# ASSESSING MANAGEMENT OF BIODIVERSITY IN THE MAASAI MAU FOREST ECOSYSTEM

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# DECLARATION

This project is my original work and has not been presented for a degree in any other University.

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# DEDICATION

To my loving husband Mr Muthaka

To my precious children Blessymoen and Juanita

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First and foremost, I give thanks to the Lord Almighty for the far He has brought me.

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Local communities living in Tendwet and Nkoben villages in Narok County participated as respondents. Community Forest Association officials and all representatives from different organisations gave their useful views as key informants. Research assistants Runya, Sheldon, Lawrence, and Stephen were instrumental in collecting data. “Asanteni sana”.

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## ABSTRACT

Biodiversity conservation and management are key to sustainable forest ecosystems, which play an important role in the well-being of world economies and societies. This study examined how biodiversity-related programs and activities are integrated into the Maasai Mau Forest Ecosystem Conservation Plan 2021 - 2031 in Kenya. The study assessed the extent to which biodiversity is integrated at three levels; species diversity, ecosystem diversity and genetic variation and whether the integration was direct or indirect. The study also assessed the focus of organisations operating in the Maasai Mau forest in relation to projects related to biodiversity conservation and management. The review included an analysis of forest planning documents and in-depth interviews with key informants from various stakeholders involved in the conservation efforts within the Maasai Mau forest ecosystem. The study found that many organisations' programs focused on community livelihood empowerment and forest restoration activities including rehabilitation of indigenous trees, enrichment planting, protection of forest and wildlife and research and monitoring of biodiversity. However, the study found that the biodiversity conservation component was not adequately integrated into the planning processes for the Maasai Mau forest, hence a limited focus that ensures adequate representation of representative species and ecosystems in the conservation systems. The report recommends intensifying efforts to mainstream biodiversity goals across government decision-making processes and programmes including the Participatory Forest Management Plans and utilizing international processes for the sustainable use of forest and biodiversity conservation.

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## ABBREVIATIONS

| | |
|---|---|
| ASALs: | Arid and semi-arid lands |
| UNCBD: | United Nations Convention on Biological Diversity |
| CBO: | Community-based organisation |
| CFA: | Community forest associations |
| CIFOR: | Centre for International Forestry Research |
| CITES: | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| CSO: | Civil society organisation |
| ENSDA: | Ewaso Ngiro South Development Authority |
| FAO: | Food and Agriculture Organization of the United Nations |
| GDP: | Gross Domestic Product |
| GoK: | Government of Kenya |
| IPBES: | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services |
| IUCN | International Union for Conservation of Nature |
| IUFRO | International Union of Forest Research Organizations |
| KBA: | Key Biodiversity Areas |
| KEFRI: | Kenya Forestry Research Institute |
| KFS: | Kenya Forest Service |
| KIFCON: | Kenya Indigenous Forest Conservation Project |
| KNBS: | Kenya National Bureau of Statistics |
| KWS: | Kenya Wildlife Service |
| KWTA: | Kenya Water Towers Agency |
| MEA: | Millennium ecosystem assessment |
| MEAs: | Multilateral Environmental Agreements |
| MENR: | Ministry of Environment and Natural Resources |
| MMF: | Maasai Mau Forest |
| MoEF: | Ministry of Environment and Forestry |
| NBSAPs: | National Biodiversity Strategies and Action Plans |
| NEMA: | National Environment Management Authority |

| | |
|---|---|
| NFP: | National Forest Programme |
| NFRAM: | National Forest Resources Assessment and Monitoring |
| NGO: | Non-governmental organisation |
| NMK: | National Museums of Kenya |
| NRM: | Natural resource management |
| NTFPs/ NWFPs: | Non-timber forest products/ non-wood forest products |
| NWFPs: | non-wood forest products |
| PES: | Payment for Ecosystem Services |
| PFM/JFM: | Participatory Forest Management/ Joint Forest Management |
| PFMP: | Participatory Forest Management Plan |
| REDD+: | Reduced Emissions from Deforestation and Forest Degradation |
| SDGs: | Sustainable Development Goals |
| SFM: | Sustainable Forest Management |
| UNCED: | United Nations Conference on Environment and Development |
| UNDP: | United Nations Development Programme |
| UNEP: | United Nations Environment Programme |
| UNFCCC: | United Nations Framework Convention on Climate Change |
| UNFF: | United Nations Forum on Forests |
| WHO: | World Health Organisation |
| WRA: | Water Resource Authority |
| WRUAs: | Water Resource Users Association |

# CHAPTER ONE

# BACKGROUND TO THE STUDY

## 1.1 Introduction

Forests are considered part of the most productive terrestrial ecosystems in the world and are vital to life on earth. These ecosystems are estimated to occupy about a third of the earth's land area or about 4 billion hectares (FAO] & UNEP, 2020). Forests support high species diversity of more than 60% of all terrestrial taxonomic categories in the world, including trees, plants, invertebrates, birds, mammals and microbes (UNCBD Secretariat, 2014; Lindenmayer *et al*., 2006). Forest biodiversity is an important part of natural capital that provides numerous supporting and regulating ecosystem services such as pollination, soil formation and nutrient cycling, carbon sequestration, and maintaining water flow which is vital to human well-being (BGCI, 2021; UNCBD Secretariat, 2016; Kraus & Krumm, 2013).

Forest biodiversity conservation and management are important tasks that have been incorporated into both international and national forest management agreements. Forests are home to a third of all vulnerable and threatened species in the world (Lindenmayer, *et.al*, 2006). Forest management programmes are human efforts meant to promote sustainable resource management in the forest sector (Mcfadden, *et al.,* 2018). According to Boncina (2011), sustainable forest management is a management strategy that assures the continued diverse use of the forest for extractive and non-extractive commodities while preserving the ecosystem's biodiversity and productivity. This management system may include programmes like silvicultural techniques that could have conflicting effects on forest biodiversity. To support biodiversity conservation, management practices should be improved to encourage structural complexity, natural regeneration, landscape connectedness, and species richness (Lindenmayer, *et.al*, 2006).

Globally, different intensities of forest management operations have changed the structure and species composition of native and natural forests. For instance, in Europe, the survival of numerous species of flora and animals that rely on the native forests for habitat has continued to be threatened by timber-oriented forest management (Chaudhary, *et al.,* 2016). The natural landscapes resulting from the disturbance regime have been extensively altered by silvicultural techniques within Europe's forest ecosystems. The reduction of microhabitat availability and

species diversity caused by forest management activities has a significant negative impact on most forest taxa that are substrate-dependent, including saprophytic beetles, lichens, bryophytes, and fungi. The impacts of different management techniques have been shown to differ significantly between bryophytes and lichens. Techniques like selective felling caused lichen species richness to significantly decline, while selected felling close to nature technique had a considerable detrimental influence on bryophyte species richness (Avon *et al*., 2010).

Additionally, frequent disturbances from forest management techniques may benefit biodiversity. Understory vascular plants, including shade-intolerant, competitive, and ruderal species, can be supported in forest ecosystems by canopy openings, soil disturbances, and litter removal. It can also favour the growth of stress-tolerant and shade-tolerant species. This leads to increased species richness within the forest ecosystem (Schmidt, 2005). Chilean old-growth forests are symbolised by regular tree-fall gaps, which support the natural regeneration of various native species, such as the bamboo species as well as provide habitats for forests birds and mammals (Chape *et al.,* 2005). The Chilean native forest management programmes such as thinning and pruning techniques have been valuable management tools that create horizontal heterogeneity and create gaps. Thinning practices have resulted in creating additional niche space for biodiversity, creating habitat complexity for forest wildlife, and increasing light penetrations, which allow understory plant establishment and growth as well as improved plant species richness (Mcfadden *et al.,* 2018).

The study undertaken on forest management in Kenya by Chebii (2015) indicated that the purpose of forest management depends on the end use of the plant type either a plantation or a natural forest. In recent years, natural forest ecosystems are mainly managed through general protection from fire cases, and other human destructive activities. However, the management programmes have inadequately incorporated activities intended for biodiversity, and inventory of species diversity and regeneration data is rarely recorded. Most of the programmes are geared towards the promotion of forest tourism activities, which in most cases is very minimal with few places such as Karura forest and Kereita forest.

Forest management programs aim to promote sustainable resource management in the forest sector and can include silvicultural techniques, which can sometimes have conflicting effects on forest biodiversity. To support biodiversity conservation, management practices should focus on

creating structural complexity, species richness and landscape connectedness. In Kenya, forest management programs have not adequately incorporated activities to support biodiversity with the focus being on general protection and extractive value.

### 1.1 Statement of the problem

About 424 million hectares (or only 10%) of the world's forests have been designated for forest biodiversity conservation and management (FAO and UNEP, 2020). Most of the management objectives focus on production and extractive value from forests (Kraus & Krumm, 2013). This calls for a clear and realistic balance between planning and management objectives and demands for forest products that support livelihoods for sustainable development. Mainstreaming biodiversity planning and management into forest management plans at all levels can contribute to the achievement of the goal of sustainable forests with positive outcomes for biodiversity and human well-being as well as reduce the negative effects of forest operations (FAO, 2018).

The need to implement forest management programs and activities that support desired outcomes for biodiversity and sustainable development has been growing on a global scale. There is, however, little evidence available that demonstrates the success of such programs (on biodiversity and ecological services) that have been on a phenomenal increase globally. There is limited information on the impacts of these programmes on biodiversity and ecosystem functions and some of the significant obstacles to the creation, adoption, and execution of these management programmes and activities are outlined in the 2019 FAO report on the state of biodiversity around the world (FAO, 2019). In particular, the report recognizes a lack of data specific to local ecosystem situations, and limited knowledge of the functions and services provided by local ecosystems, especially the precise roles played by various types of forest biodiversity (Ibid, p. 572). Lessons from Mongolia show that it is possible to successfully integrate biodiversity conservation into forest management plans while incorporating monitoring and conservation targets for biodiversity in all the country's over 500,000 hectares of forests that are home to several endangered species, including the saker falcon and musk deer (Ibid, p. 578).

In the case of Kenya, most challenges confronting forest ecosystem conservation and management have mainly been attributed to increased demand for a wide range of forest products and services (GOK, 2018). A government task force report of 2016 indicates that most of the forest management techniques in the country mainly focus on plantations and extractive

forest resources, with little or no information regarding forest biodiversity and their specific management practices. (GoK, 2016b).

The Maasai Mau Forest block under consideration in this study is a unique natural forest ecosystem situated within the larger Mau Forest complex. The area is part of the Eastern Afromontane Global Biodiversity Hotspot long recognized as an important biodiversity hotspot and essential watershed for national and international importance (Albertazzi *et al.,* 2018). It is managed under the Maasai Mau Forest Ecosystem Conservation Plan [MMECP] 2021-2031 (KWTA, 2021). The MMECP has seven management programs that help address various management issues in the Maasai Mau Forest, including a forest restoration program, a forest protection and law enforcement program, a land management program, a civic education and community governance program, a community development and livelihood improvement program, an ecological research program, and a water resource management and catchment conservation program. This study focused on examining how forest conservation and management objectives were integrated into seven management plans of the Maasai Mau Forest. Concern over the loss of biodiversity in this ecosystem (particularly genetic resources) has been a driving force behind efforts toward conservation and protection. This concern is stated in the key findings of the task force report on the conservation of the Mau Forest complex (Op. Cit., p. 38) and established that the Mau complex biodiversity was under serious threat due to poor management systems.

In particular, this study is useful in providing a deeper understanding of how the integration of elements of forest conservation and management can be achieved through Participatory Forest Management Plans (PFMPs). The goal of incorporating biodiversity programs into existing plans and institutional frameworks can ensure that forest managers, stakeholder representatives, and forest rangers have a thorough understanding of the type, distribution, and abundance of the ecosystem, species, and ecosystem services within and outside the management area. Finally, the study has the potential to strengthen future research and management goals aimed at meeting international commitments such as the Aichi Biodiversity Targets and the 2030 Sustainable Development Goals.

### 1.2 Research questions

The study seeks to address the following four questions:

1. What type of forest management programmes are prescribed at the Maasai Mau Forest station?
2. How are the forest biodiversity-related management programmes and activities being implemented at the Maasai Mau station levels?
3. Which forest biodiversity has been recorded from 2019 to 2021 at the Maasai Mau Forest station?
4. What are the future interventions and approaches for averting biodiversity threats to the Maasai Mau Forest?

## 1.3 Research objectives

The overall objective of this research is to assess the conservation and management of biodiversity in a non-gazetted forest ecosystem with the case study of the Maasai Mau Forest in Kenya.

### 1.3.1 Specific objectives

The specific objectives of this research comprise the following:

1. To evaluate the forest management programmes prescribed at Maasai Mau Forest
2. To assess specific biodiversity-related management programmes and activities implemented at the Maasai Mau Forest station.
3. To assess the forest biodiversity records from 2019 to 2021 at the Maasai Mau Forest stations.
4. To suggest formulation of future interventions and approaches to avert threats to forest biodiversity in Maasai Mau.

## 1.4 Significance of the study

The necessity of ensuring the protection and conservation of forests and their biological diversity is driven by the international community's recognition of the crucial role that safeguarding biological diversity plays in society (Shah, 2016). It is therefore critical that forests should not be limited to the extractive nature of timber provision, but should also maintain the vitality and the health of forests, forest biological diversity and protective functions (Morales-hidalgo *et al.*, 2015). The future of Kenya’s forest biodiversity depends on effective management programmes implemented. Hence, the management regime should ensure the consideration of conservation

values within an ecosystem especially forest biodiversity and critical ecosystem areas (African Centre for Technology Studies [ACTS] & African Conservation Centre [ACC], 2010).

This study aimed at finding out the forest management programmes implemented at Maasai Mau Forest and how the biodiversity-related programs have been integrated at the Maasai Mau station level. This included documenting the various biodiversity recorded at the Maasai Mau forest station. The study findings will enable forest managers in developing management programmes that will create value from the production of timber, and at the same time benefit from biodiversity goals (Filyushkina, *et al*., 2018). It will also be critical in examining the formulation of Forest Management Plans (FMP) and Participatory Forest Management Plans (PFMPs) and ensuring the integration of biodiversity-specific management approaches. Besides, the study will be significant in evaluating the country's commitment to sustaining the rich biodiversity within the forest ecosystems.

Forest managers and policymakers will need to be cognizant of the importance of the biological diversity of the forests they manage in a broader context. If not, they may unintentionally compromise global biodiversity goals and targets by managing the forests inappropriately (Keenan *et al.*, 2015). The need for monitoring and assessment applies both to production forests and natural forests. Therefore, the study is ideal towards assisting the country to achieve global biodiversity targets and the Strategic Plan for Biodiversity 2011-2020, in particular, Goal C which pays attention to enhancing the biodiversity status through conserving and protecting ecosystems, species and their genetic diversity (CBD, 2018; 2016), including the Post 2020 Strategic Plan Targets

### 1.5 Scope of the study

This study was conducted in the Maasai Mau Forest situated within the Mau Forest Complex. The study area was selected given the diverse ecosystem services and goods it provides. In the past few years, the Mau forest complex has experienced major degradation and deforestation, resulting from increased human encroachment in the forest reserves (Olang & Kundu, 2011). These adverse effects coupled with the severe impacts of climate change require the need to assess the management of forest biodiversity within the ecosystems.

The forest ecosystems provided a suitable platform to assess the impacts of different forest management programmes on biodiversity and assess species-specific management practices. The study helped to understand the forest management programmes that are implemented in the forest's ecosystem and those specific to biodiversity management.

## 1.6 Operational definition of terms

**Biodiversity management:** maximizing overall habitat diversity by sustaining circumstances that follow natural patterns and simulating natural disturbances

**Conservation management:** management and maintenance of biodiversity focusing on improving the general ecosystem and safeguarding from threats to enhance sustainability.

**Forest biodiversity indicators:** tools used for tracking and evaluating the effects of various conservation and management strategies aimed at maintaining and protecting endangered species

**Forest conservation:** the practice of planting, preserving or protecting forests for the sake of the current and upcoming generations.

**Forest management:** an area managed mainly for the production of wood and non-wood forest products as well as maintained for indirect values such as protection of water catchment areas, biodiversity conservation or recreation.

**Participatory Forest Management Plans:** participatory forest management plan (PFMP) is a framework based on the implementation of forest resource use including extractive values and non-extractive values like biodiversity conservation, carbon sequestration, and eco-tourism, as well as wood and non-wood forest products.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

This chapter presents key information from previous studies as well as articulates theories that guided this study. The section lays a basis for what is known about the issues being investigated and the gaps in knowledge that were the focus of the study. The chapter will also form the basis for discussing study findings later.

## 2.2 Forest management programmes

### 2.2.1 Overview of forest management

Forests support the highest species diversity of most taxonomic groups, including invertebrates, birds, mammals, and microbes, accounting for approximately 65% of the Earth's terrestrial biodiversity (MEA, 2005). The need to conserve and sustainably manage forest biodiversity is a vital task (FAO, 2010; Lindenmayer *et al.,* 2006). The forestry sector faces a significant challenge in attaining and upholding a sustainable approach to forest management in terms of ecology, economy, and society while simultaneously conserving biodiversity (Gamborg, 2016). The adoption of contemporary forest management models globally will significantly contribute to approaches that imitate the natural succession dynamics and enhance forest conservation (Hill *et al.,* 2019). National forest management programmes and related policies can have an extensive impact on forest outcomes due to the ultimate drivers of forest-related activities.

The predominant goal of forest management can differ extensively, from prompt profitable development through timber extraction to biodiversity conservation, to sustainable utilization and enhanced livelihoods. The forest management programmes that are executed to accomplish these predominant goals can vary in terms of land tenure agreements and the extent conservation mechanisms are included such as logging bans and protected areas ( Brandt *et al*., 2017).

