A Citizen Science-based Conservation of Threatened Biodiversity Through Protection of Sacred Natural Sites in Makueni, Kenya

A Technical Report submitted to the Rufford Foundation (United Kingdom) and the East African Herbarium, Botany Department, National Museums of Kenya

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Colophon

This report, *A Citizen Science-based Conservation of Threatened Biodiversity Through Protection of Sacred Natural Sites in Makueni, Kenya* was prepared by the authors listed below. It provides an in-depth exploration of the ecological significance of sacred groves, highlighting their critical role in preserving endangered species and enhancing biocultural conservation efforts.

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The report was produced using Microsoft Word for text composition, Adobe Illustrator for data visualization and graphics, and ArcGIS for geographic analysis. The document is formatted for optimal readability, with Times New Roman (12 pt) for body text and Times New Roman (14 pt) for headings to ensure clarity and accessibility.

The findings in this report are based on extensive fieldwork conducted between 2023 and 2024 across the different ecological zones of Makueni Subcounty, Kenya. This report is an outcome of project 41639-B, supported by the Rufford Foundation (United Kingdom) through the Nature Conservation Fund, under the 1st Booster Grant scheme. It was carried out in close collaboration with local communities, whose traditional ecological knowledge and stewardship are essential in safeguarding these ecologically and culturally significant landscapes.

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Cover Photo Description
The cover photo thumbnail highlights a boulder-strewn hillside of Nzaui Sacred Hill Forest (Top) in Makueni County, believed to be the birthplace of the Kamba community. At the base lies the Mulata Legendary Rock, bearing ancient footprints of Kamba ancestors and their ldomesticated animals. **Bottom Left:** The degraded Kalinde Sacred Grove. **Bottom Center:** Members of the Katituni S.H.G. attending their *Brachiaria* pasture nursery. **Bottom Right:** Traditional log hives hung on *Ficus* sp.

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Dedication

To Susan Mulike Musyimi (*Grandmother to the first author*) and whose life journey has been a testament to the co-existence of tradition and modernity. You have walked the path of time, embracing the wisdom of the past while welcoming the transformations of the present. Through you and others, we have witnessed sacred groves as places where faith and nature intertwine. Through such devotions, we have learned that sacred sites represent more than places of worship because they manifest ancestral knowledge along with moral obligations for Earth stewardship.

To the Nzaui-Makuli landowners, who continue to embrace ancestral teachings through which they preserve their sacred relic patches by resisting increasing pressures to repurpose the land. Your freeholder dedication demonstrates faith, through silent, but powerful vows to protect Earth for generations to come.

To the local communities, you deserve immense praise because you have acted as devoted guardians of these sacred landscapes for years despite increasing difficulties. You have sustained threatened biodiversity through your actions which protects ancestral wisdom and maintains sacred groves as life, faith sanctuaries and cultural hubs. Your outstanding dedication demonstrates that protecting nature is a sacred calling to defend the heritage, identity and spiritual essence for future human generations.

May this work be a tribute to all of you—a celebration of your dedication, a call for continued guardianship, and a heartfelt acknowledgment of the legacy you uphold.

Acknowledgement

The achievement of this project is attributable to continued collaboration, shared purpose, and the inestimable input of individuals and institutions that contributed their expertise, resources, and commitment at each phase of its realization. We express our sincerest appreciation to everyone who participated in this undertaking either through active involvement, technical advice, logistic backing, or by creating the enabling environment that resulted in the project's success.

Above all, we are forever grateful to the Rufford Foundation (United Kingdom), whose financial support was the essence of this project. Your trust in our project's vision, grassroots efforts, and dedication to nature conservation have enabled and amplified the impact of our work. It has empowered us to turn ideas into tangible results, and for that, we are sincerely grateful. We also express our particular gratitude to the National Museums of Kenya (Nairobi), our primary collaborator and host institution. Your institutional knowledge base, scientific expertise, and logistical support were crucial at every stage—from planning to implementation. The direct involvement of your staff added immense value to our research process. Your professionalism and dedication assisted in shepherding the project through practical challenges, ensuring it remained focused, responsive, and impactful.

