR and other land restoration efforts. The approaches included household questionnaires in-depth interviews, key informant interviews, focus group discussions for adults (mixed groups and gender only groups) and children, and observations through qualitative and quantitative questionnaires.

In addition, field visits and meetings were held with partners from a various stakeholder groups. To the extent possible, a balanced and representative sample of beneficiaries from the project area was engaged in the study process to validate the data obtained and determine any trends related to geographical distribution. The processes leading to engagement with the respondents/groups ensured that government restrictions, protocols, and measures to curb the spread of COVID-19 are adhered to.

Sampling Method

Multi-stage sampling was applied in this study. Three sub-counties were selected purposively since the World Vision projects operated in these areas. Cluster sampling was used to identify villages they have naturally occurring borders. A total of 42 villages were selected using stratified random sampling were there was an effort to ensure that all inaccessible and insecure villages are excluded from the sampling frame within the project's area.

Purposive sampling was employed to select the household survey participants within the selected villages with help of lead farmers and village leaders. The WVK team provided a list of all the project beneficiaries and lead farmers in the sampled clusters.

Sample Size

In total, 402 households out of a sample size 426 participated in the household survey in the project area, along with a further 102 households in a control area where FMNR lead farmers had not been active. A focus group with 10 children took place in three schools using age-appropriate participatory discussion. For the control, the study covered 102 households in three sites: 34 in each of Nakuru, Baringo and Elgeyo Marakwet counties. 3 randomly selected clusters from each control site located in the three project counties were reached. The sample size is comparable to the baseline sample of 1,200 households within the project area and 300 households in the control sites.

A sample size of 384 households was estimated to be included in the survey during the evaluation. The sample size has been determined by employing the Cochran's sample size determination formula:

$$n = \frac{Z_{\alpha/2}^2 p(1-p)}{d^2} D$$

Where:

n =the sample size;

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Z= 1.96 = the corresponding standard score with a confidence level of 95 percent;

p= is the occurrence level of the phenomenon under study (i.e., the proportion of and is equal to 0.05 where the occurrence level is not known);

D = is the design effect and the power calculations for the population size of the counties and is estimated at 1;

d = required level of precision taken to be 5 percent.

As a general rule, sample sizes equal to or greater than 30 are deemed sufficient for the Central Limit theorem (CLT) to hold, meaning that the distribution of the sample means is fairly normally distributed.

Social-Demographics of the Respondents

Majority of respondents were female 52.5% (p = 0.05) replicating farmers 73.6% (p = 0.05) above 46 years of age with basic education 83.0% (334) although the households are headed by men 82.8% (p = 0.05) as indicated in Table 1.

Table 1: Social-demographics of the Respondents

VARIABLE (p = 0.05)		**BARINGO**	**ELGEYO MARAKWET**	**NAKURU**	**TOTAL**
Lead farmer		16.1% (22)	21.8% (29)	41.7% (55)	26.4% (106)
Replicating farmer		83.9% (115)	78.2% (104)	58.3% (77)	73.6% (296)
Household Size		5.49	3.70	5.13	5.2
Gender	Female	51.1% (70)	58.6% (78)	47.7% (63)	52.5% (211)
	Male	48.9% (67)	41.4% (55)	52.3% (69)	47.5% (191)
Average age (Years)		42.32	41.92	55.77	46.60
Main occupation	Farmer/Informal employment	33.7% (130)	33.0% (127)	33.0% (127)	99.7% (384)
	Formal Employment	0.0% (0)	.3% (1)	0.0% (0)	.3% (1)
Gender of household head	Female	14.6% (20)	16.5% (22)	20.5% (27)	17.2% (69)
	Male	85.4% (117)	83.5% (111)	79.5% (105)	82.8% (333)
Household Head Education level	None, or pre-school	2.7% (11)	1.5% (8)	3.2% (13)	8.0% (32)
	Basic Education (Primary and secondary)	28.1% (113)	26.1% (105)	28.8% (116)	83.0% (334)
	Tertiary (College/ University)	3.2% (13)	5.0% (20)	0.7% (3)	8.9% (36)
No. of HH with adults living with a disability		0%	4.60%	5.30%	3.10%
No. of HH with one child living with a disability		1.5%	0.8%	3%	1.7%