### 2.2.2 Forest management programmes in Europe

The continued concern over biodiversity loss especially genetic resources is a major force towards developing effective management systems that integrate biodiversity components in Europe (Hill *et al.,* 2019*).* The European Forest Management Model focuses on the implementation of modern silvicultural approaches, such as nature-based silviculture, that meet

the needs of sustainable forestry and the conservation of biodiversity (Gamborg, 2016). According to Boutin, *et al*., (2009), management practices such as silvicultural treatment including logging operations in the primary or secondary natural forest have immediate effects that lead to significant structural alterations of the forest. Minimal logging activities of as low as 3% of trees removed to result in a reduction of the canopy cover by 50% (Bawa & Seidler, 2008).

For instance, foresters in New Zealand prescribe silviculture practices in their intensive management of radiata pine (*Pinus radiata*) that delay full canopy closure and maintain open forest conditions for long periods. These include using much wider spacing in plantings and using wide spacing in early pre-commercial thinning typically about nine years. The thinned stands produce trees with much larger average diameters and are also very open in structure and can produce a variety of other products, including forage for domestic animals (Franklin *et al.,* 2015).

### 2.2.3 Forest management programmes in Asia

In South Asia, complicated traditional caste, religious and culture-based forest management methods have conflicted with the state's top-down strategies of community involvement (Gardner *et al.,* 2010). The traditional forest management systems in India and Nepal have been overtaken by state control, resulting in the alteration of traditional forest access and control of harvesting rights (Nagendra *et al.*, 2008).

A buffer zone management strategy has been implemented by Nepal's state forest management system to facilitate the establishment of a vast network of protected areas, particularly in densely populated areas. According to Mondal & Nagendra (2011), this management strategy grants members of the buffer zone user group forest access rights, which includes harvesting forest resources in accordance with the buffer zone's management guidelines.

In India, the Joint Forest Planning and Management (JFPM) programs have been adopted as the primary model for forest management. The Village Forest Committee (VFC) of India, which is the fundamental governing body of JFPM activities, is in charge of this program. India's Forest Department established this joint coordination of forest management to establish rapport with the local communities. Members of the VFC are granted user rights to access the forests and

withdraw products under this management model. This includes the right to manage the forest and develop management plans in conjunction with relevant parties. However, forest ownership and the ability to harvest high-value tree species are still vested in India's state (Singh & Kushwaha, 2018).

### 2.2.4 Forest management programmes in Africa

The management of natural forests in African countries such as Burkina Faso has become a subject of concern, resulting in the implementation of participatory forest management with broad stakeholder participation. Forest management plans covering the technical and legalized components of natural forests, such as legislation on management disruptions, have been developed and implemented. The comprehensive management regime for the country's forest areas includes the use of annual early fire, the prevention of livestock grazing, and selective timber harvesting of half of them by 50% of the marketable standing volume on a 20-year rotation (Zida, 2007). Understanding the effects of management disturbances on the restoration of woody species is critical for developing management programs in Burkina Faso. For instance, selective timber harvesting creates gaps in the forest ecosystem, lessening competition for natural resources such as nutrients, sunlight, and water, and causing temperature variations in the soil (Zida, 2007).

Forests account for nearly 10% of Cameroon's Gross Domestic Product (GDP), making them an important part of the country's economy. Maintaining a balance between the production and use of forest resources while also protecting biodiversity is the country's primary constraining issue. The country's utilization of forest resources has increased as a result of previous forest management programs, with conventional selective logging being the most prevalent management practice. However, the process of developing and executing forest management plans in the country is too slow due to program acceptance challenges (United Nations Environment Programme World Conservation Monitoring Centre [UNEP-WCMC], 2016).

In Kenya, the management of natural forest resources has been entrenched in the management plans as a mandatory requirement (Muthuri *et al.*, 2022) as per the Forest Conservation and Management Act No. 34 of 2016 (GoK, 2016a), and according to the 2010 Kenya Constitution Article 69 (GoK, 2010). According to Amaral *et al.*, (2013) the management of Kenya's forest ecosystem is governed by the participatory forest management plan (PFMP) framework, which is

based on implementable actions targeting forest resource use. The country's natural forest presents a bigger opportunity for PFMP values to be derived through the extraction of forest resources. These include non-extractive forest values like biodiversity conservation, carbon sequestration, and eco-tourism, as well as wood and non-wood forest products. Therefore the PFMP interventions in each forest station depend on available resources and forest type either plantation or natural forest (Albertazzi *et al.*, 2018).

The Kenya National Forest Programme (NFP) emphasizes the need for each PFMP objective to be specific to the particular forest type (GoK, 2016b). For instance, the Arabuko-Sokoke forest is of the great importance of its unique ecosystem consisting of several endangered and rare species (Blackett, 1994). The forest is managed through 25 years (2002-2027) strategic management plan with nine programs that address various management issues within the forest. The major programs included are biodiversity conservation, forest protection, research and monitoring, eco-tourism and environmental education, and commercial use among others (Arabuko-Sokoke Forest Management Team [ASFMT], 2002). The forest is home to several endemic species especially the Sokoke scops owl (*Otus ireneae*). The biodiversity conservation component is well articulated in the Arabuko-Sokoke plan however, the majority of other PFMPs such as Eburru, Olposimuro, and Ngare Ndare forests among others have a generalized component of biodiversity conservation and management with few activities addressing biodiversity management issues (GoK, 2016b).

## 2.3 Integration of biodiversity conservation and management elements into forest programmes

Forest biodiversity is vital for the well-being of our society. It is part of the natural capital which supplies ecosystem services such as soil nutrient cycling, carbon sequestration, and water purification that support our economy and maintain the resilience of our socio-ecological systems (Kraus & Krumm, 2013). Despite the critical role that biodiversity contributes to the environment, economic and social aspects, it continues to be in dire need of urgent action. Land use changes, climate change, invasive alien species, overexploitation, and pollution are the primary drivers of biodiversity loss, resulting in a threatened or endangered status. As a result of human activity, the global wildlife population has declined by 60% over the last four decades (European Commission [EU], 2020).

The Aichi Biodiversity Strategic Goal A focuses on the fundamental causes of biodiversity loss and the integration of biodiversity elements into all levels of decision-making. Understanding and appreciating diverse values of biodiversity values is critical to addressing the primary causes of biodiversity loss. According to the EU (2020), analysis of countries' reports presented to the CBD, most of the nations are participating in public awareness creation and sensitization of biodiversity, however, very few countries have programmes that focus on activities that people can implement towards conserving and sustainably utilising biodiversity. Additionally, the mainstreaming of biodiversity into development policy-making processes as a significant consideration has been lacking, leading to derailing conservation efforts (UNEP-WCMC, 2016).

According to Boutin *et al.,* (2009), a significant criterion frequently listed in forest management plans and certification programs is the maintenance of biodiversity. Society expects the government and forestry sector to manage biodiversity, hence this requires monitoring and reporting on it. The level to which this is accomplished is a major indicator of the extent to which, the forest sector has progressed in its obligation to progress beyond the specific focus of wood supply to the broader goals incumbent in ecosystem management (Beaudrot, 2016).

Approaches based on species are a crucial component of biodiversity to take into account during the planning stage as they are very understandable and facilitate data collecting owing to the availability of scientific research (Lise *et al*., 2020). Furthermore, species elements are important in reflecting other biodiversity variables such as ecosystem structure and processes (Allendorf & Brooks, 2017). It is also simple to map the distribution of species within an ecosystem, which can subsequently be integrated into the planning outputs as maps and tables and utilized as implementation tools. The identification and prioritizing of keystone, umbrella or indicator species is an important factor in this method, that assists to lessen the challenges resulting from having a large species list. This may become a challenge during implementation owing to insufficient people and financial resources (Laurance, 2007).

Another important aspect of biodiversity to consider during integration is crucial areas of importance with significant ecological processes. Consideration aspects include species' habitats, interactions between species and habitats, as well as ecosystem structures and their functional diversity (Adrian, 2007).

### 2.3.1 Integration of biodiversity elements into forest management plans in Asia

Nepal's buffer zone management approach provides a detailed plan that includes forest zonation planted with various tree species. The management plans also restrict timber harvest and grazing within the forest. Furthermore, it promotes the planting of indigenous tree species and the maintenance of natural regeneration. To combat unlawful extraction, Nepal army officers monitor protected forest regions. As a result, this management strategy increases biodiversity significantly within the buffer zone compared to other forests such as community forests that lack this approach (Nagendra *et al.*, 2008).

The JFPM concept in India strives to involve various actors in forest management while also meeting local needs such as fuelwood and access to non-timber forest products (NTFPS). The program is expected to restore and rehabilitate degraded forest lands by conserving biodiversity-rich areas and ensuring natural resource sustainability. The program emphasizes the connection between natural resources and local livelihoods as a key feature. (Singh & Kushwaha, 2018).

### 2.3.2 Integration of biodiversity elements into forest management plans in Europe

According to Van der Plas *et al*., (2016), there is a shift in European regions toward more diverse multi - purpose forest management strategies. This aims at delivering a range of ecological services, enhancing biodiversity conservation and reversing ecological degradation as well as benefiting generations in future. The region's transition from a management approach of conventional even-managed forests that focused on monocultures of conifer to the promotion of a more diverse management approach referred to as "Close-to-nature" forest management (CTNFM) that consist of mixed uneven-aged forests ecosystems that are ecologically more stable. The new management approach put more emphasis on biological diversity, ecological stability and productivity and the continuity of ecosystem services. Additionally, the CTNFM has resulted in the integration of multiple management objectives at small geographic scales within individual forest ecosystems (Larsen, *et al*., 2022). The EU Biodiversity Strategy for 2030 underlines the need for legally binding targets within the EU regions that will facilitate the restoration of the degraded EU forest ecosystem. The EU Commission has been called upon by the legislative council to move away from voluntary commitments and set legally binding restoration targets for the EU that are ambitious and inclusive for the EU to meet the international commitments on restoring ecosystems such as the 2050 vision under the CBD, 2030

Sustainable Development Goals, the UN Decade for Restoration among other agendas (EU, 2022).

Countries such as Turkey have taken into perspective the integration of biodiversity into forest management plans by adopting Ecosystem-Based Multipurpose Planning (ETCAP) through the functional planning management approach (UNEP 2018). According to Lise *et al.,* (2020), the functional planning approach adopted by Turkey factored in biodiversity elements such as species with conservation priority, incorporation of inventory of these species, modelling their distribution within Turkey's forest and establishment of forestry activities that relate to the species.

### 2.3.3 Integration of biodiversity elements into forest management plans in Africa

The African continent contains outstanding biodiversity with vast collections of mega fauna. However, according to UNEP-WCMC (2016), the species population is rapidly declining. More than 6,000 animals and over 3,000 plants were listed as endangered on the International Union for the Conservation of Nature (IUCN) Red List in 2014. Additionally, African birds have been on the decline for the past 25 years putting them at risk of extinction (IUCN, 2018a). On the other hand, biodiversity habitat continues to be subjected to immense pressure from development, encroachment for settlements and agriculture (Hills *et al*., 2019). This has resulted in more than 3 million hectares of natural habitats being converted to other land uses annually in Africa (UNEP, 2018).

A case study that was undertaken by Boshier *et al*., (2011) in Ghana for *Talbotiella Gentii* (sequoin), one of the few endemic and endangered forest tree species, showed that the species ecosystem has been designated as a globally significant biodiversity area. This has been prioritized within Ghana's Biodiversity Conservation Strategy, due to the conservation importance of the tree species. Despite these conservation efforts in Ghana, effective management of these species has been hampered by a lack of data on the species' ecology. According to the study, different stakeholders have unanimously advocated for urgent management and research geared towards maintaining the ecological integrity of these ecosystems.

In Cameroon, the government has deliberately integrated its Forest and Environment Sector Programme (PSFE) into the Document on Growth and Employment (DSCE). This is mainly to mainstream biodiversity into its economic development (UNEP-WCMC, 2016). Consequently, through the partnership involving the Ministry of Forestry and the Ministry of Social Affairs, and by integrating PSFE into DSCE, the country has shown that biodiversity can be mainstreamed into growing the sectors within the country (Ingram & Redford, 2012).

According to a study by Thenya (2014) which analysed the implementation of Participatory Forest Management (PFM) in different forest ecosystems in Kenya observed that the main goal for implementing the PFM was to ensure increased ownership and general protection of the forest from fires and illegal logging. Though the study highlighted several species which are of tourism importance within the study areas in Gathiuru and Hombe forests in Central Kenya, the specific management practises for the different forest biodiversity were not mentioned or were not part of the focus of the PFM.

### 2.3.4 Kenya's forest biodiversity management – historical perspective

According to Kigomo (1991a), in the late 1890s, forest management in Kenya was focused on industrial plantations, primarily in the highlands. This was until the 1900s when the establishment of indigenous forests and arid area afforestation began to receive major attention. According to the Kenya Forestry Master Plan (KFMP), in the early 1930s, forestry research was primarily focused on the natural regeneration of commercially relevant indigenous species and the trial of exotic species (Forest Department of Kenya (FDK), 1991). From the 1930s to the 1970s, research focused on supporting softwood plantation development programs for timber and pulpwood in the highlands (Gachanja *et al*., 2005). There was a significant movement in forestry policy in the 1980s in favour of conservation and rationalized use of natural forests and indigenous tree species.

As a result, there was a rising demand for research on the ecology of natural forest ecosystems and silvicultural practices for indigenous species usable as plantation species (FDK, 1994). According to the Master Plan, there was an inadequacy of information on how natural forest stands were likely to respond to management disturbances (FDK, 1991). Kigomo (1991b) also stated that there was little information available on the ecological status of distinct forest

ecosystems, species regeneration, and the possibility of sustainable and multi-purpose usage. Furthermore, Kigomo (1991a) stated that there were no research initiatives aimed at developing

One of KFMP's distinct and still outstanding conservation action plans was to raise public awareness of Kenya's natural forest ecosystems, the useful and rare species of both flora and fauna that they contain, and the benefits that they provide (FDK, 1994). Furthermore, while the plan recommended the development of conservation management plans for the sustainable use of natural forest ecosystems resources and specific biodiversity, no action was taken to put the recommendations into action.

The main objective of the Kenya Indigenous Forest Conservation programme (KIFCON) was to prepare conservation management recommendations to be included in the KFMP, also set up a monitoring system covering all indigenous forest ecosystems (UNEP & Kenya Forest Working Group [KFWG], 2008). According to Kenya's fifth national report to the CBD (GoK, 2015), relatively inadequate attention has been given to the research on the ecological functioning of indigenous forests and prescriptions for their sustainable management in the past decades. A recommendation was given on establishing strong programmes in indigenous forests with an emphasis on the management of mixed and pure forest biodiversity. It was also highlighted that there was little commitment to developing technical guidelines and technical orders on the management of natural forests and the indigenous species found within.

### 2.4 Forest biodiversity monitoring

Sustainable forest management is described and assessed by criteria and indicators that are applicable for evaluating and monitoring the status and variations in the forest ecosystem. The indicators capture the qualitative and quantitative data regarding the extent of forest resources, the forest biodiversity, and productive functions of forest resources, forest health and vitality, socioeconomic functions of the forest among others (Beaudrot *et al.*, 2016). Operational forest biodiversity indicators should be used to monitor and assess the impacts of different management approaches aimed at maintaining and protecting endangered species, increasing the biodiversity as well as the general management of the forest ecosystem (Lindenmayer *et al.*, 2006).

Monitoring of forest biodiversity in Canada is insufficiently established to give suitable, scientifically accurate, and trustworthy information to develop indicators that would allow

successful biodiversity management. The country's biggest problem is that the fundamental data utilized to evaluate the status of species is frequently inconsistent due to variances in record quality compared to actual changes in the risk of extinction. Furthermore, there is a scarcity of information related to forest management units on indicator standards, monitoring techniques, or sampling designs (Boutin *et al.*, 2009).

Despite the African region encompassing outstanding biodiversity including the intact collections of big mammals on earth, species abundance in the region continues to decline (UNEP-WCMC, 2016). According to Chaudhary *et al.,* (2016), the fifth national report to the CBD indicated that one of the common problems in the region was the lack of appropriate and harmonized biodiversity indicators used to monitor and assess the conservation needs and National Biodiversity Strategies and Action Plans (NBSAPs) progress. The CBD decision for COP 13 on the strategic actions aimed at enhancing the implementation of Aichi Biodiversity targets indicated the lack of readily available data on Africa's Forest biodiversity, despite the existence of old and elaborate forest management programmes (CBD, 2016). This presents a barrier to assessing the accurate status and trends, threats and conservation needs of forest biodiversity in the region.

The Improving Capacity in Forest Resources Assessment in Kenya (IC-FRA) report documented that the quality, quantity and trends in yields and growth of Kenya's natural forest resources are poorly known (KFS, 2016). Most of the available data on tree resources growing stock is mainly from state plantations. Forest inventories undertaken in Kenya began in the 1990s during the development of the Kenya Forestry Master Plan (KFMP) (Langat *et al.,*2015). Consequent forest inventory and resource assessments such as the Kenya Indigenous Forest Conservation Project (KIFCON) in 1993, the Mt. Elgon forest mapping and inventory in 1997, the inventory for the indigenous forest in the Arabuko Sokoke Forest Reserve in 2001, the inventory of indigenous trees species and vegetation survey in the Mt. Elgon Reserve in 2001, the inventory of trees and vegetation survey in the Mukogodo landscape in 2005, the inventory of tree resources in the South Nandi forest reserve in 2005, and the mapping of the Kakamega forest by the Biota Project in 2005 (GoK, 2009).

## 2.5 Areas for enhancing biodiversity conservation

The goal of forest biodiversity monitoring programmes is to address knowledge gaps and contribute towards developing ecologically responsible management approaches that enhance conservation prospects (Gardner *et al.*, 2010). Future opportunities for increasing biodiversity conservation in natural forests should emerge at both a policy level, through the implementation of appropriate biodiversity conservation incentives, and at a more practical and convenient management level, informed by ecology (Norton & Miller, 2012).