To the Makueni County Government, through the Departments of Environment and Culture, we appreciate you most sincerely for your organizational backing in promoting the initiative at the county level. Your efforts to align the project with local policy priorities ensured broad-based relevance and public engagement. By endorsing public awareness activities, you anchored the project within the local governance framework. This helped translate it into meaningful community benefits. Our sincere appreciation also goes to the Kenya Forest Service (KFS) for the permission to access sites under your jurisdiction. These areas, bio-culturally significant, were central to our project. Your collaborative approach and ongoing support for Participatory Forest Management created an atmosphere of mutual respect and knowledge exchange, allowing us to carry out our work sensitively and responsibly.

We are deeply thankful to the local communities and administration for your willingness to share knowledge, and grant us access to the study sites. Therefore, this project achievement is as much yours as it is ours since you dedicated some of your time and resources to us. We are incredibly thankful for your selfless deeds. To the project team, thank you for your admirable commitment, coordination, and integrity. Your discipline from inception to decommissioning ensured execution that exceeded expectations. To my referees; Professor Stanley M. Makindi, Professor Mohamed Hamdy Amar, and Dr. M. Ngumbau, your mentorship was priceless.

Finally, to anyone inadvertently left unmentioned, please accept this as a sincere note of appreciation. Your contributions, seen or unseen, were vital to the success of this project. We remain deeply thankful.

Preface

The conception of this project is deeply rooted in the stories my grandmother told me and whose teachings significantly influenced my knowledge of the sacred natural sites within our community. One of the most significant among them was the creation story of the Kamba community, tied to the Nzaui Sacred Hill (within the study site). Even today, evidence of these stories endures in the form of legendary rock, where the footprints of our ancestors and their livestock remain visible. Through her storytelling, I understood the religious significance of sacred groves and the deep respect and reverence they commanded within our community.

With storytelling finesse, she linked our obedience, or lack thereof, to moral tales that, while often fictitious, were deeply instructive. She frequently told us about spirits (*Aimu/Maimu*) protecting sacred groves since they would not allow anyone to pass by after dark. While once rooted in fear, these beliefs instilled a sense of environmental stewardship, teaching us to preserve these sacred spaces from encroachment and destruction. One story, in particular, told of how women's workgroup (*mwethya*) sheltered rain within a sacred grove, only for the grove to swallow them whole, forming a permanent spring locally referred to as *Kitho*—a reliable source of water even today. For a long time, such beliefs prohibited using plastics, metallic containers, or any structural modification. The beliefs sought to encourage the maintenance of the water's natural flow.

As I grew older, I realized some beliefs attached to these sacred sites were not entirely factual. I came to appreciate their inspiration for ecological and cultural stewardship. The fear and reverence for these sites were not simply hinged on myth but were mechanisms of environmental preservation, discouraging human encroachment and destruction. In this way, my grandmother's stories instilled in me the belief that actual knowledge begins with reverence, respect for nature, and understanding its intrinsic value.

This report is timely, as the destruction of sacred groves in our region has reached alarming levels. It is an urgent call for the conservation of these sites as cultural landmarks and vital contributors to biodiversity. Through a renewed understanding of the connection between these sacred sites and environmental sustainability, particularly within the framework of Judeo-Christian eco-theology, we seek to reframe sacred groves as integral to protecting nature. This is not an effort to propagate and pmote idolatry but rather to encourage a balanced view that values both cultural heritage and ecological preservation. The report advocates for the protection and restoration of sacred groves as key assets in the conservation of biocultural heritage. By reframing these sites as eco-tourism assets, we aim to make them accessible to a broader audience, fostering understanding and support for their protection. Hopefully, this work will help align stakeholders' priorities and inform policies that will guide the sustainable management of sacred natural sites in Makueni County and beyond.