Majority of respondents were replicating farmers at 73.6% (p = 0.05) with 26.4% (p = 0.05) as lead farmers. The main economic activity of residents in the CRIFSUP region were farming and informal employment at 99.7% (p = 0.05). The main household heads were men. Education levels in the region is low with most household heads having basic education at 83% as compared to college graduates at 8.9%. Most respondents were female at 52.5% (p = 0.05), farmers (93.5%) (p = 0.05) and their average age was 46.6 years in the study area. Majority of the households (63.4%) (p = 0.05) had school going children between age of 6 years to 12 years. The study area has 3.1% (p = 0.05) of adults living with disabilities.

Extend of Land Restored through FMNR and Ever Green Practices

The restoration methods applied to restore land in CRIFSUP regions included FMNR and other evergreen agricultural practices such as climate smart agriculture, holistic pasture management and re-greening activities. The total acreage of land under FMNR managed in the project area increased from 500 acres at inception in 2017 to 4,588 acres in 2019 then to 6,938 acres in project year 2021. This was attributed to farmers recognising benefits of FMNR such as increased pastures, firewood, honey, milk productions and training to replicating farmers and lead farmers (Figure 6).

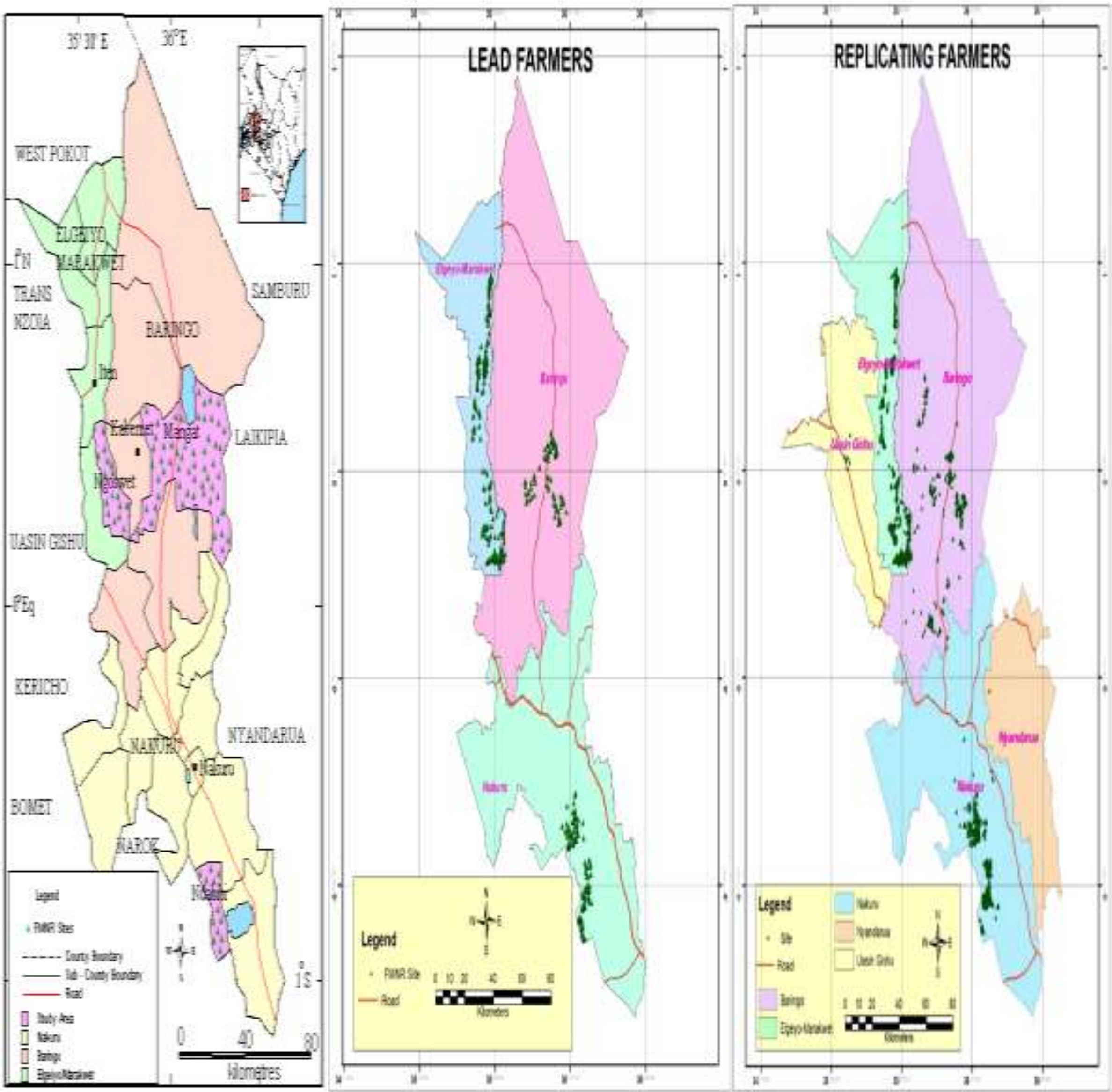

Figure 6: Lead and Replicating Farmers in CRIFSUP Region

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The average household land under FMNR during the baseline period in CRIFSUP region was as indicated in Table 2.

Table 2: Land acreage per household under FMNR

(CI 95%)	NG'OSWET	MARIGAT	NDABIBI	TOTAL
Maximum (Acres)	3.00	20.00	10.00	20.00
Mean (Acres)	0.67	1.47	1.44	1.19

Source: WVK Baseline Report, 2018

To the positive at end term period, the average acreage per household under FMNR in the project area had increased tenfold as indicated in Figure 6.

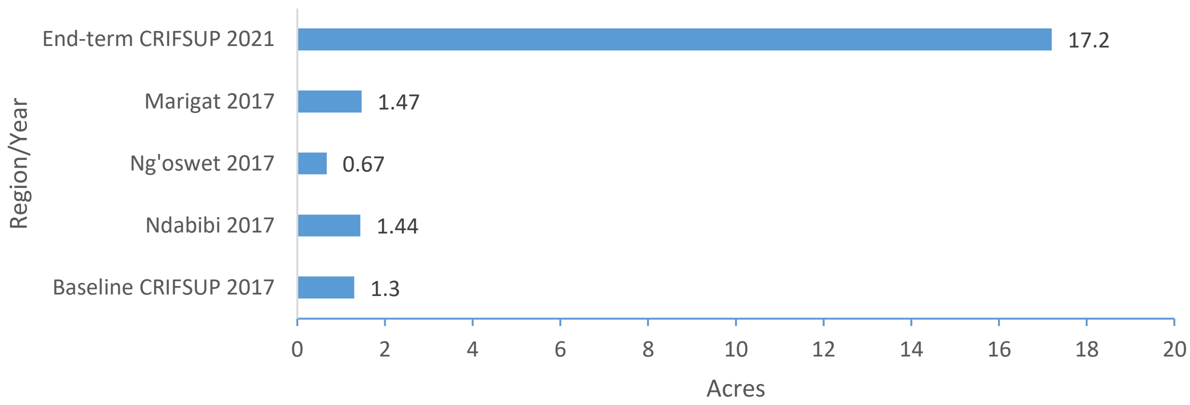

Figure 6: Mean Land Size per Household under FMNR

The low adoption levels at end of project term was attributed to little knowledge on FMNR in those regions. It was reported that overall, 92.2% (p= 0.05) of respondents in the control area had never heard of FMNR leading to only 4.9% (p= 0.05) of the respondents practice FMNR in the control region. That was a marginal proportion compared to the project area which reported 84.6% (p= 0.05) of the respondents practicing FMNR.

Over 33,000 children and adults are currently benefitting from land restoration efforts directly or indirectly. Tree coverage per hectare increased, attributed to the positive impacts of the project as the project supported the communities with FMNR practices.