Conservation and management of protected natural forest areas necessitate a comprehensive approach that includes good management methods and an effective execution mechanism (Biodiversity Management Bureau (BMB) & GIZ, 2017). This will complement Kenya's national measures to minimise the effects of climate change, restore forest ecosystems, improve biodiversity conservation, and monitor forest regeneration and growth (Makhanu, 2015).

According to Dupuy (2000), planning for natural forest management requires accurate data and information on each of the available forest resources. The PFMP should be based on this information which should be available including, tree volumes, flora and fauna species diversity, the threatened and rare species within, and regeneration and mortality of species among other biodiversity parameters (FAO, 2016). The report recommends the need to integrate biodiversity aspects in the management plans to enhance the appropriate conservation.

## 2.6 Research gaps

According to Kraus and Krumm (2013), it is critical to integrate biodiversity-related management strategies within forest management plans to ensure the effective delivery of multifunctional ecosystems with a variety of goods and services. This will guarantee effective conservation and management of forest biodiversity in the face of changing nature. Shah (2016) evaluated the integration of biodiversity MEAs in legal frameworks and national policies for Kenya, although the inclusion of forest biodiversity in forest management plans was not covered.

Although Kenya's natural forest ecosystem covers more than 95% of the forest area, the primary focus has been on timber production and commercial plantations. In the past, some sections of prime indigenous forests and national biodiversity hubs such as Kakamega forest and Mt. Kenya ecosystems have been converted into less biodiverse commercial forests around the country. This

has led to the implementation of simplified and generalized forest management plans with no consideration for forest biodiversity restoration. As a result of the lack of explicit enforceable standards for biodiversity conservation and management, conservation efforts for biodiversity in natural forests have been undermined. There is no clear requirement in the management plans for the assessment and monitoring of biological diversity, as well as a need for a complete mapping of healthy and degraded forest areas. This challenge, compounded by significant perturbations such as climate change, invasive species, pests, and diseases, results in deteriorating loss and eventual extinction of biological variety.

There have been no studies conducted to determine if Kenya's gazetted and non-gazetted forests have explicit biodiversity restoration management strategies. Furthermore, no research has been conducted to assess the extent of integration of biodiversity components such as species diversity, ecosystem diversity, and their genetic variations across distinct PFMPs and FMPs.

### 2.7 Theoretical framework

Ecological niche theory is established as a foundation for decision-making in contemporary nature conservation. The concept was first coined by naturalist Joseph Grinnell in 1917, where he explained that the niche of a species is determined by the habitat in which it lives and associated behavioural adaptation (Grinnell, 1917). Most of the research undertaken in nature conservation directly or indirectly refers to the ecological niche concept and its sources. Some direct examples include ecological niche models that have been used for the allocation of conservation areas, the assessment of habitat loss and invasive species management (Adrain, 2007).

Two interconnected attributes of conservation that require the attention of society are biodiversity and ecological integrity. Ecological integrity is a pre-condition for species conservation as species depend on it and regularly contribute to processes, which sustain their niches. This indicates that an ecosystem strategy for conservation is needed. To ensure effective protection and management of endangered and threatened species, relevant policy should be formulated that aims at managing and conserving population processes which permit the viability of populations at the landscape and regional scale (UNEP-WCMC, 2016; Chape *et al.,* 2005).

In particular, system dynamics, scale and areas of heterogeneity have feasible results on the efficiency of conservation programmes. To effectively protect several endangered and endemic rare species, the forest policy should aim at managing and conserving population processes which permit the viability of populations at the landscape and regional scale. Ecological niche theory and conservation practice, as a result, demonstrate the coexistence and co-occurrence of species with variations among species that are critical for their survival under changing environmental conditions in space and time (Khatibi, 2016).

### 2.8 Conceptual framework

Natural forests and other protected forest areas continue to be an important strategy for forest biodiversity conservation and management. The conceptual framework depicted in **Figure 2-1** demonstrates how the structure and composition of a forest ecosystem are affected by site factors and management regimes. By implementing appropriate and applicable forest management and biodiversity conservation programs, which are the independent variables, the desired objectives of various management strategies in an ecosystem, such as timber resources, diversity of species of flora and fauna, non-wood products, and well-conserved habitat, can be attained. Integrating multiple management approaches into forest conservation is thus crucial for assuring the protection of biodiversity hotspots, particularly the critically endangered and threatened species. The outcomes of effective integration of biodiversity components into the forest planning process guarantee that societal needs are met, as well as ensuring crucial biodiversity indicators are in place.

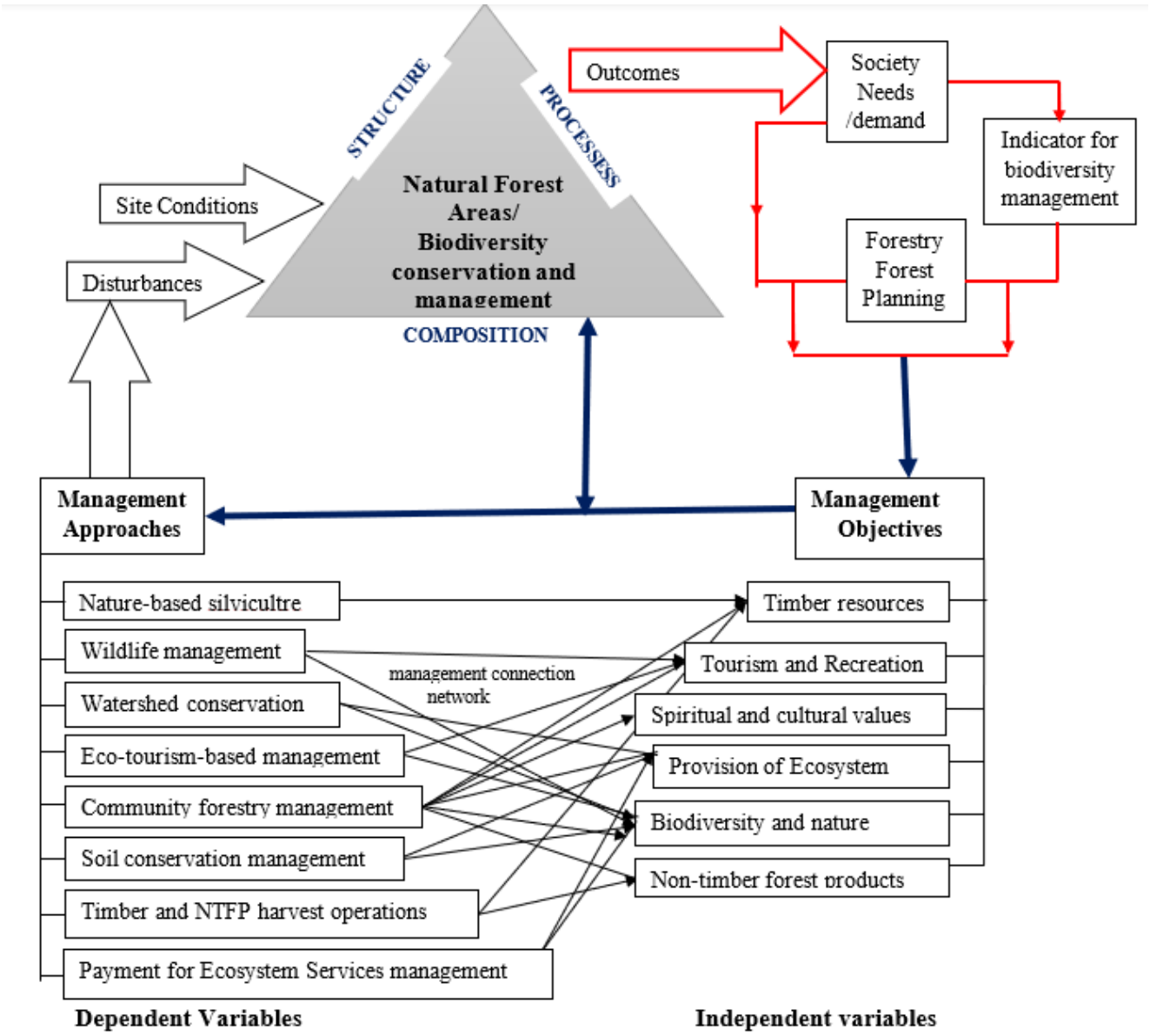



**Figure. 2-1: Conceptual framework**

**(Source, modified from (Boncina, 2011)**

# CHAPTER THREE:

# METHODOLOGY

## 3.1 Introduction

This chapter examines the methods used to address the research objectives. It comprises the description of the study area, the manner and form by which the research is designed, various sources of the data which were utilized by the study, methods of data collection, data analysis and interpretation techniques.

## 3.2 Study area

The study was undertaken in the Maasai Mau Forest, one of the montane indigenous forests within the larger Mau Forest complex. The Mau Forest complex is the largest nearly continuous montane indigenous forest in East Africa with an estimated land surface area of 273,300 hectares (KWTA, 2019). It is the most extended water tower in Kenya composed of 22 forest blocks. The forest complex borders several counties in Kenya, to the west borders Kericho, Nakuru to the northern side, Narok county to the south and Bomet to the southwest side (Albertazzi, *et al.*, 2018).

Maasai Mau Forest (MMF) is located in Narok County, approximately 17km North of Narok Town (Gachanja, *et al.*, 2005). The forest block lies between the latitude -0.8065 [S] and the longitude 35.7802 [E]. It borders the Olposimoru forest block to the North and Transmara forest block to the North West (KWTA, 2020). MMF traverses 14 locations namely; Olposimoru, Olokurto, Naituyipaki, Olorropil, Nkareta, Lower Melili, El Donyo Ngíro, Siyiapei, Topoti, Melelo, Enabelibel, Sogoo, Sagamia and Mau Narok as shown in. It covers an area of 97,091 ha (the forest covers 46,283 ha while the buffer covers 50,808ha) (KWTA, 2021).

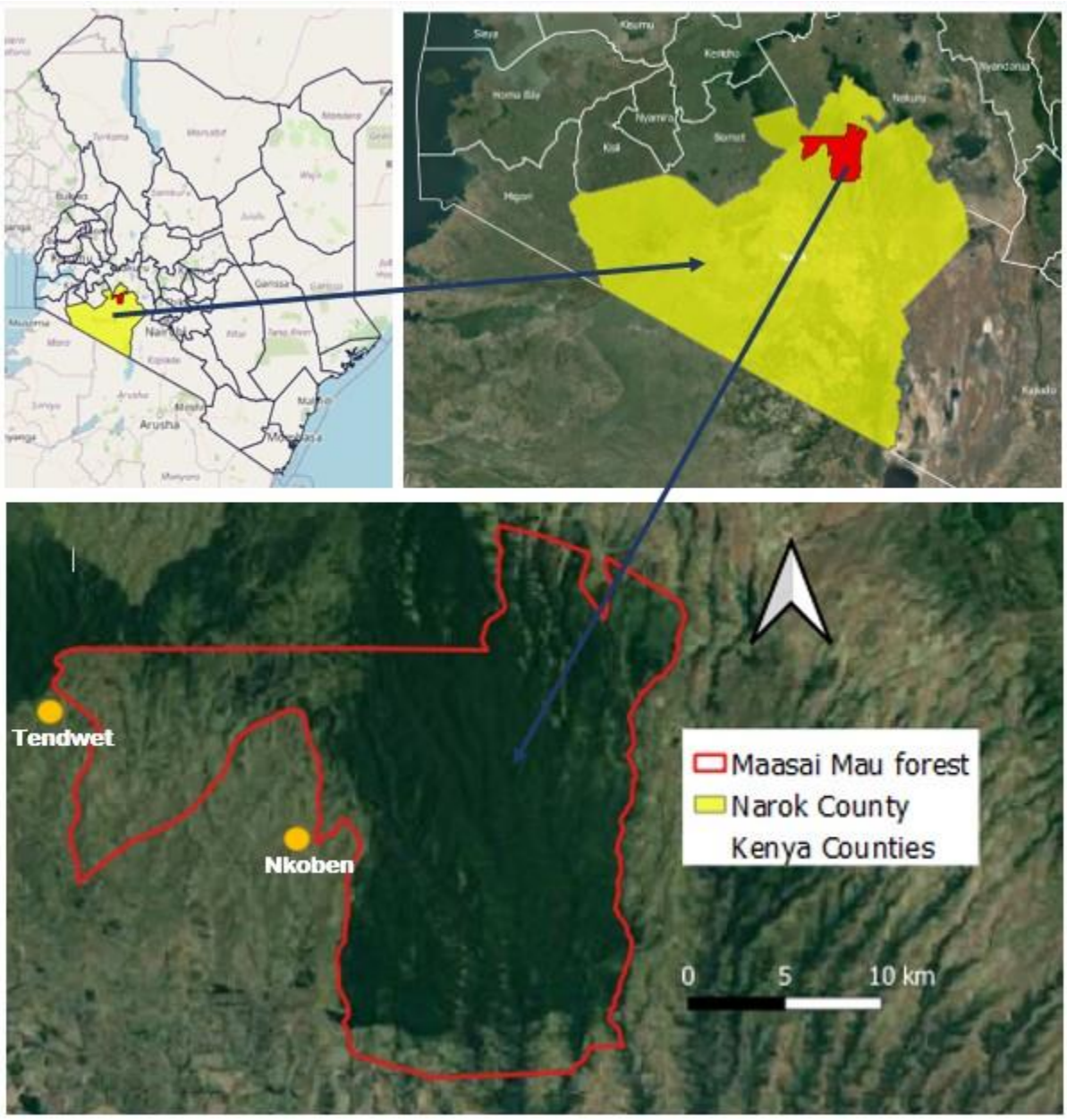



**Figure 3-1: Geographical location of Maasai Mau Forest block**

**Source: Researcher, 2023**

i) **Biophysical and topographic features in the study area**

The forest is located between 2000 and 2700 meters above sea level at Nkareta to the west and Olpusimoru to the north, respectively. The main geomorphologic features include hills, escarpments, plains and rolling lands (Kipkoech *et al.,* 2011). The northern and eastern regions of Narok County are populated by volcanic geological formations. According to Olang & Kundu (2011), quaternary and tertiary volcanic deposits make up the majority of the MMF region.

According to the Food and Agricultural Organization of the United Nations' soil classification procedure (FAO-UNESCO, 1988), the soils contain a significant amount of silt and clay as a result of Ferrasols, Nitisols, Cambisols, and Acricsols.

The Maasai Mau Forest is the source of three major rivers and numerous tributaries that flow into Lake Natron and Lake Victoria. The upper catchment of Ewaso Ngiro, which flows into Lake Natron, includes almost the entire forest area. The Amalo river originates in the western portion of the forest and feeds the Mara River, which flows into Lake Victoria through the Serengeti National Park and the Maasai Mara National Reserve (KTWA, 2021).

**ii) Climate and rainfall**

The North-South movement of the Inter-Tropical Convergence Zone (ITCZ), which is influenced by local orographic effects, has a significant impact on the climate of Maasai Mau Forest (MMF).The climate is tri-modal in terms of seasonality, with the long rainy season occurring most frequently between May and June and the short rainy season occurring most frequently between September and November (Olang & Kundu, 2011). According to KWTA (2019), the region typically experiences monthly rainfall events of 30 to 120 millimeters and an average annual rainfall of approximately 1300 millimeters.

**iii) Land use and land cover**

MMF occupies different land cover classes. The land cover class with the largest area is grassland at 37,225ha which comprises wooded grassland and open grassland. Forestland class follows in terms of extending covering an area translating to 31,147ha. It also comprises two sub-categories which are indigenous forestland and exotic forestland. Land cover under cropland being the third largest class occupies an area of 28,293ha. Other land classes covering 201ha of the total area consist of bare rocks, bare soil and settlement, which is predominantly found within the buffer zone (KWTA, 2020). The settlement class covers a small percentage of the land area at 162ha and consists of town centres like the Sogoo, Tendwet, Nkoben and Kisiriri. The waterbody class includes rivers, dams, pans and springs which cover 225ha (Narok County (CIDP), 2018).

The MMF adjacent communities mainly practice farming and livestock keeping. Livestock keeping is the most dominant within the area due to the pastoral nature of the community, this

also explains the presence of the grassland class occupying the largest area in the forest block that is used for feeding the animals. Farming involves growing crops both at a large scale and for subsistence use, crops grown include; beans, potatoes, wheat, carrots, onions, maize, peas, and barley among others (Kipkoech, *et al.*, 2011).

**iv) Biodiversity**

a) **Flora**

The Maasai Mau Forest is considered floristically diverse owing to the high variety of plants, mainly due to the differences in altitude, topography, rainfall and disturbances levels. The forest has an open tree canopy with dense herbaceous and shrub layers which indicates human disturbances (KWTA, 2021). According to the Environmental and Social Impact Assessment report for the fencing of Maasai Mau Forest (KWTA, 2019), the highest plant life form representation within the forest is the herbs at 43%, shrubs at 34%, trees at 17% while grasses and sedges at 6%. The major plant communities in the forest are the *Podocarpus-Maytenus-Juniperus* community; *Podocarpus-Dombeya*; *Podocarpus-latifolius* and *Dombeya torrida-Podocarpus-Maytenus.*

The most threatened tree species within the ecosystem as per the IUCN Red list include African pencil cedar *(Juniperus Procera),* red stinkwood (*Prunus Africana),* East African olive *(Olea Capensis),* African redwood *(Hagenia abyssinica),* Parasol tree *(Polycias kikuyuensis)* and red fruited podo *(Podocarpus Latifoli)* (IUCN, 2018b). Majority of the species have been severely fragmented with the mature population rapidly declining in extent and area. Human interference from illegal logging and charcoal burning continues to threaten the species' population (GoK, 2009). Other plant species of conservation importance include the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) listed species African sandalwood (*Osyris lanceolata*), medicinal plants such as Aloe spp and *Piper capensis* (KWTA, 2021).

**b) Fauna**

The Maasai Mau Forest is a designated Important Bird Area (IBA) due to the presence of several bird species of conservation priority, with some being considered scarce including the Scarce Swift, Red-throated Wryneck *(Jynx ruficollis),* the afro-tropical migrants including Harlequin Quail (*Coturnix delegorguei*) and Golden-winged Sunbird (*Drepanorhynchus reichenowi)* and

the regionally threatened African Crowned Eagle (*Stephanoaetus coronatus)*, among other endemic species (Mekonen, 2017).