By
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08-04-2025

List of Acronyms and Abbreviations

a.s.l.	Above Sea Level
APG	Angiosperm Phylogeny Group
ASALs	Arid and Semi-Arid Lands
CBA	Cost Benefit Analysis
CBC	Competency-Based Curriculum
CBD	Convention on Biological Diversity
CECM	County Executive Committee Member
CIS	Culturally Important Species
CITES	Convention on International Trade in Endangered Species
CKS	Cultural Keystone Species
CSS	Culturally Significant Species
EAH	East African Herbarium
ENSO	El Niño Southern Oscillation
FGDs	Focused Group Discussions
GBF	Global Biodiversity Framework
GEBs	Global Environmental Benefits
IKBFs	Indigenous knowledge-based weather forecasts
ILK	Indigenous and local knowledge systems
IPLCs	Indigenous People and local communities
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
KFS	Kenya Forest Service
KIIs	Key Informant Interviews
Ksh	Kenya Shilling
KTB	Kenya Tourism Board
NbS	Nature-based Solutions
NBSAP	National Biodiversity Strategy and Action Plan
NGOs	Non-Governmental Organizations
nMDS	Non-metric Multidimensional Scaling
NMK	National Museums of Kenya
OECMs	Other Effective area-based Conservation Measures
POWO	Plants of the World Online
ROAM	Restoration Opportunities Assessment Methodology study
ROI	Return on Investment
SGR	Standard Gauge Railway
SHG	Self Help Group
SNSs	Sacred Natural Sites
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TEK	Traditional Ecological Knowledge
ToTs	Training of Trainers
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WRI	World Resources Institute

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EXECUTIVE SUMMARY

General Introduction: Nature conservation has been part of cultural norms, especially among rural communities across the world. Sacred Natural Sites within the *Combretum*-wooded grassland of Makueni Subcounty manifest as groves (*Mathembo*), sacred hills, mystical caves, springs, and legendary rocks and serve as repositories of the community's rich biocultural heritage. They are safe havens for threatened biodiversity and locals' treasured sources of herbal medicine, vital food supplements, water, nutritious wild fruits, and other products of equal importance. Despite fading cultural values, traditional beliefs, taboos, and totemic restrictions have long protected these sites. Although their cultural importance is relatively appreciated, their ecological significance remains unknown, mainly necessitating further studies. Seventeen sacred sites were identified and mapped within the Nzaui-Makuli landscape. While 18% of these sites are legally protected within gazetted forests, the majority (82%) are within community lands, thus vulnerable to external pressures.

Community Perception: The local community's attitudes towards sacred sites vary significantly, with many perceiving them as irrelevant and idle lands. This perspective often differs by age, with older people acknowledging their cultural importance while younger generations remain unaware of their biodiversity value. Surprisingly, many people associate these sites with great fear rather than respect and reverence, mainly due to the superstitions and beliefs that have historically surrounded them, overshadowing their potential biocultural significance. Importantly, the majority believe that their value can be enhanced through eco-tourism.

Plant Diversity: A total of **253 plant species**, from **162** genera and **61** families, were documented across the **17** sacred sites, presenting the first comprehensive checklist of flora associated with sacred groves in the region. Most recorded species were shrubs and trees, signifying a complex, multi-layered structure with diverse ecological niches that provide shelter and sustenance. *Ficus* species were the most prevalent, reflecting the longstanding cultural tradition of establishing sacred sites under these species. This inventory underscores the vital role of these sites in biodiversity conservation. Remarkably, species such as *Cola greenwayi* var. *keniensis*, *Oxyanthus goetzei* subsp. *keniensis* and *Craibia brownii* are reported here for the first time, representing new regional records. Also, this suggests great potential for further botanical discoveries. According to IUCN criteria, 11 species (4.35%) were identified as of conservation concern, including critically endangered species like *Dorstenia arachniformis* and *Aloe ngutwaensis*, recently discovered in the area. However, a significant proportion of species (44%) are not assessed under IUCN criteria, suggesting that additional species may be at risk, particularly *Cola greenwayi*, which have extremely restricted Extent of Occurrence (EOO) and Area of Occupancy (AOO). The presence of 10 species listed under CITES Appendix II, including *Osyris lanceolata*, *Dalbergia melanoxylon*, various orchids, and *Aloes*, further highlights the importance of these sacred groves in safeguarding vulnerable plant species. Additionally, 22 plant species (8.7%) were identified as Culturally Significant Species (CSS) among the Kamba community, often used in establishing sacred groves or performing rituals. Therefore, these sites hold great biodiversity potential, highlighting the urgent need for sustainable management and enhanced protection.