CHANGES IN TREE DENSITY

In 2017, households in the three ADPs allowed trees to grow on their farms and mainly around the homesteads at 51.7% or along field boundaries at 32.5% and crop and grazing fields at 29.7% and 12.9% respectively. The highest Number of trees per household were recorded in Ng'oswet during baseline at 54.6 trees/hectare and Marigat registered the least tree density at 72.6 trees per hectare. The average tree density in 2017 in CRIFSUP area was 79.5 trees per hectare as indicated in Table 3.

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Table 3: Tree Density (Per Hectare) as Recorded in 2017

Region	Area of Operation	Control population
Ng'oswet	84.6 ± 1.53a	84.0 ± 4.70a
Marigat	72.6 ± 1.53a	46.4 ± 4.70a
Ndabibi	80.8 ± 1.53a	64.5 ± 4.70a
Overall	79.3	64.9

± Standard error of the mean
a – No statistical difference in the means

There were positive changes in tree densities after CRIFSUP project phase that ended in 2021. The average number of trees per hectare in areas practising FMNR was 115.9 trees; significantly higher compared to areas where there was no FMNR practice such as community land allocated to individual households where average number of trees per hectare was 69.89 trees. There was increased average tree density in communal land, farmland and farm border land in the three project areas as indicated in Figure 7.

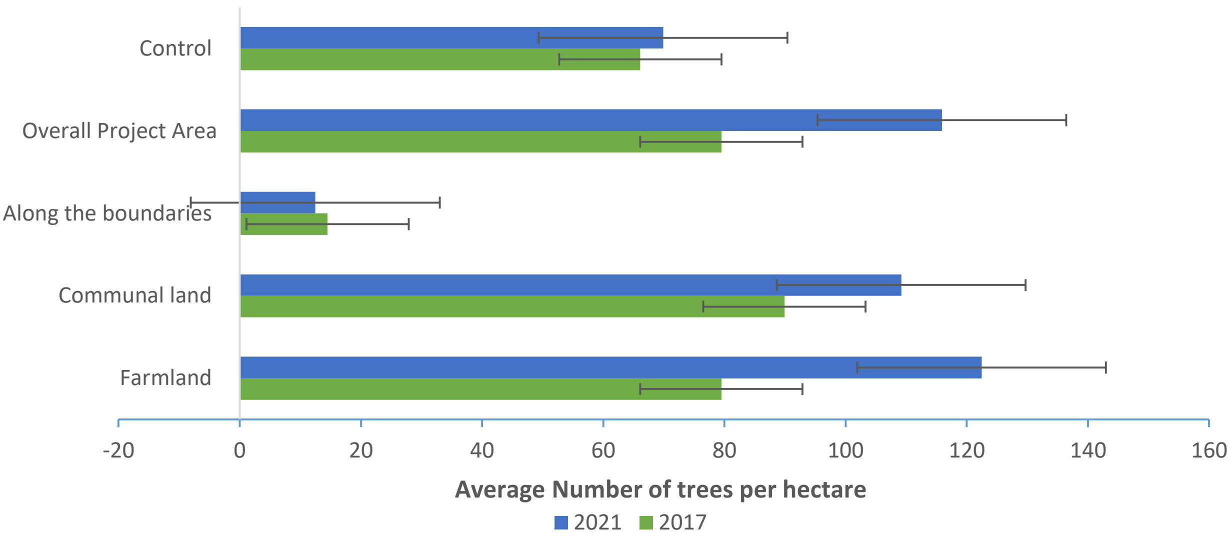

Figure 7: Average Tree Densities

On the other hand, farm boundaries recorded the lowest number of tree populations at 14.5 trees/ha and 12.47 trees/ha before and after project intervention, respectively (Figure 7). There was however, no significant difference in tree densities in along the boundaries and among the control farmers before and after project intervention ($p = 0.08$). To the contrary, the tree densities for farmlands, communal land and overall in the area of project operation were significantly higher after intervention of CRIFSUP project ($p = 0.02$). This was attributed to increased knowledge on FMNR practices as where 45.0 % ($n = 181$) farmers indicated knowledge on natural regeneration of trees as shown in Figure 8, while 27.9% ($n = 112$) displayed knowledge on protection of naturally regenerated trees and seedlings. Other practices included pruning trees and marking trees.