The forest also has a diversified and abundant mammalian species, which is similar to that of other tropical forests and is of international conservation concern (Riggio, *et al*., 2019; Tarus, *et al.,* 2018). Seven orders were identified from the forest and nearby farmlands in the environmental and social impact assessment for the proposed fencing of the MMF (KWTA, 2019): Rodentia (39%), Carnivora (17%), Artiodactyla (13%), Primates (9%), Eulipotyphla (9%), Lagomorpha (4%), and Proboscidea (4%). Three mammal species found in the habitat, including the African Leopard (Panthera pardus), the African Bush Elephant (*Loxodonta africana*), and the Giant Forest Hog List (*Hylochoerus meinertzhageni*), are classified as vulnerable by the IUCN Red (IUCN, 2018b).

Most of the herpetofauna species present in the forest and nearby farmlands include amphibians such as plain grass frog *(Ptychadena anchietae)* and large-mouthed frog *(Amietia nutty),* Senegal running frog *(Kassina senegalensis)*, Marsabit clawed frog *(Xenopus borealis)* and Molo frog *(Amietia wittei)* and reptiles such as African striped skink *(Trachylepis striata)*, spotted bush snake *(Philothamnus semivariegatus)*, Jackson's forest lizard *(Adolfus jacksonii)* and common slug eater (*Duberria lutrix)* (Butynski & Jong, 2016).

### 3.3 Research design

This study sought to assess different forest management programmes, biodiversity management activities at the forest station, information on recorded biodiversity within the ecosystem over the years and recommend opportunities to be enhanced in the future. In terms of research design, the researcher employed both qualitative and quantitative approaches. To gain insight into the phenomenon of interest, the qualitative approach requires the collection of narrative data. The approach includes the use of open-ended questions to respondents to get their views and interpret information gathered from the field, it also involved the review of organizational documents to analyze the content therein. The quantitative approach involves the collection of numeric data including pie charts, bar graphs and means to acquire the phenomena of interest. Questionnaires, in-depth interviews and field document reviews were used to gather data for the study.

The study utilized a cross-sectional study design which included both random and purposive sampling. Random sampling involved the collection of data from households, it was preferred due to its unbiased nature representing the whole population. For in-depth interviews and document reviews, purposive sampling was used targeting specific organisations involved in the management and conservation efforts of the Maasai Mau Forest. In-depth interviews targeted the forest station manager for MMF and the representative of the target organization based in the region. The data collected was then analysed using both statistical and non-statistical techniques.

### 3.4 Data sources

The study used primary and secondary data sources to ensure that the research has relevance in addressing the research and knowledge gap to inform decisions.

#### 3.4.1 Primary data

The primary data included the use of (1) structured interviews using the household's questionnaires, and (2) semi-structured interviews, which included the use of key informants' interviews such as forest station manager, representatives from organisations, CFAs officials, and Narok County forest officers among others. The study also used observation, photography and field notes.

#### 3.4.2 Secondary data

The study relied mostly on secondary data in the form of literature reviews that have been for past studies on biodiversity conservation in Africa and the Kenyan context. This involved analysing how different researchers have articulated the concept of conservation and management of forest biodiversity. The main search engine that was used included, google scholar, research gate, science direct and Scopus. This ensured that the scientific literature was obtained from published data and recognised journals. Furthermore, relevant unpublished research reports from masters and doctoral thesis, reports from NGOs, and multilateral and development organizations research were compiled and used to support the study. These were obtained from institutions and organizational websites, peer referrals, publication alerts, and document repositories of forestry-based institutions, including management plans and technical orders, as well as the National Museums of Kenya. Further reading was based on Multilateral Environmental Agreements (MEAs) that focus on the conservation of biodiversity, such as the

Convention on Biodiversity (CBD), and the Aichi Biodiversity Targets. These literature reviews formed the basis of the development and success of the study.

## 3.5 Sampling frame and target population

### 3.5.1 Data collection strategy

The research depended mainly on primary data collected from the field and secondary data from the forest station was used to support the primary data.

Using questionnaires, the primary data were obtained from community households and representatives of various organizations working within the Maasai Mau Forest (MMF) ecosystem. On the other hand, secondary data regarding the management of the Maasai Mau Forest were gathered through the review of organization records, publications, and reports.

### 3.5.2 Sampling

Two administrative locations within the Maasai Mau Forest were selected purposively, namely Nkoben and Tendwet for the household survey based on their direct proximity to the forest hence acquiring first-hand information from the respondents. The local community-based in the two locations living 5km from the MMF border were considered as the study respondents. Simple random sampling was used to select household respondents living within the aforementioned distance from the forest. A table with random numbers was developed using excel Microsoft office and the needed random numbers were selected from it for the two locations.

### 3.5.3 Determination of sample size for household questionnaire

The population data to be used for the household surveys for the two administrative locations was obtained from the KNBS (2019) database. Nkoben and Tendwet are two major locations within MMF, with communities living adjacent to the forest. The population data for the two locations were then sorted in terms of community households living 5km from the forest border. To obtain more accurate information regarding the households to be sampled, the number and distribution of households for the two locations were obtained from the local area chiefs.. In addition, this was confirmed through ground truthing in transects walks that were 5km from the forest boundaries. Consecutive numbers from 1 to N value (where N is the total number of households living 5km from the forest borders in each location) were assigned to the households. The estimated number of households within the 5km distance as per the local chief's database

was 261, which formed the target population with 135 and 126 for Tendwet and Nkoben respectively. As per the random selection of the respondents, a total of 84 households were selected for the study in both locations, Tendwet (46) and Nkoben (38), as indicated in the distribution in **Table 3-2**. The selection of the sample size was done using Cochran's (1977) formula as illustrated in the equation.

Scenarios where the samples are drawn from a relatively small population, as is the case in this study, call for a sample size that is more than 5% of the total population. Hence I applied the finite Cochran's (1977) formula;

$$n' = \frac{N}{1 + {}^{(n-1)}/_{N})}$$

Where: n'(n-prime) = the sample size to be used for the study

N= the size of the total population from which n is being drawn.

1= constant

The sampled households were proportionately distributed based on the number of households in the two locations as indicated in **Table 3-2**.

**Table 3-2: Sample size of households living 5km from the forest border**

| **Constituency** | **Location** | **Total No. of households** | **Households located 5km from forest border** | **Selected sample size** |
|---|---|---|---|---|
| Narok North | Tendwet | 505 | 135 | 46 |
| Narok South | Nkoben | 382 | 126 | 38 |
| | Total | 887 | 261 | 84 |

**Data source: KNBS (2019)**

### 3.6 Data collection

Mixed methods of data collection were used, which combined both qualitative and quantitative research techniques. The first group involved 13 respondents selected from 9 organizations established and functioning within the Maasai Mau Forest as listed in **Table 3-1**, as well as the forest planning document reviews obtained from the organisations. While the second group involved 84 local community households adjacent to MMF selected randomly.

The organizations operating within MMF were purposively selected based on organizational programs geared toward the management and conservation of MMF. The organisation's representatives were considered the main key informants for the study based on adequate knowledge of their organization's activities within MMF, as well as knowledge of relevant documents to be reviewed. While the community households were chosen at random as the study's major respondents. Data were obtained from the two groups using two sets of questionnaires based on responder categorization.

### 3.6.1 Reconnaissance

The primary data collection was preceded by a reconnaissance visit to the study area to familiarize with the study site as well as get easy entry points to research the area. This was mainly to help understand the socio-political and ecological nature of the study area and the earlier identification of research enumerators who assisted in data collection. The field visit was conducted on the 15$^{th}$ and 16$^{th}$ of February 2022 to the Maasai Mau Forest areas and a courtesy visit to the main organisations in the study including Kenya Forest Service (KFS), KWTA and meeting the Sogoo CFA officials.

### 3.6.2 Training of enumerators

The research assistants were recruited and underwent training on how to use the mobile application for household data collection and a pre-test of the survey tool. The questionnaires were also pre-tested in 10 households in one of the villages, which was not part of the sampled villages. During the pre-testing, a few changes were made to the questionnaire to suit the study context.

### 3.6.3 Review of forest planning documents

This involved purposely selecting documents availed for the study by different organisations involved in the management of the Maasai Mau Forest. The research analysed 16 documents comprising the Maasai Mau Ecosystem Management Plan, restoration plans, forest planning manuals and technical orders, organization reports on forest activities, forest biodiversity records, and implementation plans regarding the Maasai Mau Forest. The review guide as detailed in appendix 2 involved establishing thematic areas mainly – forest programmes, biodiversity-related programmes, programmes and projects implemented by the organisation concerning biodiversity. The document reviews were designed to help generate key information

regarding the forest management programmes related to biodiversity implemented at the station levels and the specific management of biodiversity. It helped in generating questions targeting the key informants to gather further detailed information.

### 3.6.4 Biodiversity Integration Rating Index (BIRI)

To determine the integration of biodiversity-related programs within the Maasai Mau Ecosystem Conservation plan, the study used the Biodiversity Integration Rating Index (BIRI) (Researcher, 2022) computation piloted for the first time. This was based on the frequency in which each management programme mentioned the three biodiversity components at the species, genetic, and ecosystem diversity levels classified as direct integration, while other generalized biodiversity-related elements were classified as indirect such as training, awareness creation and sensitization on forest biodiversity conservation, this was assigned a lower scoring. As shown in **Table 3-3**, the BIRI rating categorization was used to assess the level of integration of biodiversity-related programs. For instance, under species diversity, each mention of flora or fauna in a particular programme is given a score of one, irrespective of the number of times specific species is mentioned. For analysis, the biodiversity indicators were further sub-divided into key thematic areas and the species were further categorised into taxa including mammals, avifauna (birds), flora(plants), invertebrates, and herpetofauna (amphibians & reptiles).

**Table 3-3: Level of biodiversity integration rating scale**

| Biodiversity indicators | Key thematic words integrated into the programmes | Species taxa | Scoring value |
|---|---|---|---|
| Species diversity | Specific forest biodiversity | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | Threatened and endangered species, | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | Rare and endemic species | Mammals | 1 |

| Biodiversity indicators | Key thematic words integrated into the programmes | Species taxa | Scoring value |
|---|---|---|---|
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | Specific management of indigenous species | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | | **Total** | **20** |
| **Ecosystem diversity** | Priority conservation areas of interest | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | Forest biodiversity hotspot | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | Mapping of conservation areas | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | Species zonation | Flora (trees) | **1** |
| | Mapping of conservation areas | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & | 1 |

| Biodiversity indicators | Key thematic words integrated into the programmes | Species taxa | Scoring value |
|---|---|---|---|
| | | reptiles) | |
| | | **Total** | **21** |
| **Genetic diversity** | Genetic varieties | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | Endangered and rare species' genetic variation | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | In-situ and ex-situ conservation | Mammals | 1 |
| | | Flora (Plants) | 1 |
| | | Invertebrates | 1 |
| | | Avifauna (birds) | 1 |
| | | Herpetofauna (Amphibians & reptiles) | 1 |
| | | **Total** | **15** |
| **Indirect integration** | General summarization of the three forest biodiversity components | Any general biodiversity-related components | 1 (max 5) |

*Total scores converted to percentage **Source, Researcher, 2023**

### 3.6.5 Questionnaires

The household questionnaires as detailed in appendix 1 were programmed using the Open Data Kit (SurveyCTO), which is a mobile application software for data collection using smartphones and has the advantage of assigning GPS and photographic images. The survey's household samples were selected through random sampling, this was done using transects that extend 5 kilometers away from the Maasai Mau Forest border.

To obtain more quantitative data, a questionnaire containing both open-ended and closed-ended questions was created and distributed to households in the study areas. Based on the study's

objectives, the questionnaires were divided into four sections. The first section contained the respondent's demographic information, which included their age, gender, educational level, household distance from the forest border, and membership in the local Community Forest Associations (CFAs) or Community-Based Organisations (CBOs); the second section contained questions regarding the first objective, on the various forest management programmes as contained in the study area management plan; the third section contained the specific biodiversity management programmes and the respondent engagement in them; the fourth section comprised of restoration data recorded over 3 years (2019 -2021) and indicators used for monitoring the management, lastly, the respondent recommendation on future interventions and approaches to avert threats to forest biodiversity was established.

### 3.6.6 Key Informants interviews

Key informant interviews (KIIs) were conducted to elicit additional information about the study topic to verify and seek clarity on issues raised in the document reviews and questionnaire survey. **Table 3-1** depicts the distribution of organizations selected purposively based on the MMF-related programs and projects they are implementing. From the organizations, 13 key informants were chosen based on their expertise, involvement in the conservation and management of forest ecosystems, and capacity to provide important research information. The target respondent included officials from the CFAs, the forest station manager from KFS, officers from KWTA, Forest rangers, Biodiversity and conservation personnel from Narok County Government, NGOs involved in the area such as Eden Reforestation Projects, Greenbelt Movement, and Ewaso Ngiro South Development Authority (ENSDA). A checklist of 10 questions as detailed in appendix 2 was generated based on available information and field visits.

**Table 3- 1: Respondents per organisation**

| | **Organization** | **Organization representative (Respondent)** | **No. of respondents per organization** |
|---|---|---|---|
| 1 | Kenya Water Tower Agency (KWTA) | - Regional coordinator<br>- Ecosystem Research Planning officer | 2 |
| 2 | Kenya Forest Service (KFS) | - Forest health and biodiversity conservation officer<br>- Forest manager | 3 |

| | Organization | Organization representative (Respondent) | No. of respondents per organization |
|---|---|---|---|
| | | - Forest rangers | |
| 3 | Kenya Wildlife Service (KWS) | - Biodiversity research officer | 1 |
| 4 | Kenya Forestry Research Institute (KEFRI) | - Regional officer | 1 |
| 5 | Community Forest Association (CFAs) | - CFA officials | 2 |
| 6 | Ewaso Nyiro South Development Authority (ENSDA) | - Regional coordinator | 1 |
| 7 | Eden Reforestation Projects | - Regional coordinator | 1 |
| 8 | Narok County government | - Forest officer | 1 |
| 9 | Greenbelt Movement | - Regional extension officer | 1 |
| | | **Total** | **13** |

**Source: Researcher, 2023**

### 3.6.7 Observation and field records

Observation of some evident management practices within the study areas was made with a particular focus on forest biodiversity. Besides, photography was used to store data that was relevant to the study as well as field notes which recorded additional information of importance while in the field.

### 3.6.8 Data processing and analysis

Before going out into the field to collect data, questions were created following the methodology provided for the study. The data collected was thoroughly evaluated for completeness and quality control, with frequent checks to see if the questions were filled in the correct field or not. Furthermore, confirming that the filled questionnaire contained all of the essential information. The collected data was then uploaded to the R program and advanced excel for analysis.

Data were analysed using descriptive statistics such as percentages and frequency and presented using tables and graphs. The use of frequencies and percentages aided in checking for errors and comprehending the distribution of the study variables. This also involved the use of cross-tabulation with multiple correspondence analysis to establish the link between the forest management programs and the specific biodiversity-related activities integrated.

### 3.6.9 Research ethics

Before commencing this research, several ethical concerns were taken into consideration and well-observed till the end. During the field survey, each respondent was presented with a letter of introduction obtained from the University of Nairobi's Department of Geography, Population and Environmental Studies. In addition to the introduction letter, the researcher presented a letter of consent highlighting the main scope and purpose of the study. The enumerators obtained actual consent from each respondent about their right to be exempt from the study if they felt not appropriate to be interviewed without fear of further consequences. The researcher ensured maximum confidentiality and privacy of data collected from the participants observed and maintained, keeping the views of each respondent anonymous. Upon completion of the project write-up, the researcher ensured that all data collected during the key-informant interviews as well as the document reviews interviews was destroyed to avoid unethical practices.

# CHAPTER FOUR

## RESULTS AND DISCUSSION

### 4.0 Introduction

This chapter presents the study results and findings. The findings are based on data collected between April and June of 2022. It explains the field findings based on the objectives of the study in chapter one. The findings include a review of various documents from stakeholders involved in Maasai Mau Forest management. A review of the forest management programs and the focus related to biodiversity was conducted. The specific programmes and projects related to biodiversity implemented by various stakeholders were considered in the study. To present the findings, various approaches have been used, including the use of graphs, and tables for descriptive analysis.