Bird Diversity: A total of 109 species and 680 individuals from 41 families were documented across 13 sacred sites. Matooi Mystical Cave, Kwa Sammy, and Syuvinda Sacred Groves were the most species-rich sites. All surveyed sites exhibited a high degree of species evenness, ranging

from 0.85 to 0.96, indicating a balanced ecosystem. However, the dominance of forest visitors (f) (88%) over forest specialists (4%) suggests a shift towards a more generalist-dominated avian community, often indicative of a degrading ecosystem. Forest specialists (FF), which rely on intact and undisturbed forests, were few, while forest generalists (F), capable of thriving in disturbed environments, were also in low numbers. This suggests that the forests are either highly degraded or lack transitional habitat features such as secondary growth, diverse vegetation layers, or edge habitats. Regarding feeding guilds, the bird community was dominated by insectivores (38%) and omnivores (32%), indicating a working, albeit possibly fragile, ecosystem; however, these could be threatened by further habitat degradation. The comparatively low representation of nectarivores and frugivores suggests that plant diversity and the ecosystem's stability are under threat, further necessitating the restoration of plant diversity. Hindes Babbler (*Turdoides hindei*) was identified as the only species of conservation concern within the sacred sites. This Kenyan endemic bird is globally threatened and classified as Vulnerable under the IUCN criteria. Notably, the sighting of this bird within the Kithuma sacred grove in Miaani Village (Kalamba location) marks its southernmost documented range, further extending its known distribution. Habitat loss/degradation, alongside the introduction of *Eucalyptus* monoculture plantations, are some of the primary threats to bird species in the region.

Butterfly Diversity: The study recorded 57 butterfly species and 387 individuals across eight sacred groves in the Nzaui-Makuli Landscape. All the species recorded belonged to the five butterfly families known from Kenya, including Nymphalidae (37%), which had the highest species composition, followed by Pieridae (26%), Lycaenidae (16%), Hesperiidae (14%), and Papilionidae (7%) had the least species composition. Matooi mystical cave was the most species-rich and abundant, owing to the relatively large habitat with minimal disturbance. Kwa Kalinde and Kwa Lilya had fewer species richness and abundance due to degradation from frequent grazing. Most of the documented butterflies were generalists, though some exhibited specific habitat preferences. For instance, *Papilio dardanus* is typically found in riverine forests, while *Graphium leonidas* lives within transition zones between forest and savanna ecosystems. Similarly, *Junonia natalica*, normally considered a forest species, was unexpectedly recorded in open areas, far from its usual forest habitat. This phenomenon, where forest-dependent species are found in more open or disturbed areas, can be attributed to their mobility and ability to tolerate habitat disturbance. Such behavioral flexibility allows these species to persist and adapt to changing environments, reflecting their resilience in response to ecological changes. Notably, *Papilio nireus*, *Papilio demodocus*, and *Papilio dardanus* from the Papilionidae family were observed and documented within the sites with abundant host plants, particularly from the Rutaceae plant family like *Clausena anisata* and *Teclea*. The striking appearance of these butterflies presents an opportunity for butterfly-based enterprises, including eco-cultural tourism from fast-growing towns like Wote, also strategically located along the Mombasa and Nairobi highway. This could help generate local and international market opportunities, benefiting the community while supporting conservation efforts.

Nature-Based Livelihoods: Most locals rely heavily on natural resources for their livelihoods, often leading to overextraction. Therefore, there is an urgent need to strengthen the adoption of alternative, nature-based livelihoods among the community members. As such, this project promoted modern beekeeping technologies and *Brachiaria* hay, a climate-smart pasture with great potential in the area. A cost-benefit analysis revealed that *Brachiaria* farming offers the highest return on investment (214.8%), making it the most profitable livelihood option compared to traditional crops like maize, beans, and green grams. For every Ksh 100 invested in *Brachiaria* pasture production, the farmer realized an additional profit of Ksh 214.8 after recovering the original amount. Beekeeping also proved to be a viable venture, with a return on investment of 61.2%. Beekeeping profits were almost double that of green grams and nearly four times that of maize. In support of this, the project procured 15 Langstroth hives, including accessories and distributed them to 2 local groups within the study area. At the time of this report, 117 kg of honey had been harvested and sold, generating Ksh 102,000. Half the proceeds were reinvested into the project to procure more hives and equipment. Similarly, 141 farmers benefited from 4230 *Brachiaria* splits to promote fodder production and commercialization. Four of the beneficiaries harvested hay and reported the production and sale of 800 bales of hay, earning Ksh 240,000. Despite the success, challenges such as the lack of standardization in hayballing and the need for more training in beekeeping remain. Additionally, there is a need for better processing equipment for enhanced quality. Unfortunately, most of the farmers sold their honey in litres rather than by weight, thus the need for sensitization by the county government and other relevant stakeholders to cushion them from exploitation. Further, to mainstream restoration within their production systems, 2,631 *Melia volkensii* seedlings were produced and distributed to farmers, schools and faith-based organizations. This aligns with the Makueni County government's efforts to promote climate-smart agriculture to help local farmers adapt to climate change, particularly in light of unreliable rainfall and frequent droughts. The county has also supported agroforestry initiatives, distributing trees to farmers for landscape restoration.