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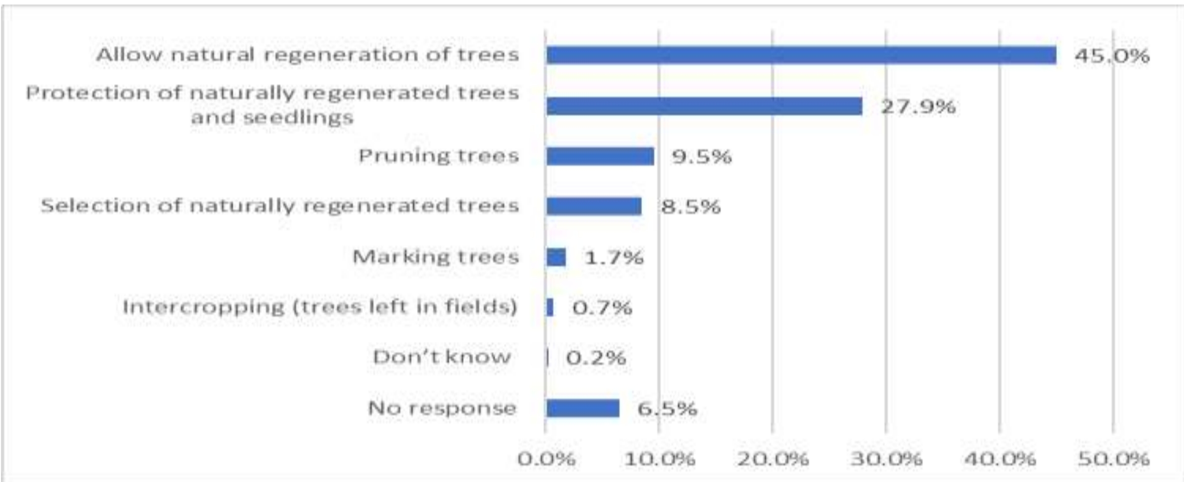

Figure 8: Indicators Demonstrating Knowledge of Farmer-Managed Natural Regeneration

There was a positive correlation between the training of the farmers ($r = .65, p < 0.001$), the education levels of the family heads in households ($r = .75, p = 0.001$) and their involvement in a farmers group ($r = .64, p < 0.001$) and knowledge on FMNR practices ($r = .44, p < 0.001$). Women were particularly disadvantaged in this regard, due to lower levels of education in this demographic. Female headed households who had only basic education or no education at all, were less likely to be members of a farmers group that was key in enhancing FMNR knowledge.

COMPOSITION OF REGENERATED VEGETATION

It is assumed that a substantial proportion of the trees regenerated were through natural regeneration as many farmers had knowledge on natural regeneration and management. However, re-greening activities were recorded in the region as 74.1% of farmers had rain-fed farms who indicated that they used the rain seasons to plant trees considered of high value. Such trees included citrus trees, pawpaw trees and mango trees. This finding agrees with Ndegwa et al., 2017 who alluded that the majority of species reported after land regeneration are exotic to the African continent. The fact that exotics also regenerate through FMNR contradicts assertions that farmers use FMNR to regenerate indigenous tree species only, while exotics are established through tree planting. The finding also agrees with Kindt et al. (2008) who also found that of the small proportion of exotics found across farming landscapes 90% were also able to regenerate naturally.

Most trees allowed to regenerate naturally were the acacia spp. mainly for charcoal production. Other uses of trees in included (1) Fruits, (2) Honey, (3) Firewood, (4) Poles, (5) Sawn timber, (6) Seedlings, (7) Seeds, (8) Medicinal products, (9) Leaves, (10) Barks, (11) Fodder, and (12) Handicraft. However, that was not the order of importance attached by the different communities. For example, in Ngo'oswet the order of importance of trees were as follows; firewood (70.1%), sawn timber (47.8%) and fruits (43.3%). In Marigat, tree importance was as follows firewood (70.1%), charcoal (47.8%) and honey (15.1%). In Ndabibi, the order of tree importance was as follows; firewood (81.7%), fruits (21.0%) and charcoal (17.0%). Some of the indigenous trees that were identified from the natural regeneration in Ng'oswet included, Balanites aegyptiaca, Terminalia brownie as indicated in Table 4.