### 4.1 Forest management programmes prescribed in Maasai Mau Forest

The Maasai Mau Forest block under consideration in this study is managed under the Maasai Mau Forest Ecosystem Conservation Plan [MMECP] 2021-2031 (KWTA, 2021). The MMECP has seven management programs that help address various management issues in the Maasai Mau Forest, including a forest restoration program, a forest protection and law enforcement program, a land management program, a civic education and community governance program, a community development and livelihood improvement program, an ecological research program, and a water resource management and catchment conservation program. The study outlined the management programs and their areas of focus, as shown in **Table 4-1**. The programs were created in response to specific management issues affecting the MMF, with the main challenges being encroachment, illegal logging of indigenous trees, and overgrazing within the forest area

**Table 4-1: Forest management programs prescribed in the MMECP 2021-2031**

| | MAASAI MAU ECOSYSTEM CONSERVATION PLAN | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Forest restoration program** | **Forest protection and law enforcement program** | **Land management program** | **Civic education and community governance program** | **Community Development and Livelihood Improvement Programme** | **Ecological Research Programme** | **Water resource management and catchment conservation program** |
| Program focus | Restore degraded forest land to its original state<br><br>Using appropriate species and technologies, restore the degraded buffer zone | Improve the capacity of joint enforcement units to protect forests effectively.<br><br>Increase the use of technology in forest monitoring and surveillance | Improve farm agroecological practices<br><br>Improve pasture and livestock management practices | Communities' involvement in conservation<br><br>Community benefits from the forest resources<br><br>Bring about collaboration between the government and the community | Improve livelihoods by enhancing nature-based enterprises.<br><br>Create long-term financial resources by applying the payment-for-service principle to forests | Generate and disseminate knowledge through research | Regulate water abstraction and control pollution to enhance water availability<br><br>Improve community institutions to support catchment conservation efforts |

| | MAASAI MAU ECOSYSTEM CONSERVATION PLAN | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Forest restoration program** | **Forest protection and law enforcement program** | **Land management program** | **Civic education and community governance program** | **Community Development and Livelihood Improvement Programme** | **Ecological Research Programme** | **Water resource management and catchment conservation program** |
| Management issues addressed by the programs | Forest and land degradation<br>Logging and charcoal burning of indigenous trees<br>Encroachment<br>Forest fires<br>Loss of biodiversity<br>Overgrazing | Illegal forest activities<br>Ineffective forest protection | Cultivation on steep slopes, soil loss, and soil fertility loss<br>Unplanned grazing and forest degradation<br>Unclear forest boundaries<br>Inadequate knowledge and information on good land management practices | Political interference and community conflicts<br>Inadequate community participation in conservation | Low adoption of information and knowledge on agroforestry and on-farm tree growing | Inadequate information on the ecosystem<br>Information gaps on threatened species in MMF | Illegal water abstraction<br>Catchment degradation<br>Soil erosion in farmlands and riparian land<br>Overgrazing in riparian areas |

**Source KWTA, 2021**

### 4.1.1 Biodiversity conservation and management elements integrated into the management programs

The integration of biodiversity aspects into MMECP initiatives was evaluated. The biodiversity aspects were classified into three levels: species diversity, ecosystem diversity, and genetic diversity. The degree to which these factors were integrated into the seven management programs was evaluated and classified as direct or indirect, as shown in **Table 4-2**.

In terms of direct biodiversity elements, species diversity has been incorporated into the plan, but in a generalized manner. For example, the forest restoration program captures the indicated activities for conserving natural forest cover, including rare and endemic tree species, but no information has been provided about which species are rare and endemic within the forest ecosystem. Furthermore, the forest protection program highlights activities related to forest biodiversity protection without delving into the specific forest biodiversity that requires protection and the mechanisms for protection. Similarly, the ecological research program highlights activities related to improving the conservation status of MMF-threatened species and developing a checklist of species of conservation concern without delving into which species are threatened or are of conservation concern. The scarcity of information makes it difficult to carry out activities and regular species monitoring.

Furthermore, biodiversity at the ecosystem level was reviewed to determine the extent of integration into the plan; the land management program had identified certain clear activities for inclusion, such as forest zonation and mapping biodiversity hotspots. However, the zonation categories have not been explicitly specified, nor have the important biodiversity hotspots that require mapping been articulated. Furthermore, the forest restoration program emphasizes efforts on rehabilitation and adoption of degraded regions, but this has not specified the rehabilitation techniques to be used or the biodiversity that has been degraded or requires rehabilitation. The biodiversity level at genetic diversity had the least information, merely underlining the necessity for in-situ conservation training programs under civic education.

**Table 4-2: Elements of biodiversity integrated into the management programs using BIRI**

| | **Integration of biodiversity conservation and management elements in the forest programmes in MMECP** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Biodiversity elements integrated** | **Forest restoration program** | **Forest protection and law enforcement program** | **Land management program** | **Civic education and community governance program** | **Community development and livelihood improvement programme** | **Ecological research programme** | **Water resource management and catchment conservation program** |
| **Species diversity** | Conserve the natural forest cover including the rare and endemic tree species | Forest biodiversity protection | Enhance natural regeneration and enrichment planting of trees in the reclaimed areas | Create awareness of species diversity and species of conservation importance | Establishing tree nurseries | Enhance conservation status of the MMF threatened species | Promotion of indigenous tree species in water catchment areas |
| | Maintain buffer zone with favourable species | N/A* | N/A | N/A* | Form community wildlife game scouts responsible for monitoring wildlife | Develop a checklist of species of conservation concern; develop best collaborations for species conservation | Planting of species like bamboo on the river banks |
| | Enrichment planting of indigenous trees and uprooting of exotic species through controlled felling plan | N/A* | N/A* | N/A* | N/A* | Routine monitoring of unique wildlife; Implement standardized methods for studying large | N/A* |

| | Integration of biodiversity conservation and management elements in the forest programmes in MMECP | | | | | | |
|---|---|---|---|---|---|---|---|
| **Biodiversity elements integrated** | **Forest restoration program** | **Forest protection and law enforcement program** | **Land management program** | **Civic education and community governance program** | **Community development and livelihood improvement programme** | **Ecological research programme** | **Water resource management and catchment conservation program** |
| | | | | | | carnivores; identify target species forest | |
| | Establish seedling survival rates and undertake beating-up of dead seedlings | N/A* | N/A* | N/A* | N/A* | Tag various species of wildlife to monitor the pattern of movement | N/A* |
| | | | | | | Undertake species/habitat interaction surveys | |
| **Ecosystem Diversity** | Rehabilitate the degraded areas; Adoption of rehabilitation areas; Establish tree nurseries in areas around the forest | Maintain gazetted boundaries; Protect the reclaimed land | Zone the forest and develop grazing plans; | N/A* | Riverine planting programmes; Identify specific catchments | Enhancing ecological conservation; Protection of the habitat for this unique wildlife | Catchment conservation and rehabilitation |
| | Controlled grazing; Determine the carrying capacity of the forest; Identification of grazing areas | Zonation of the restoration area | Map biodiversity conservation hotspots | N/A* | N/A* | Map and protect Wildlife corridors | Map degraded areas in the catchment and riparian areas; |

| | Integration of biodiversity conservation and management elements in the forest programmes in MMECP | | | | | | |
|---|---|---|---|---|---|---|---|
| **Biodiversity elements integrated** | **Forest restoration program** | **Forest protection and law enforcement program** | **Land management program** | **Civic education and community governance program** | **Community development and livelihood improvement programme** | **Ecological research programme** | **Water resource management and catchment conservation program** |
| | | Establish Human-Wildlife conflict hotspots | N/A* | N/A* | N/A* | Conduct security surveillance on target ranges; Enhance identification and protection of hotspot areas | Map out Ecologically Sensitive Areas and secure them |
| **Genetics diversity** | N/A* | N/A* | N/A* | Training programmes on in-situ conservation | N/A* | N/A* | N/A* |
| **Indirect integration** | Sustainable consumption of non-wood forest resources | Increase the number of wildlife security personnel | Establish grazing user group; develop rules and regulations for grazing in the forest through a participatory process | Create awareness and initiate programmes for forest/tree conservation | Identify potential tourism sites | Sensitize the community on the wildlife corridors; | Identify catchment-Catchment mapping and delineation; |

| | Integration of biodiversity conservation and management elements in the forest programmes in MMECP | | | | | | |
|---|---|---|---|---|---|---|---|
| **Biodiversity elements integrated** | **Forest restoration program** | **Forest protection and law enforcement program** | **Land management program** | **Civic education and community governance program** | **Community development and livelihood improvement programme** | **Ecological research programme** | **Water resource management and catchment conservation program** |
| | | Map hotspot areas | | | Build capacity on Carbon Credit projects | Identify wildlife poaching hotspots | |
| | | Patrolling and documentation of illegal activities | Institute proper land management practices | | Introduce Payment for Ecosystem Services | Undertake studies on Human-wildlife conflict | Identify/Establish tree nurseries for rehabilitation |
| | | | | | | Undertake Biodiversity assessment-Comparative studies with previous studies on trends and ecosystem recovery | |

**N/A* – not applicable** **Source KWTA, 2021**

Based on **Table 4-2**, the seven management programs were scrutinized to determine the extent to which biodiversity features were integrated. To rate the level of integration as a percentage, the Biodiversity Integration Rating Index (BIRI) computation was employed, as shown in **Table 3-2** in **Chapter 3**. The biodiversity factors were classed as direct, which included species diversity, ecosystem diversity, and genetic diversity, and indirect which included other generalised biodiversity-related initiatives as indicated in **Table 4-3**.

**Table 4-3: Level of biodiversity elements integrated into the MMF management programmes**

| **Biodiversity indicators elements** | | **Forest restoration** | **Forest protection & law enforcement** | **Land management** | **Civic education & community governance** | **Community development & livelihood improvement** | **Ecological research** | **Water resource management & catchment conservation** | **Percentage integration levels** |
|---|---|---|---|---|---|---|---|---|---|
| **Direct** | **Species diversity** | 68 | 15 | 15 | 20 | 25 | 75 | 35 | **36%** |
| | **Ecosystem Diversity** | 30 | 50 | 36 | 10 | 20 | 50 | 50 | **35%** |
| | **Genetics Diversity** | 0 | 0 | 0 | 20 | 0 | 0 | 0 | **3%** |
| **Indirect integration** | | 10 | 34 | 24 | 15 | 30 | 48 | 25 | **26%** |

**Source, Researcher, 2023**

Concerning the biodiversity factors, all seven management programs listed in **Table 4-1** had broad information that did not define specific species of conservation priority interest or detailed information on ecosystem diversity that required attention, as well as genetic information. However, based on the general information provided, the ecological research program had the highest integration level of all the biodiversity elements, with an average of 43%, while civic education and community governance had the lowest integration level, with an average of 16%, indicating a 27% integration disparity. The species level had the highest integration in the ecological research program (75%), followed by the forest restoration program (68%). The level of genetic diversity was only included in the civic education and community governance program with training activities for in-situ conservation at 16% as shown in **Figure 4-1.**

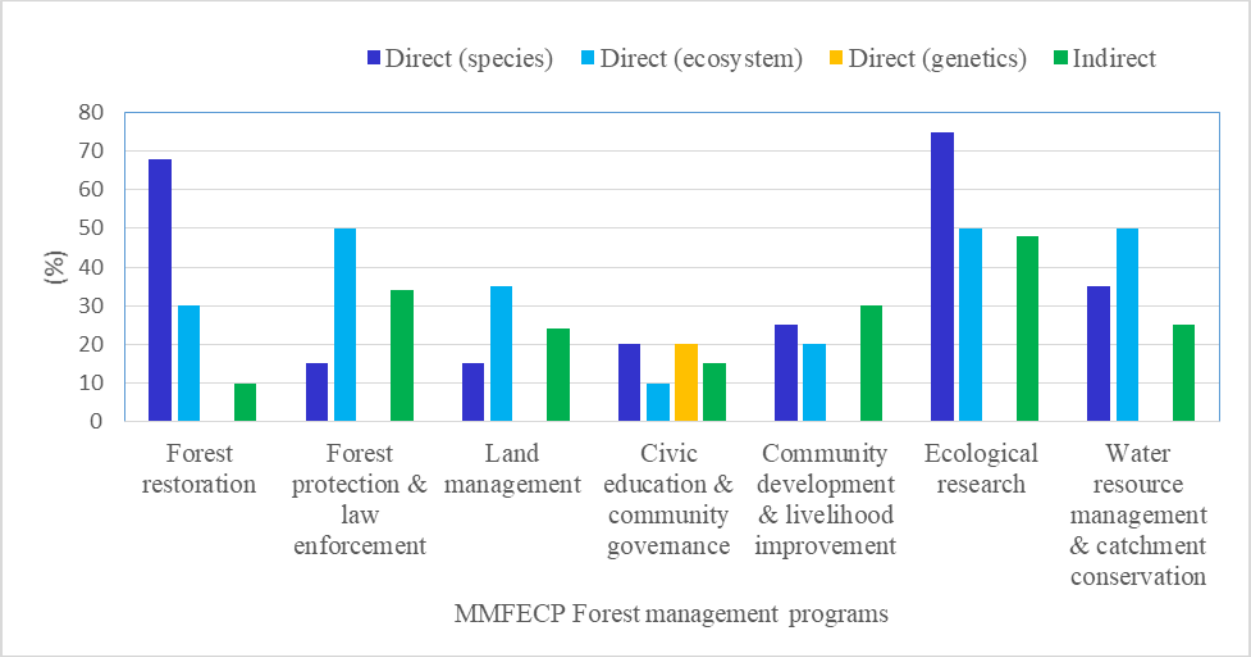



**Figure 4-1. Summary of biodiversity elements integrated into the MMECP management programs**

**Source: Researcher, 2023**

## 4.2 Specific biodiversity management programmes implemented at the Maasai Mau Forest station.

The institutional programs that contribute to biodiversity management and conservation in the Maasai Mau Forest were reviewed. Significant stakeholders participating in the joint management of the forest ecosystem, such as KWTA, KFS, KWS, WRA, CFAs and WRUAs, Maasai Mara University, ENSDA, Greenbelt Movement, and Eden Reforestation Projects, were considered in the study as illustrated in **Plate 4-1.** Stakeholder participation in various initiatives and activities related to biodiversity conservation and management was assessed as indicated in **Table 4-4.** The activities were also rated as a percentage based on the BIRI computation to establish the organization's level of involvement.


**Plate 4-1: Data collection meeting with stakeholders such as the KFS forest manager, forest ranger, and CFA representatives**

**Source: Researcher, 2023**

All of the stakeholders interviewed had a component that contributed to biodiversity management and conservation as shown in **Figure 4-2** in section 4.1.1. The KWTA and KFS had the majority of the biodiversity-related activities, with 60% of the activities being rehabilitation and enrichment planting of indigenous trees, and 55% and 60% of the activities being tree nursery establishment. KFS and KWS were responsible for 70% and 60% of forest and wildlife protection, respectively, as required by law. KWTA (40%), Eden Restoration Projects (30%), and the CFAs (30%) were also active in forest protection through community scouting and patrol actions in the forest.

All stakeholders were involved in ecological studies relevant to biodiversity aspects, either directly or indirectly as shown in **Figure 4-2**. Direct activities addressed the three components of biodiversity, including species, genetic, and ecosystem levels, whereas indirect activities had a distant relationship to the biodiversity elements. KWS received the highest scores of 50% on wildlife research and 60% on wildlife biodiversity monitoring and evaluation for mainly the big five animals elephants, rhinos, buffalo, leopards, and lions some of which were spotted during data collection such as the African bush elephant as shown in **Plate 4-4**. KWTA also had a component of forest biodiversity assessment (30%) during the assessment of the status of the Maasai Mau water tower. Other organizations with less than 20% of the total scores for ecological studies in biodiversity elements include ENSDA, KFS, and Maasai Mara University, while Eden Reforestation Projects, WRA, CFAs/WRUAs, and Green Belt had 10%, primarily during restoration work such as identification of native species to be used for rehabilitation and providing indigenous knowledge on existing biodiversity for the CFAs.

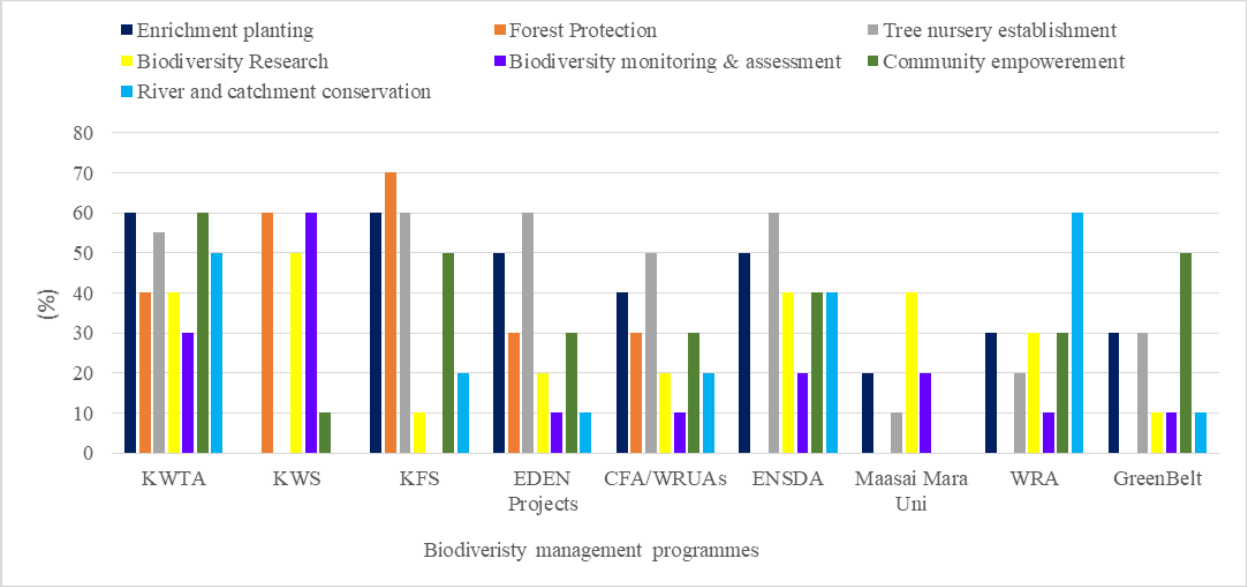



**Figure 4-2. Biodiversity management activities implemented by stakeholders at Maasai Mau Forest**

**Source: Researcher, 2023**

**Table 4-4: Summary of institutions' involvement in MMF management programs relating to biodiversity management.**

| MMF Stakeholders | Forest restoration program | Forest protection and law enforcement program | Land management program | Civic education and community governance program | Community Development and Livelihood Improvement Program | Ecological Research Programme | Water resource management and catchment conservation program |
|---|---|---|---|---|---|---|---|
| KWTA | Forest rehabilitation; Enrichment planting of the indigenous tree; Tree nursery establishment | Fencing of MMF hotspots areas to secure and reclaim land; Recruit and empower community forests scouts | Reclamation of encroached land; Implement forest adoption strategies; Zonation of restoration areas | Training of CFAs on biodiversity conservation | Capacity building and training communities in nature-based initiates related to biodiversity management | Forest area assessment; biodiversity assessment; | Riparian tree planting; Map degraded areas in the catchment and riparian areas and secure them |
| KWS | N/A* | Enforcement and wildlife protection within the protected areas | N/A* | Training of communities on game scouts, human-wildlife conflicts | Training on wildlife campaigns and sensitization on tourism issues | Mammals survey and assessment; | N/A* |

| MMF Stakeholders | Forest restoration program | Forest protection and law enforcement program | Land management program | Civic education and community governance program | Community Development and Livelihood Improvement Program | Ecological Research Programme | Water resource management and catchment conservation program |
|---|---|---|---|---|---|---|---|
| KFS | Forest rehabilitation; Enrichment planting of the indigenous tree; Tree nursery establishment | Enforcement and forest protection of restoration areas | Reclamation of encroached land; Implement forest adoption strategies; Zonation of restoration areas; train on grazing management | Training of CFAs on conservation | Local communities sensitization; Train and implement nature-based enterprises; Sensitize local communities on illegal forest activities | Collaborating with other partners in identifying species within the forest | Riparian tree planting; Conservation of the catchment areas |
| EDEN Projects | Forest rehabilitation; Enrichment planting of the indigenous | Scouts employment and patroling | N/A* | Training farmers on suitable agroforestry practices and | Issuing of indigenous and exotic tree species to farmers for agroforestry program; establishing school woodlots | Indigenous plant species assessment; | Planting indigenous trees in riparian areas |

| MMF Stakeholders | Forest restoration program | Forest protection and law enforcement program | Land management program | Civic education and community governance program | Community Development and Livelihood Improvement Program | Ecological Research Programme | Water resource management and catchment conservation program |
|---|---|---|---|---|---|---|---|
| | tree; Tree nursery establishment | | | efficient charcoal production methods | | | |
| CFA/WRUAs | Forest rehabilitation; Enrichment planting of the indigenous tree; Tree nursery establishment | Enhance community forest policing and patrols | Enforce grazing regulation, and forest zonation | Mobilizing communities for capacity building sessions; Identifying knowledge gaps of local communities on conservation for training | Implementing nature-based enterprise initiatives; Sensitize local communities on illegal activities | Guide and assist in forest and biodiversity research activities; provide indigenous knowledge on existing and history of the forest and biodiversity | Sensitize the community and abstractors on abstraction regulations |

| MMF Stakeholders | Forest restoration program | Forest protection and law enforcement program | Land management program | Civic education and community governance program | Community Development and Livelihood Improvement Program | Ecological Research Programme | Water resource management and catchment conservation program |
|---|---|---|---|---|---|---|---|
| ENSDA | Forest rehabilitation; Catchment rehabilitation with indigenous bamboo species; Tree nursery establishment | N/A* | N/A* | N/A* | Community support & empowerment on conservation issues | Agroforestry program; issuance of exotic tree species to adjacent communities | Catchment rehabilitation with indigenous bamboo species; |
| Maasai Mara Uni | Forest rehabilitation | N/A* | N/A* | N/A* | N/A* | Undertake ecological surveys and assessment | N/A* |

| MMF Stakeholders | Forest restoration program | Forest protection and law enforcement program | Land management program | Civic education and community governance program | Community Development and Livelihood Improvement Program | Ecological Research Programme | Water resource management and catchment conservation program |
|---|---|---|---|---|---|---|---|
| WRA | River and catchment areas rehabilitation; Enrichment planting of indigenous tree | N/A* | Reclaim and map out degraded riparian and catchment areas | Train and capacity build the WRUAs | N/A* | Assessment of riparian status including the biodiversity | Strengthen Water Resource User Associations; Map the water abstraction points; Enforce abstraction laws and regulations |
| GreenBelt | Enrichment planting of indigenous trees; Tree nursery establishment | N/A* | N/A* | Capacity building and training on tree nursery establishment | Local communities sensitization; Implement school greening programs; train and implement nature-based enterprises and promotion of income-generating activities | On-farm tree planting; tree nursery establishment on community land | N/A* |

**N/A*** - not applicable **Source, Organization records; KWTA, 2021**

### 4.2.1 Local community involvement in the management of biodiversity in relation to the MMF management programs

The local community living adjacent to MMF is crucial in assessing biodiversity management within the forest ecosystem. The study considered the community's awareness of MMF management initiatives, as well as their participation in program implementation, particularly activities associated with biodiversity conservation. The community's membership with CFA or WRUA was also evaluated to determine what influenced their participation in the forest biodiversity programs. The study only included community members who lived within 5 km of the forest boundary.

#### 4.2.1.1 Respondents' biodata

Male respondents dominated the survey in terms of gender composition, accounting for 65% of all respondents. The literacy level of the respondents was examined and classified into five groups: primary, secondary, incomplete secondary, university/college, and no formal education. The distribution of education levels was analyzed using frequency scores concerning respondent age categories of 18-35 years, 36-50 years, and 51+ years. This was critical in determining whether their knowledge of MMF biodiversity management programs was influenced by their age or education level. The study found that most of the young respondents between the ages of 18 and 35 had formal education, with more than 40% having secondary and university/college education, resulting in a greater interest in comprehending the content of the MMFECP programs. Responders aged 36-50 years, on the other hand, had the majority of them (83%) with no formal education and 33% with university/college education, as illustrated in **Figure 4-3**.

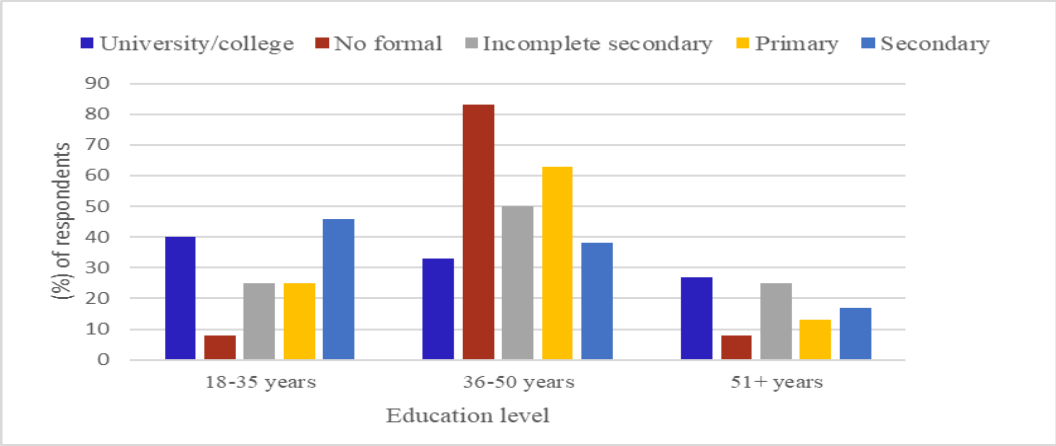



**Figure 4-3 Respondent age distribution in relation to education level**

**Source: Researcher, 2023**

#### 4.2.1.2 Respondent residence distances from forest borders and awareness of the MMF biodiversity-related management programmes

The distance between respondents' households and the forest boundary ranged from 0 to 5 km. There were four distance classifications taken into account: boundary to the forest, between 1-3 kilometers, between 3-5 kilometers, and more than 5 kilometers from the forest border. The study found that over half of those surveyed resided within 3 km of the forest's boundaries. The respondent's housing distance from the forest borders was regarded as a key factor in measuring their awareness of MMF biodiversity-related projects. As illustrated in **Figure 4-4**, community membership to CFA or WRUA was also analyzed in relation to the respondent's residence to identify what influenced their involvement in the forest biodiversity programs.

Regardless of their residence distance from the forest boundary, the study found that around 80% of those interviewed were familiar with the biodiversity programs within the Maasai Mau Forest. This demonstrated that the distance had no effect on the level of awareness of the programs. Respondents living closer to the forest borders (0-3km) were more aware of biodiversity-related initiatives such as rehabilitation efforts, tree nursery establishment, forest conservation through scouting and patrols, and participation in research activities within the forest, among other activities. This level of commitment was primarily due to interactions of community members living near the forest with stakeholders implementing initiatives within the forest. As shown in **Figure 4-4**, the majority of respondents familiar with MMF biodiversity projects were affiliated with community groups such as CFA and WRUAs, with an average rating of 12%, while those who were not involved with any association had an average percentage rating of 7%. The affiliation to the association decreased as the respondent's distance from the forest boundary increased, showing that the further the respondent lived from the forest border, the less active they are with the forest's biodiversity programs.

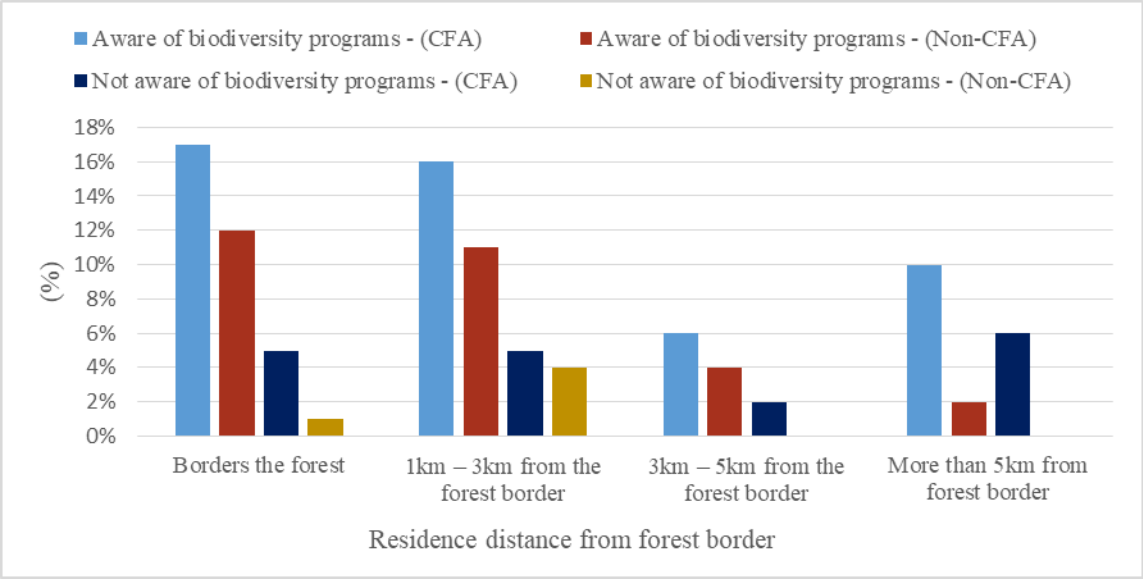



**Figure 4-4. Respondent's awareness of MMF biodiversity-related programmes**

**Source: Researcher, 2023**

#### 4.2.1.3 Respondent involvement in biodiversity management-related programs and activities

All of the respondents who were questioned stated that they participated in various biodiversity-related projects that intended to restore and conserve MMF. The majority of the respondent as illustrated in **Plate 4-2** were engaged in enrichment planting and restoration of degraded forest land with indigenous tree species (90%), and more than half (67%) of the responders had been empowered and actively engaged in on-farm planting of commercial trees such as pine and cypress and fruit trees such as Hass avocado and mangoes. As illustrated in **Figure 4-5**, the study findings demonstrated that as a result of organizations such as KFS and KWTA training and capacity building the local community, 52% of the respondent were actively involved in forest protection with a focus on endangered species and 38% had been trained on forest patrols and community scouting and engaged in it.

Few community members, particularly village elders and CFA officials who were ideally positioned to comprehend the forest's biodiversity dynamics, were active in biodiversity-related research (37%), the contribution of indigenous knowledge about Maasai Mau and its biodiversity (15%), and the zonation of biodiversity hotspots (45%) that necessitated the need for installation of electric fence within the forest.

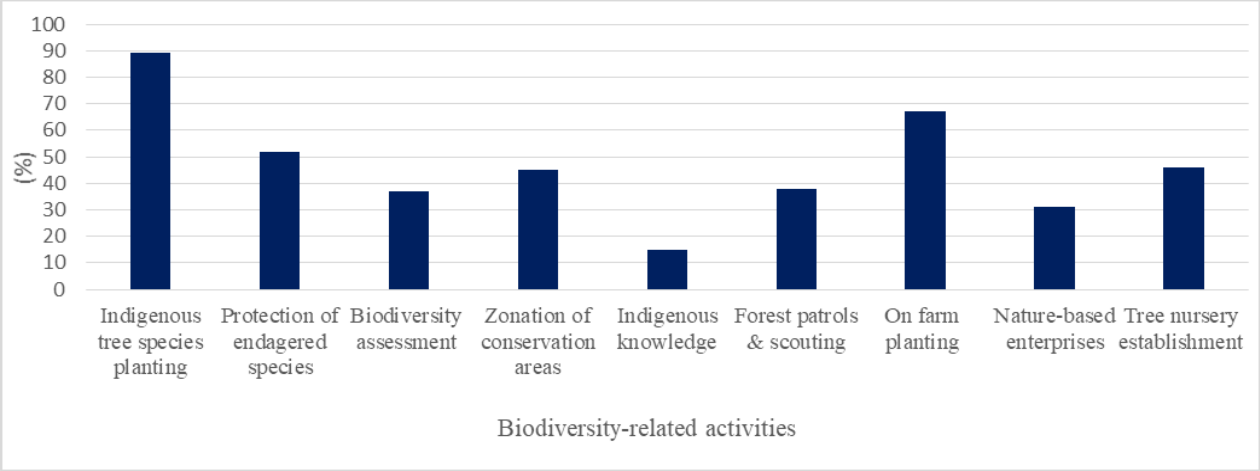



**Figure 4-5. Respondent's involvement in MMF biodiversity-related activities**

**Source: Researcher, 2023**

**Plate 4-2: Community participation in rehabilitation activities within Maasai Mau Forest**

**Source: Researcher, 2023**

### 4.3 Assessing forest biodiversity records from 2019 to 2021 at the Maasai Mau Forest stations

Document examination of records obtained at the Maasai Mau Forest station, including forest restoration activities and other biodiversity assessment data, was conducted. Since 2019, multiple stakeholders have adopted a total of 10,800 hectares of degraded forest area for rehabilitation, with Eden Reforestation Projects adopting the largest area of 5,700ha, followed by KEFRI 3,200ha, which includes aerial seed planting. KFS and KTWA have each adopted 500ha for rehabilitation. KEFRI has planted 100ha of direct seedlings, while ENSDA has adopted 200ha of

riverine habitat for restoration with bamboo species. NEMA, Total Kenya, and Maasai Mara University have each adopted 100ha. **Figure 4-6** depicts the blocks adopted by each stakeholder, a single block with roughly 100 hectares of degraded forest area within the Maasai Mau Forest.

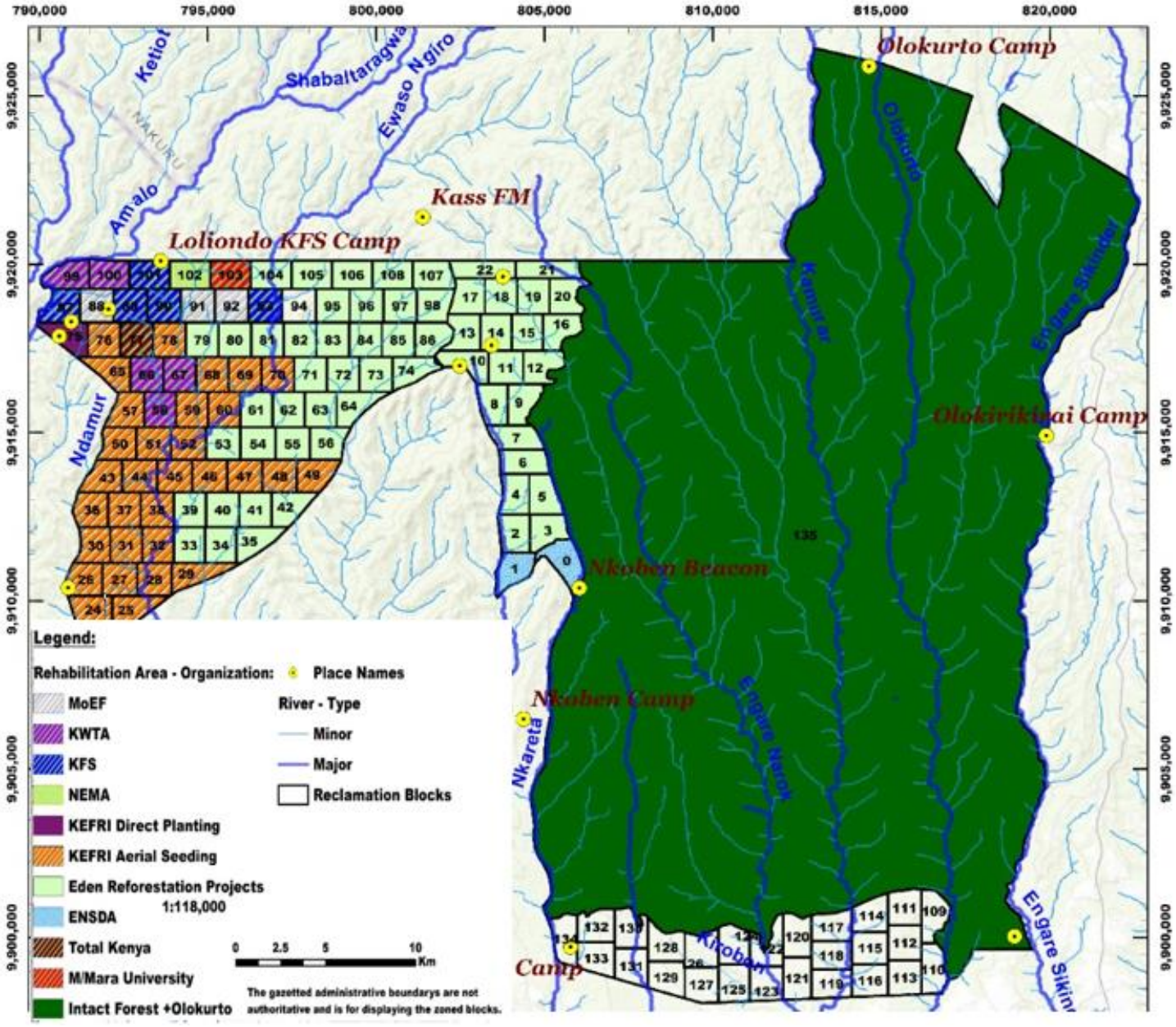



**Figure 4-6: Stakeholders mapping with adopted rehabilitation forest block within Maasai Mau**

**Source KWTA, (2019)**

To improve biodiversity conservation, diverse stakeholders ranging from government institutions to private organizations and corporations planted a total of 2,931,474 indigenous tree seedlings in the Maasai Mau Forest block between 2019 and 2021, as indicated in **Table 4-5**.