Table 4: Most Valuable Indigenous Tree Species – Ng'oswet

Tree name in local language	Botanical name	Purpose/notes	Method of use	Groups using resource	Status of population
Ng'oswet	*Balanites aegyptiaca*	Medicinal, fodder, vegetables, wild fruits, timber, firewood	Roots, leaves and seeds	Both men and women	Declining
Kalaswet	*Terminalia brownii*	Medicinal, fodder, poles, timber and firewood and source honey	Bark, leaves stem, branches flowers	Both men and women	Declining
Kokchat	*Zanthoxylum chalybeum*	Medicinal, poles and timber, fodder for goats	Roots and buck and stem	Both men and women	Declining
Lokoiwet	*Ficus sycomorus*	Fodder, wild fruits, water catchment	Leaves and fruits	Both men and women	Declining
Arwet	*Tamarindus indica*	Wild fruits and medicinal	Leaves and fruits	Both men and women	Declining
Sesiat	*Acacia tortilis*	Fodder, medicinal and fire wood,	Seeds and roots	Both men and women	Declining
Manakurwet		Wild fruit, poles timber and firewood	Stem, seeds, branches	Both men and women	Declining
Uswet	*Uclea divinorum*	Fodder for goats, colouring woven baskets	Seeds, bark,	Both men and women	Declining
Sitiot	*Grewia bicolar*	Poles, food	Stem and leaves		
Tilolwet	*Ziziphus mauritania*	Food	Leaves and fruits	Humans and animals	Declining
Cedar (Tarakwet)	*Juniperus procera*	Poles, timber	Stem	Men	Decreasing
Otonwet	*Croton megalocarpus*	Medicinal purposes, charcoal	Roots, stem and branches	Both men and women	No significant change
Mogonja	*Grewia villosa*	Fencing, construction of houses	Stem	Men	Declining in population (almost extinct)
Kaponwet		Making beehives	Stem	men	
Koloswet	*Terminalia brownii*	Medicinal purposes (both livestock and humans), making beehives, for timber	All parts	Both men and women	Unchanged

Source: WVK, 2018

Some of the introduced exotic tree species included Jacaranda mimosifolia, Citrus sinensis as shown in Table 5.

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Table 5: Most Valuable Introduced Tree Species – Ng'oswet

Tree name in local language	Botanical name	Purpose/notes	Method of use	Groups using resource	Status of population
Jacaranda	*Jacaranda mimosifolia*	Timber, fodder, firewood	Leaves, stem, branches	Both men and women	Declining
Citrus	*Citrus sinensis*	food	Fruit	Both men and women	Increasing
Mangoes	*Mangifera indica*	Food and firewood	Fruits and branches	Both men and women	Increasing
Gravellea	*Grevellea robusta*	Fodder, firewood, shade, soil conservation and timber	Leaves, branches and stem.	Both men and women	Increasing
Lucinia	*Leucaena leucocephala*	Fodder and timber	Leaves and stem	Both men and women	Increasing
Pine	*Pinus sabiniana*	Firewood, timber	Stem,	Men and women	Unchanged

Source: WVK, 2018

Tree planting is not common in Marigat due to inadequate rains. In addition, private land is often not enclosed to allow for tree protection, and partly because community members are not adequately sensitized on tree planting. Some of common indigenous and exotic tree species in Marigat are indicated in Table 6 and Table 7.