**Table 4-5: Maasai Mau Forest restoration activities by organization 2019 to 2020**

| | | No. of seedlings planted (yr.) | | | | |
|---|---|---|---|---|---|---|
| **Organisations** | **Area adopted (2019-2021) (ha)** | **2019** | **2020** | **2021** | **Total seedlings planted per organization** | **% seedlings planted per organization** |
| KFS | 500 | 437,800 | 414,700 | 165,000 | 1,017,500 | 35% |
| KTWA | 500 | 410,000 | 305,000 | 246,250 | 961,250 | 33% |
| ENSDA | 200 | 73,500 | 300,500 | 5,400 | 379,400 | 13% |
| Energy sector companies (Total Kenya, Kengen, Base Titanum) | 100 | 5,000 | 20,000 | 15,170 | 40,170 | 1% |
| NEMA | 100 | 3,500 | 3,000 | - | 6,500 | 1% |
| MoE&F | 400 | 286,000 | - | - | 286,000 | 9% |
| Eden Reforestation Projects | 5,700 | - | - | 229,654 | 229,654 | 7% |
| Maasai Mara University | 100 | - | - | - | - | - |
| KEFRI Direct Planting | 100 | 11,000 | - | - | 11,000 | 1% |
| KEFRI aerial seeding | 3,200 | | | | | |
| **Total** | **10,900** | **1,226,800** | **1,043,200** | **661,474** | **2,931,474** | |

**Source, Researcher, & organization records**

As illustrated in **Figure 4-7**, the year 2019 had the most restoration efforts with 1,226,800 tree seedlings planted, followed by 2020 with 1,043,200 tree seedlings planted, and 2021 with the fewest trees planted with a capacity of 661,474. KFS planted the most seedlings over the period, totaling 1,017,500 tree seedlings, followed by KWTA, which planted 961,250 and ENSDA, which planted 379,400 tree seedlings, with the majority of species being bamboo. Eden Reforestation was the private organization that planted the most trees during this period, with 229,654 tree seedlings. Other organizations involved in the restoration efforts included the MoEF planting 286,000 seedlings, the National Environment Management Authority (NEMA) planting 6,500 seedlings, energy sector companies such as Total Kenya, Kengen, and Base Titanum planting a total of 40,170 seedlings, and KEFRI direct planting of 11,000 seedlings and additional aerial seeding over a 3,200ha area.

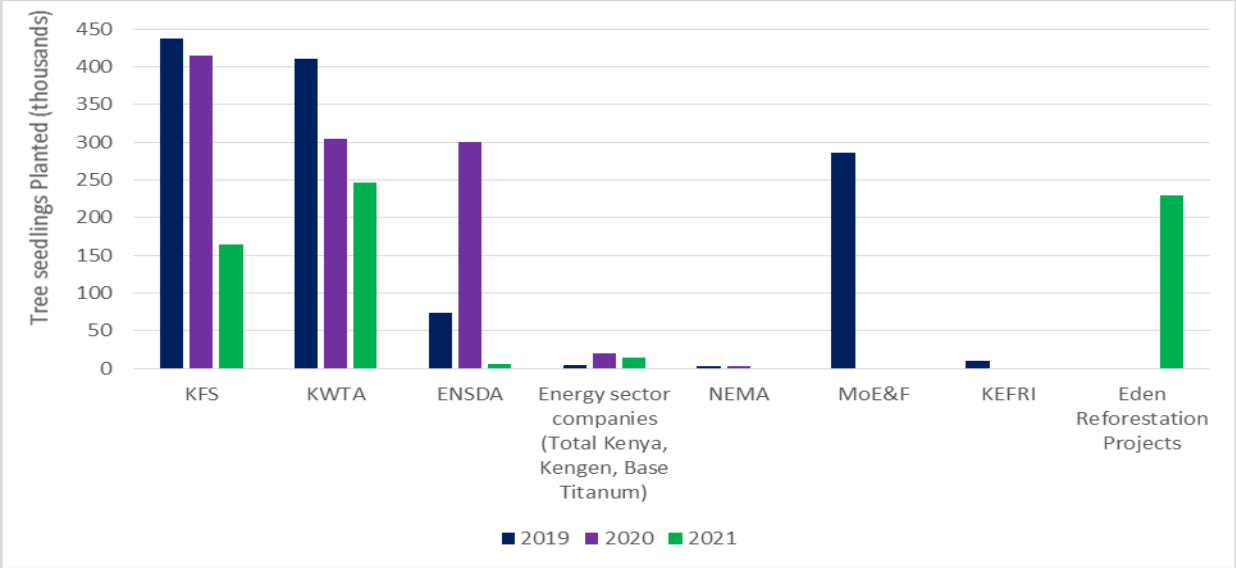



**Figure 4-7. Organization records in the restoration of MMF for 3 years (2019-2021)**
**Source: Researcher, 2023**

Based on reference healthy forest existing species, approximately 47 distinct indigenous tree species were chosen in MMF rehabilitation operations. According to the organization's records, the species were classified based on their zonation inside the forest block, which ranged from the lower zone, primarily riparian areas, to the highest mountainous zone, as shown in **Table 4-6**.

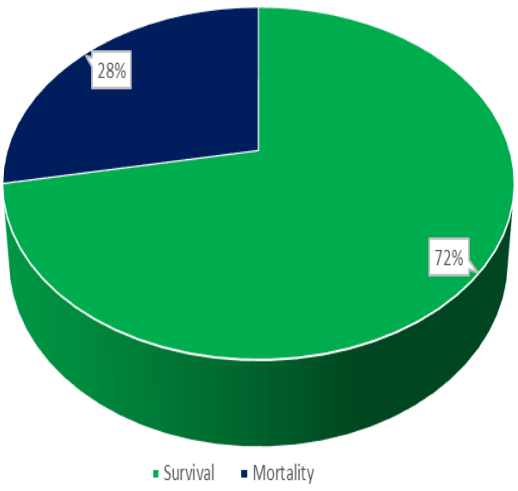
**Table 4-6: Summary of indigenous tree species within MMF as per the forest zonation**

| | Species name | Local name (kipsigis) | Lower zone A. (Riparian/ riverine) | Middle zone B. | Highest zone C. (Rocky mountains) |
|---|---|---|---|---|---|
| 1 | *Afrocarpus latifolius* | Saptet | ✓ | ✓ | |
| 2 | *Agauria salicifolia* | Ortet/borborwet | | | ✓ |
| 3 | *Albizia gummifera* | Seet/Seyet | ✓ | ✓ | |
| 4 | *Allophylus abyssinicus* | Sasuriet | ✓ | ✓ | |
| 5 | *Allophylus rubifolius* | Chepkeleliet | ✓ | ✓ | |
| 6 | *Breonadia microcephala* | Porpornet | | ✓ | ✓ |
| 7 | *Caesseria battiscombe* | Chepchabayet | ✓ | ✓ | |
| 8 | *Cassipourea malosana* | Muagaita | | ✓ | ✓ |
| 9 | *Croton macrostachyus* | Tebeswet | ✓ | ✓ | |
| 10 | *Croton megalocarpus* | Lulukwet | ✓ | ✓ | |
| 11 | *Celtis africana* | Sokwet | | ✓ | ✓ |
| 12 | *Dombeya torrida* | Silibwet | ✓ | ✓ | |

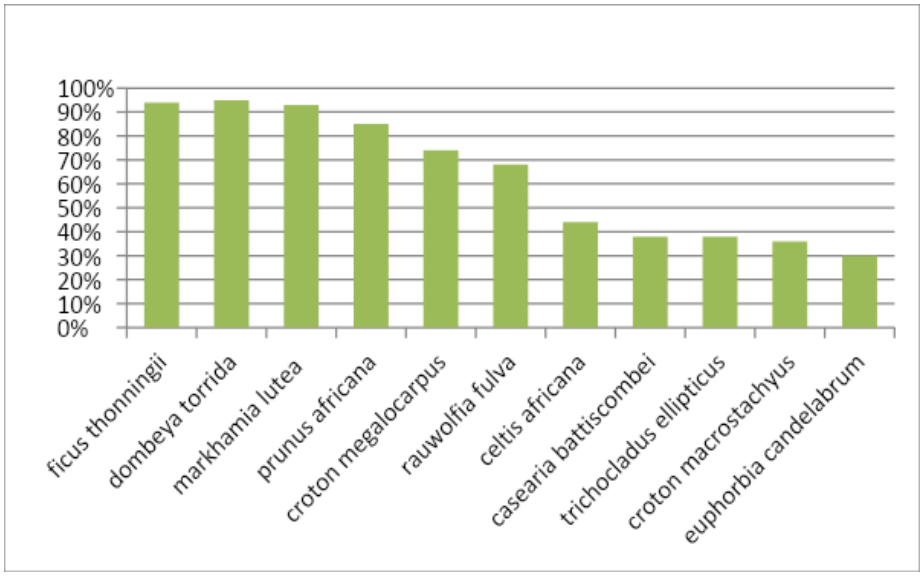
| | Species name | Local name (kipsigis) | Lower zone A. (Riparian/ riverine) | Middle zone B. | Highest zone C. (Rocky mountains) |
|---|---|---|---|---|---|
| 13 | *Dovyalis abyssinica* | Nokiat | | ✓ | ✓ |
| 14 | *Dracaena steudneri* | Lepekwet | ✓ | ✓ | |
| 15 | *Ehretia cymosa* | Mutereriet | ✓ | ✓ | |
| 16 | *Ekebergia capensis* | Araruet | ✓ | ✓ | |
| 17 | *Erythrina abyssinica* | Kipisorwet | ✓ | ✓ | |
| 18 | *Euphorbia candelabrum* | Usuet | | | ✓ |
| 19 | *Ficus sycomorus* | Mogoyuet | ✓ | ✓ | |
| 20 | *Ficus thonningii* | Simotwet | ✓ | ✓ | |
| 21 | *Hagenia abyssinica* | Bondet | ✓ | ✓ | |
| 22 | *Macaranga kilimandscharica* | Logumaita | ✓ | ✓ | |
| 23 | *Markhamia Lutea* | Kibabustaniet | | ✓ | |
| 24 | *Mystroxylon aethiopicum* | Keburwet | | ✓ | |
| 25 | *Neoboutania macrocalyx* | Sapetet | ✓ | ✓ | |
| 26 | *Olea africana* | Emitiot | | | ✓ |
| 27 | *Olea capensis* | Masaita | | ✓ | |
| 28 | *Oncoba spinosa* | Tungurwet | | | ✓ |
| 29 | *Pistacia aethiopica* | Pirigora | | | ✓ |
| 30 | *Pittosporum viridiflorum* | Chemororiet | ✓ | ✓ | |
| 31 | *Polyscias fulva* | Aonet | ✓ | ✓ | |
| 32 | *Prunus africana* | Tendwet | ✓ | ✓ | |
| 33 | *Rauwolfia fulva* | Sitotwet | | | ✓ |
| 34 | *Rhus vulgaris* | Siriat | | ✓ | ✓ |
| 35 | *Schefflera volkensii* | Tinet | ✓ | ✓ | |
| 36 | *Schrebera alata* | Kabigiriet | | ✓ | ✓ |
| 37 | *Sclerocarya birrea* | Sewerwet | ✓ | ✓ | |
| 38 | *Scolopia zeyheri* | Tangururwet | | | ✓ |
| 39 | *Tabernaemontana holstii* | Sitotwet | ✓ | ✓ | |
| 40 | *Tarchonanthus camphoratus* | Lelechuet/leletua | | | ✓ |
| 41 | *Trichocladus ellipticus* | Paragaiwet | | ✓ | ✓ |
| 42 | *Vachellia nilotica* | Chemnyalilyet | | | ✓ |
| 43 | *Vachellia xanthophloea* | Chepitiet | | | ✓ |
| 44 | *Vangueria madagascariensis* | Kimwolwet | ✓ | ✓ | ✓ |
| 45 | *Vepris nobilis* | Kuriot | | ✓ | ✓ |
| 46 | *Warburgia ugandensis* | Soget/Sogoet | ✓ | ✓ | |
| 47 | *Bamboo species* | | ✓ | | |

**Source, organisation records**

The document review records indicated that a high survival rate of 72% of planted seedlings and natural regeneration assessment was reported by the monitoring department of various organisations such as Eden Reforestation projects. Strangler fig *(Ficus thonningii),* forest dombeya *Dombeya torrida, and Nile tulip (Markhamia lutea)* indicated the highest survival rate of 92%, with African cherry (*Prunus Africana)* having 83%, this was mainly because the species were well adapted in the region.




***Species survival and mortality rate***




***Species showing high survival rates***

**Figure 4-8: Tree species survival rate**

**Source: Eden Reforestation Projects, (2021)**

Plate 4-3 (a): wild olive (*Olea africana)*

Plate 4-3 (b): red fruited podo (*Podocarpus Latifolia)*

Plate 4-3 (c):croton *(Croton Megalocarpus)*

Plate 4-3(d): forest dombeya *(Dombeya torrida)*

**Plate 4-3: Good survival of planted tree seedlings from different planted points within the study area**.

**Plate 4-4: African elephant (*Loxodonta africana*) sighted within the study area**

Source: Researcher, 2023

## 4.4 Establishment of future interventions and approaches required to avert threats to forest biodiversity in the Maasai Mau Forest block

The respondents outlined various approaches that would be practical and effective in averting threats to forest biodiversity within the Maasai Mau Forest block. These included restricting livestock grazing capacity (81%), a ban on charcoal burning of indigenous tree species (80%), a ban on illegal logging of indigenous trees (68%), and community awareness and sensitization programs (68%) among other programs as shown in **Figure 4-9**.

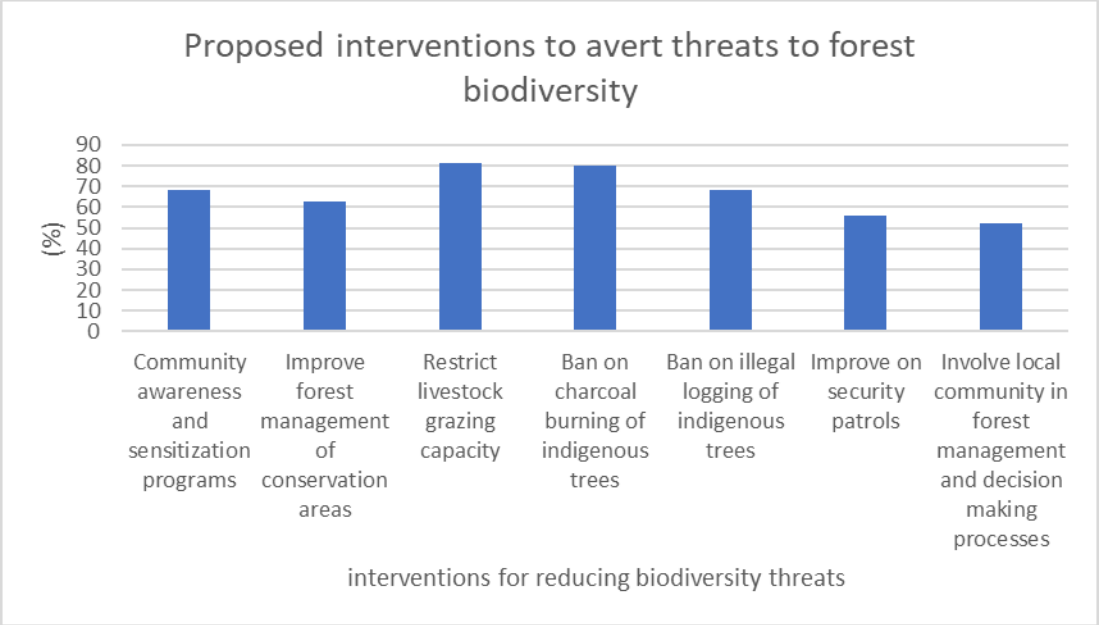



**Figure 4-9: Proposed interventions to avert threats to forest biodiversity.**

**Source: Researcher, 2023**

## 4.5 Discussion

### 4.5.1 Forest management programmes prescribed in Maasai Mau Forest

The study findings indicated seven management programmes being implemented at the Maasai Mau Forest. This is very key as indicated in the study of Boncina (2011), which indicates that forest planning is a significant instrument required to meet the management objectives of a forest ecosystem and the biodiversity conservation status. Boncina (2011) estimates that only 1% of Africa's forest area is managed using a forest plan.

The study by Shah, (2016) on the obligations of MEAs in conserving biodiversity, showed that various ecosystems within Kenya such as Arabuko Sokoke Forest and Amboseli national park have shown significant levels of biodiversity conservation and management geared towards protecting endangered, vulnerable and threatened species in this ecosystem through various organisations such as KWS. This was partly evident in the study, which indicated an integration level of about 35% of biodiversity programmes into the main management programmes within the Maasai Mau Forest.

Ecological research programme had the highest level of biodiversity integration at 75%, this is similar to a study undertaken by Hansson (2000) whose emphasis was the allocation of ecological assessments and evaluation in particular the biodiversity elements at the species level, ecosystem and their genetic variations. Hansson indicates that this emphasis on the allocation of biodiversity assessment is essential in determining suitable and applicable projects and activities geared towards effective biodiversity conservation and management strategies and restriction of threats.

### 4.5.2 Specific biodiversity management programmes implemented at the forest station.

A study by Shah (2016) on CITES showed that various organisations such as KWS and NGOs had highly contributed to creating awareness and continuously educating the general public in regards to biodiversity conservation, especially the big five animals such as elephants and rhinos. This is similar to the study findings which indicated that KWS had the majority score of 50% regarding wildlife biodiversity and activities geared towards the monitoring and assessment of the big five mammals.