Table 6: Most Valuable Indigenous Tree Species – Marigat

Tree name in local language	Botanical name	Purpose/notes	Method of use	Groups using resource	Status of population
Ltepes (acacia)	*Acacia tortilis*	*Fodder for livestock, firewood, fencing, charcoal production*	*Branches, fruits*	*Men, young mean, livestock*	*Declining*
Sokotei	*Salvadora pasica*	*Medicinal, shade*	*Branches, roots, leaves*	*Men, all groups*	*Declining*
Salabani	*Cordia sinensis*	*Poles*	*Branches, leaves*	*Men, and all groups*	*Declining*
lkioriti	*Acacia nilotica*	*Medicinal, poles, flower is fodder*	*Tree bark, flowers, stems*	*Men, all groups*	*Declining*
Sessie	*Acacia tortilis*	Charcoal, firewood, fencing, livestock fodder, wood, making bee hives, shade	Branches Stem	All groups	Abundant
Ngoswe	*Balanites aegyptiaca*	Fodder, fencing, timber, poles, shade	Leaves Branches Stem	All groups	Few but Protected
Ngorore	*Acacia mellifera*	Honey, medicine, fencing, posts	Flowers Bark Stems Branches	All	Abundant
Lokoiwe	*Ficus sycomorus*	Fodder, bee hives, hanging bee hives, fruits	Leaves Stem Branches fruits	All	Found on river banks
Sokoteiwe		Tooth brush, medicine	Branches Roots	Adults	Available on river Banks
Ndumeiyon		Firewood, medicine	Roots Branches	Adults	Few
Lowei		To control high fever and joint pains (medicinal), fodder for livestock, produces sweet fruits eaten by children	Leaves Branches are cut and given to livestock Fruits	Women, all groups	Decreasing- due to the increasing manifestation of *prosopis juliflora*
Sesia	*Acacia tortilis*	Poles, fencing homesteads, charcoal production, shade, fodder for livestock	Leaves Bark Branches Fruits	Elderly men, Women and young men	Declining

Source: WVK, 2018

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Table 7: Most Valuable Introduced Tree Species – Marigat

Tree name in local language	Botanical name	Purpose/notes	Method of use	Groups using resource	Status of population
Mathenge (Figure…)	*Prosopis juliflora*	*Charcoal burning, fencing, firewood, poles, Fodder for livestock*	*Stems, branches, leaves*	*All groups*	*Increasing*
Mwarubaine	*Azadirachta indica*	*Medicinal, shade*	*Tree barks, stems*	*Men, all groups*	*Increasing*
ltutupayo		*Shade*	*Leaves, branches*	*All groups*	*Increasing*
Maembe (Mango tree)	*Mangifera indica*	Fruits, shade	Fruits, leaves	All groups	Increasing
Machungwa (Citrus)	*Citrus sinensis*	Fruits, shade	Fruits, leaves	Men Women Children	Increasing
Papai (Paw paw)	*Carica papaya*	Fruits	Fruits	Men Women children	Increasing

Source: WVK, 2018

The most common tree in Marigat is the Mathenge plant (Prosopis juliflora) (Plate 5); an exotic invasive species that the community utilises for burning, fencing, firewood, poles and Fodder for livestock.

Plate 5: Mathenge Plant

Source: WVK, 2018

In Ndabibi, community members grow trees and almost all the trees planted are introduced ones such as Eucalyptus globulus, Grevellea robusta (Table 9) although there are a few indigenous trees such as Dombeya torrida, Olea europaea as indicate in Table 8. The planting is not on a large scale and the explanation from the FGDs was that this was due to limited rainfall, lack of titles for their land parcels and lack of adequate awareness. Trees are planted on boundaries, along the fences and wood lots.

Table 8: Most Valuable Indigenous Tree Species –Ndabibi

Tree name in local language	Botanical name	Purpose/notes	Method of use	Groups using resource	Status of population
Mukeu	*Dombeya torrida*	Charcoal, Firewood, Fencing, Making Bee Hives, Shade	whole tree	All groups	Very few
Mutamaiyu	*Olea europaea*	Fencing, Timber, Shade	whole tree	All groups	Few
Mukinduri	*Croton megalocarpus*	Firewood, Fencing, Posts, Charcoal, Medicine	Whole tree	All	Abundant
Leleshwa	*Tarchonanthus camphoratus*	Fodder, Bee hives making, Hanging bee hives, Fruits	whole tree	All	Abundant
Mugaa (Acacia)	*Acacia abyssinica*	Medicinal, Firewood, Charcoal	Whole tree	All	Few
Muthuri	*Acacia xanthophloea*	Firewood and charcoal	Branches	Youth, women	Declining
Mubiribiri	*Osyris lanceolata*	Charcoal, Firewood, Fencing, Shade, Medicinal, Making traditional toothbrush	whole tree	All groups	Very few
Murereshwa	*Warbugia ugandansis*	Firewood, Charcoal, Fencing	Stem and branches	Women and men	Declining