The study by Martin *et al*., (2021) found approximately 174 organisations that are involved in reforestation and tree planting activities within the tropics. This included both government and non-government agencies who have taken the initiative of tree planting. KWTA (2021) status report on the Maasai Mau Forest indicates that institutional linkages and strong collaboration have been essential in engaging stakeholders towards reforestation and enrichment planting activities within the ecosystem. This was evident in the study finding as almost all of the organisations engaged in the research had a component of rehabilitation within the Maasai Mau Forest with Native species. KFS and KWTA which are state agencies had the highest score of

60% on enrichment planting with Eden Reforestation Projects a non-state organisation having a majority score of 50%.

The study by Shah, (2016) indicated that programs aimed at biodiversity conservation at the grassroots level in developing countries have been on the increase since 1992 UNCED. The mechanism involving the local community in biodiversity conservation has been attributed to a growth in forest cover and recovering the diversity of species (Malla, 2003). Logan & Moseley, (2001) indicated that livelihood improvement programmes such as ecotourism that integrated the conservation of wildlife in Zimbabwe contributed to high economic development as well as reduced human-wildlife conflicts. The programmes involve educating communities on biodiversity-related training that aims at conserving threatened animal species such as the chimpanzee.

The study findings showed that the majority (75%) of the respondents residing within the Maasai Mau Forest were directly involved in biodiversity-related activities by the various organisations operating within the ecosystem. The major program in which the local communities were involved was the rehabilitation of the forest. The village elders and CFAs officials contributed significantly in guiding the stakeholders on the choice of native species to be planted within the forest, this also involved them acting as key informants in various ecological research undertaken within the forest to generate their indigenous knowledge of the forest. Organisations such as the Greenbelt movement involved the local community in agroforestry programmes through on-farm tree planting, this helped reduce the pressure from the forest as well as improve their livelihood through the fruit and timber trees planted. The state agencies including KFS, KWS and KWTA also trained the community in forest scouting to ensure the safeguarding of the forest and conservation of the biodiversity is enhanced. This finding aligns well with the Kenya National Biodiversity Strategy and Action Plan 2019-2030 (GoK, 2019) Goal 1 strategic target 1, which indicates that by 2030 latest, local communities and the general public are sensitized through the participatory engagement of the biodiversity values and the necessary measures to conserve them.

### 4.5.3 Forest biodiversity records at the forest stations

The study by Martin *et al.,* (2021) established that the mean number of trees planted annually within the tropics has dramatically increased from 2010 to 2020 due to the increasing number of

organisations involved in tree-planting initiatives. 21 organisations within the Martin *et.al* study had adopted approximately 372,000 ha within the tropics for rehabilitation by 2030. This is similar to the study findings, whereby a total of 10,900ha of forest area within the Maasai Mau had been adopted by various organisations since 2019 for rehabilitation. Nearly 3 million trees were planted by various organisations between 2019 and 2021, with KFS as the main state agency mandated for the rehabilitation of forests taking the lead with planting 1,017,500 indigenous tree seedlings during this period.

The majority of the organisation had records of the species planted, although data on several species differed from the organisation. In total, 47 native species were recorded from all the organisations indicating the categorisation of each species' zonation regarding planting. Although the organisations reported a high diversity of native species in total, a majority indicated that they concentrated on species which were easy to propagate and their seeds were easily available. The local communities also indicated that they preferred species to which they easily associated their value including medicinal and livestock fodder benefits. The study did not record the on-farm species used for commercial purposes by the community as this was outside the scope of the research. Only two organisations had a monitoring department which periodically assessed the survival rate of the planted species. Most of the native species were well adapted in the region as illustrated in **Plate 4-3** in the field photos recording a survival rate of above 90% this included *Ficus thonningii, Dombeya torrida and Markhamia lutea.*

In regards to wildlife biodiversity, KWS and KWTA were the only organisations which had programmes involving the assessment of wildlife geared towards their conservation. However, the study found that KWS mainly focussed on the big five mammals namely elephant, rhino, lion, buffalo and leopard. KWTA being the main organisation managing the Maasai Mau water tower had assessed the fauna especially species of international conservation priority within the forest such as the Leopard (*Panthera pardus*), the African elephant (*Loxodonta Africana*), Mountain Bongo (*Tragelaphus eurycerus*), Giant forest hog (*Hylochoerus meinertzhageni*) and the Yellow-backed duiker (*Cephalophus silvicultor*).

The study concurs with Guthiga & Mburu (2008) on the need to reconcile biodiversity conservation interventions with societal goals, by gathering information from the local communities and stakeholders on future approaches that can avert threats to conservation.

# CHAPTER FIVE
# SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 Summary of findings

This study examined how biodiversity-related programs and activities were integrated into the seven management programmes stated in the Maasai Mau Ecosystem Conservation Plan 2021-2031. The study considered the extent of integration of diverse biodiversity elements at three levels: species diversity, ecosystem level and their genetic variation. The degree to which the three levels were integrated was examined as direct or indirect. The study also considered the focus of organisations operating within the Maasai Mau Forest in terms of projects being executed, particularly those linked to biodiversity conservation and management.

According to the study findings, the ecological research program had the highest score of integration levels of biodiversity aspects at both species diversity and ecosystem. This mainly involved studies undertaken by researchers into various biodiversity components within the forest. Through efforts to restore the forest ecosystem with native tree species, the program on forest restoration was also considered to have a high level of integration of biodiversity at the species level.

The study also examined the respondent's awareness of the Maasai Mau Forest management programmes. It revealed that most of the residents who bordered the forest or were less than 5km from the forest borders were members of the local CFA and had come across the Maasai Mau Forest Ecosystem Conservation Plan. This indicated that most of the respondent living adjacent to the forest were aware and sensitized to the ongoing programmes within the forest. This was mainly because, stakeholders opted to interact with the local community living adjacent to the forest for ownership of the restoration activities.

From the document review process undertaken and the key informant interviews, it was clear that the Maasai Mau ecosystem is an area of interest due to the international and national importance of the Mau Forest Complex, with interest from many stakeholders towards rehabilitation efforts of the forest. The majority of the documents especially internal records indicated that community livelihood empowerment was the major programme being undertaken

either through income-generating activities (IGAs). The key informants indicated that community livelihood was a major component towards the successful conservation of forest biodiversity, as empowerment and awareness creation will result in less destruction of the forest.

The study findings establish that forest management programmes implemented have positively impacted forest biodiversity. Most of the respondents indicated that they were engaged in the enrichment planting of indigenous tree species and forest protection through the stakeholders' initiatives. This resulted in secondary forest succession in the area as well as the regeneration of species from the soil seed bank. This finding is similar to Schaltegger & Beständig (2012), who report that various fields' operations can result in either change in species composition, the invasion of allien species, regeneration or succession of species, destruction of ecosystem and loss of biodiversity depending on the magnitude and type of the field operation.

### 5.2 Conclusion

The Maasai Mau Forest ecosystem constitutes of afro montane terrestrial forest which is the repository of vast forest biodiversity and is recognised as a biodiversity hotspot and important bird area. Major tree species recorded in the stakeholders' restoration plans included the Strangler Fig *(Ficus thonningii)* and Parasol tree *(Polyscias fulva)* dominating the riverine, Forest Dombeya *(Dombeya torrida),* Forest velvet false currant (*Allophylus abysinica),* red stinkwood *(Prunus Africana)* dominating the open areas and the most dominant species in the ecosystem, while African wild olive *(Olea Africana)* and small-fruited Teclea *(Vepris nobilis)* dominating the rocky areas.

The goal of incorporating biodiversity programs into existing plans and institutional frameworks is to ensure that forest managers, stakeholder representatives, and forest rangers have a clear knowledge of the type, distribution, and abundance of the ecosystem, species, and ecosystem services within and outside the area under management (Biodiversity Management Bureau, 2017).

Integrating and mainstreaming biodiversity conservation programs into national plans, particularly forest management plans, is critical, and should be prioritized and recognized due to their high values that support and sustain economic development and human well-being. This is a major goal of the Kenya National Biodiversity Strategy and Action Plan 2019-2030 (GoK,

2019), which reaffirms that the underlying causes of biodiversity loss should be addressed in all decision-making processes. The values of biodiversity should be incorporated into institutional frameworks such as national and county poverty reduction initiatives, development plans, and frameworks.

Countries such as Sri Lanka have ensured that relevant and effective biodiversity conservation measures are incorporated into the country's planning processes. This process of planning ensures that representative species and ecosystems are represented in conservation systems (IUCN, 2018a). According to the study findings, this component is not adequately integrated into the Maasai Mau planning processes or the various parties involved. The stakeholder's focus is more on community empowerment and improving local livelihoods. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019), the inclusion of biodiversity priority in conservation plans and forest management programs is crucial to sustaining local livelihoods and enhancing economic development at the local and national levels.

According to research done by Kaimowitz and Sheil (2007), a large portion of the forest's biodiversity, including its products and services, are necessities that the local community uses to support its well-being. As a result, development plans and other planning processes should consider this. According to Sachs and Reid (2006), it is essential to incorporate biodiversity conservation programs into regional and local plans to ensure that conservation priorities are explicitly acknowledged for their purposes. This will help to support development and conservation needs in a balanced manner with fewer conflicts over land allocations.

## 5.3 Recommendations

### 5.3.1 Recommendation for policy and programmes

The need for intensifying efforts to mainstream biodiversity goals across government-sector decision-making processes, including those unrelated to tackling biodiversity challenges, is crucial for conservation. Furthermore, the integration of biodiversity conservation programmes into the PFMPs and FMPs. Additionally, the use of international mechanisms to provide opportunities that encourage the sustainable utilization of forest ecosystems and promote biodiversity conservation is required.

The government need to strengthen biodiversity research by enhancing institutional capability, increasing research funding, and allocating more resources for the dissemination of biodiversity conservation knowledge. Furthermore, the government should strengthen the science-policy interface by regular monitoring and dissemination of biodiversity indicators to inform decision-making processes, as well as incorporate measures for the management, prevention, and recognition of invasive alien species in national legislation, institutional programs, and budgetary allocation.

### 5.3.2 Suggestions for management

There should be increased efforts aimed at strengthening community participation in conservation activities. This will be linked to the Aichi biodiversity target 1 on raising awareness of biodiversity including the use of formal mechanisms such as workshops training, giving incentives and campaigns on the benefit of biodiversity. Additionally, enhance the dissemination of biodiversity-related research findings and data collection to aid in the achievement of the Aichi Biodiversity Targets and Sustainable Development Goals.

### 5.3.3 Recommendation for further research

Further research is recommended for the following identified gaps

a) Assessment of the status and trends of biodiversity within the Maasai Mau and larger Mau Forest complex
b) Comprehensive analysis to determine the impact of management practices on biodiversity.
c) Evaluation of the implementation and achievement of the Aichi Biodiversity Targets across the Maasai Mau Forest and other indigenous forests within the country
d) Comparative assessment of invasive alien species and the threat they pose to forest biodiversity in particular within the study area

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# LIST OF APPENDICES

**1: Household questionnaires**

**ASSESSING THE MANAGEMENT OF FOREST BIODIVERSITY IN MASAI MAU FOREST. QUESTIONNAIRE**

**General Information**

Forest ecosystem: **……..…..** County **……**

Date: **……** Geo location **……**

**A. Biodata**

1. Gender (select one) ☐ {1}Male ☐ {2}Female
2. Age (select one):

| Group in years | 18-35 | 36-50 | 51+ |
|---|---|---|---|
| (Tick one) | ☐ {1} | ☐ {2} | ☐ {3} |

3. Respondent literacy level (select_one):

☐ {1} Illiterate
☐ {2} Primary
☐ {3} Secondary
☐ {4} Incomplete secondary
☐ {5} Higher

4. Respondent main occupation (select_multiple)

☐ {1} Charcoal production
☐ {2} Farming including large scale and subsistence
☐ {3} Livestock keeping
☐ {4} Salaried employee
☐ {5} Commercial tree growing
☐ {6} Tree seedlings/nursery production
☐ {7} Bee keeping
☐ {8} Others ……..

5. Respondent home's distance from the forest boundary

☐ {1} Borders the forest
☐ {2} 1km – 3km from the forest border
☐ {3} 3km – 5km from the forest border
☐ {4} more than 5km from forest border

6. (a) Are you a member of a CFA or CBO?

{1} Yes {2} No

7. (b) If yes, Are you involved in any forest user groups under the CFA or CBO

{1} Yes {2} No

8. (c) if yes, which user group?

{1}Tree Nursery/Seedling production
{2} Bee Keeping
{3}Grazing
{4}Herbalist
{5} Forest protection scout
{6}Others ……..

**B. Forest Management Plans and Programmes**

9. (a) Have you come across the Maasai Mau Ecosystem Conservation Plan?

1} Yes {2} No

10. (b) If yes, were you involved in the development and implementation of the plan?

{1} Yes {2} No

11. (c) Does the Forest management Plan address the needs and interests of the local community? (select one):

{1} Yes {2} No {3} Don't Know

12. Which forest management programmes are you involved in (select_multiple)

{1} Forest restoration program
{2} Forest protection and law enforcement program
{3} Land management program
{4} Civic education and community governance programme
{5} Community development and livelihood improvement program
{6} Ecological research program
{7} Water resource management and catchment conservation program

**C. Forest Biodiversity related programmes**

13. (a) Are you engaged in any specific biodiversity-related programmes or activities?

{1} Yes {2} No

14. (b) If yes, which ones

{1} Protection of endangered species

- [ ] {2} Indigenous tree species planting
- [ ] {3} Assessment and monitoring of forest biodiversity
- [ ] {4} Zonation of biodiversity conservation areas
- [ ] {5} Contribution of Indigenous knowledge on MMF forest biodiversity
- [ ] {6} Tree nursery establishment
- [ ] {7} Involvement in nature-based enterprises.
- [ ] {8} Involvement in on-farm tree planting
- [ ] {9} Forest scouting and patrols

15. What are the management issues affecting the forest biodiversity conservation?

- [ ] {1} Illegal logging
- [ ] {2} Charcoal production,
- [ ] {3} Lack of awareness and inadequate community involvement,
- [ ] {4} Encroachment for agriculture,
- [ ] {5} Livestock grazing
- [ ] {6} Wildlife poaching
- [ ] {7} Insecurity and tribal conflicts
- [ ] {8} Don't know

16. What approaches would be practical and effective to reduce this threat to biological integrity?

- [ ] {1} Community awareness and sensitization programs
- [ ] {2} Improve forest management of conservation areas.
- [ ] {3} Restrict livestock grazing capacity
- [ ] {4} Ban on charcoal burning of indigenous trees
- [ ] {5} Ban on illegal logging of indigenous trees
- [ ] {6} Improve on security patrols
- [ ] {7} Involve local community in forest management and decision making

**"I Thank You For Your Time And Help In This Research Questionnaire. I Wish To Reaffirm That This Information You Have Provided Shall Remain Confidential."**
**Thank You for Your Co-Operation!!!**
**God Bless You**

**2: Key informant interview and document review guide**

**Key Informants interview guide**

1. Which organisation do you represent and what is your role
2. Are you involved in the management and conservation of Maasai Mau Forest ecosystem
3. Have you aware of the Maasai Mau Ecosystem conservation plan 2021-2031 or the Maasai Mau Strategic Plan 2015-2020
4. What are the main areas of biodiversity conservations concern and priority does your organisation focus on in MMF
5. Which biodiversity related activities and projects have you undertaken in the past 3 years?
6. Do you have a restoration plan for the MMF
7. Which other organisations do your organisation collaborate with in the management and conservation of MMF with this region
8. What extent do you involve the local communities and CFA living around MMF in your programmes related to biodiversity?
9. What are the main challenges in the implementation of the biodiversity-related programmes and the MMFECP in general?
10. What are the main challenges in running the management plan over the past decade?

**Document review guide**

Thematic areas addressed included

1. Main management programmes outlined in the MMFECP
2. Focus areas and management issues addressed
3. Specific biodiversity-related programmes or activities outlined in the MMFECP, organisations record, restoration plans and reports
4. Records of forest biodiversity reported in the various organisation
5. Who are the key players or organisation involved in the implementation of the MMFECP management?
6. Document relevance in terms of biodiversity aspect integration specifically the species diversity, ecosystem diversity and their related genetic diversity
7. Records of rare, threatened or representative species and ecosystems, as well as stands for preservation of the forest genetic resources.
8. Record on forest zonation of biodiversity conservation areas and species-site matching records
9. Records/reports on inventory procedures, monitoring and evaluation framework for forest biodiversity and species of conservation concern and priority

**Appendix 3: Department letter and research permit**

**UNIVERSITY OF NAIROBI**

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25th January 2021

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**RESEARCH PERMIT: CAROLINE KERICHU– C50/12463/2018**

This is to confirm that the above named is a Masters student at the Department of Geography and Environmental Studies, University of Nairobi. She is pursuing Master of Arts in Biodiversity and Natural Resource Management.

She is currently undertaking a research project titled: **"Assessing the Management of Biodiversity Management in Gazetted Forest Ecosystems. Case of Eburu Forest Reserve in Maasai Mau National Reserve."**

Any assistance accorded to her will be highly appreciated.

CHAIRMAN
Department Of Geography
Environmental Studies
UNIVERSITY OF NAIROBI

**Dr. Boniface Wambua**
**Chair, Dept. of Geography and Environmental Studies**

REPUBLIC OF KENYA

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# RESEARCH LICENSE

This is to Certify that Ms.. CAROLINE KERICHU of University of Nairobi, has been licensed to conduct research in Nakuru, Narok on the topic: ASSESSING THE MANAGEMENT OF BIODIVERSITY IN KENYAN GAZETTED FOREST ECOSYSTEMS: CASE OF EBURU AND MASAI MAU FORESTS for the period ending : 28/January/2022.

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