Source: WVK, 2018

Table 9: Most Valuable Introduced Tree Species – Ndabibi

Tree name in local language	Botanical name	Purpose/notes	Method of use	Groups using resource	Status of population
Mubau (Blue gum)	*Eucalyptus globulus*	Timber, Shade, Charcoal, Fence, Firewood	Whole tree	All	Increasing
Mukima (Grevellea)	*Grevellea robusta*	Timber, Manure, Shade, Charcoal, Fence, Fodder, Firewood	Whole tree	All	Increasing
Bottle brush	*Callistemon citrinus.*	Fodder, Medicine, Toothbrush	Whole tree	All	Increasing
Cypress	*Cupressus sempervirens*	Timber Shade Charcoal Fence Fodder firewood	Whole tree	All	Few
Pine	*Pinus sabiniana*	Timber, Shade, Charcoal, Fence, Fodder , Firewood	Whole tree	All	Few

Source: WVK, 2018

Benefits of Land Restoration

Our study demonstrates that farming practices in the three counties studied have changed following the introduction of Farmer Manages Natural Regeneration. The majority of respondents (74.1%) reported that their farms are rain-fed agriculture only compared to 45.2% reported during the baseline. 11.7% reported that their farms were rain-fed agriculture and some irrigation. 5.5% reported having agro-pastoralist farms compared to 18.5% during the baseline, while only 0.7% compared to 3.3% reported during the baseline having livestock-only farms. This shows the impact of planting more trees, thus more reliable rains over the years. The respondents were asked whether they or their other household members have ever been trained on FMNR. Majority, 77.6% (321) comprising of 78.7% (166) female and 76.4% (146) male respondents reported that they had been trained in FMNR compared to 4.2% (50) reported during baseline. Just 2.9% of the respondents in the control areas reported that they were trained, a proportion which was equal to what was reported during the baseline; 92.2% (94) of the respondents in the control area did not know what FMNR is, while 4.9% (5) reported that they had not been trained on FMNR in the control area. 84.6% (340), reported that they practice FMNR compared to 16.4% in the baseline. This result shows a community movement beyond direct training.

There was a strong uptake of the approach as it is easily replicable at a low cost. FMNR is said to have a positive effect on livelihoods, food security, resilience and risk reduction leading to lifting yields and income. The farmers reported that they had experienced positive results on income earned at the household level. It had impact on tree cover and diversity and availability of tree products which provide income through sale, and impact on-farm yields through soil improvement and protection.

In terms of environmental impact, results are consistently positive. The evaluation team heard many examples of increased pasture/fodder for livestock (Plate 6), contributing to the reported increase in milk production, better availability of tree products, better household nutrition and incomes, as well as improved micro-climate, improved aesthetic value, and climate restoration from increased tree cover and biodiversity richness related to new species of trees regenerated.

Plate 6: Increased Pasture

Source: WVK, 2020

In conclusion, FMNR and other evergreen methods were found to enhance vegetation cover and through enhanced tree densities in the three regions. There was enhanced vegetation composition although mainly from re-greening activities. Farmers appreciated the importance of land restoration and conservation by taking up the techniques. The effect of conservation was felt beyond areas of operation witnessed by the increased tree densities in control areas. Still, natural resource management can be effectively integrated with poverty reduction.

Recommendations

Community FMNR learning centre(s) should be established to reach out to a wider population for higher vegetation cover.

1. Embracing of technology is necessary since most farmers now own smartphones, the use of social media could increase the uptake of the FMNR technique among farmers.
2. Exchange programme with farmers are important so that new farmers can make visits and witness the success stories of other farmers and see first-hand the benefits of FMNR.

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