Citizen-Science-Based Strategy for Enhanced Biodiversity Conservation: The increasing pressures on biodiversity in Makueni County, compounded by rapid population growth and climate change, call for an inclusive, community-driven approach to conservation. Building on lessons from previous Rufford Small Grant projects, the study embraced a tripartite citizen-science model. This strategy expanded on earlier models that involved a community-mobilization approach (Contributory Citizen-science) towards the conservation of threatened biodiversity, which later evolved into community-led conservation (Collaborative and Co-creation Citizen-science) in the second Rufford Small Grant that exclusively involved citizens and scientists. A key addition to the strategy was the role of the "*Enabler*," an entity that facilitates engagement, bridges knowledge gaps, and promotes partnerships, ensuring that the conservation framework is comprehensive and inclusive. The strategy aims to change negative perceptions, particularly among younger generations, by promoting sacred groves' ecological and cultural value. Citizen scientists were trained to use tools like *iNaturalist* and *BirdLasser* for long-term biodiversity monitoring. Nature-based solutions such as *Brachiaria* farming and beekeeping were introduced as sustainable livelihood alternatives to destructive practices. The Makueni County government played a vital role as an enabler, mainstreaming the preservation of biocultural heritage within their 2023-2027 County Integrated Development Plans (CIDPs) and advocating for their legal protection. To this effect, 17 sacred groves are in the process of achieving formal protection from the County Government of Makueni, demonstrating its commitment to the initiative. Embedding this initiative within the current Competency-Based Curriculum (CBC) under the 2-6-3-3 education system in Kenya sought to strategically sustain environmental awareness among school-going children. Through this, it is hoped that they will grow to be responsible people who value conservation of nature.

CHAPTER 1: BACKGROUND INFORMATION

1.1 INTRODUCTION

Biodiversity, simply *biological diversity* enables human survival by providing fundamental resources such as food, water, medicine, energy and clean air. However, this source of our sustenance is being lost at a rate unprecedented in history. Alongside biodiversity, human cultural diversity which have historically safeguarded biodiversity across generations faces equal risk.

Throughout history, human societies have set aside specific areas in their environments because they were believed to harbor unique physical and spiritual elements. Khan *et al.* (2008) defines sacred groves as patches of “virgin forest that were left untouched by the local inhabitants, harbor rich biodiversity, and are protected by the local people due to their cultural and religious beliefs and taboos that the deities reside in them” (p. 278). Many indigenous cultures perceive natural features including mountains, rivers and particular trees as embodying divine spiritual power. According to Gokhale *et al.*, (2013), these areas receive protection from human exploitation due to their sacred nature. They function as protected forest areas and this stems from community taboos that hold that spirits or deities live within these territories.

Across the world, societies established cultural mechanisms for conserving species that provided vital resources for their subsistence and economic survival. These societies instituted various cultural institutions, including taboos, seasonally determined hunting restrictions, and protected hunting grounds to prevent overexploitation of resources. For example, the local communities of the Pacific Island established local *tabu* sites that served as customary marine protected areas to promote the sustainability of food by protecting fish populations (Cinner *et al.*, 2012). Similarly, various indigenous communities in Africa established "sacred forests" and "sacred wetlands" that served both the spiritual requirements and practical ecological objectives. These sites were conserved through the imposition of taboos, ritual prohibitions, and community stewardship in preserving biodiversity components like medicinal herbs, wildlife, and water resources.

In the West Africa, the Yoruba people maintained some of the forests as sacred sites for performing rituals and worship. Indigenous plant of botanical importance thrived well in such forests as they were protected against human disturbance. In Nigeria, Osun-Osogbo sacred forest is a cultural heritage site, providing coexistence of threatened animals and the preservation of essential water sources for locals (Akinyemi *et al.*, 2016). In Central and southern Africa, the Bantu-speaking people preserved sacred groves for ritual purposes, indirectly providing habitats for antelopes and primates. Traditional forest management in the sacred forests of Cameroon and Democratic Republic of the Congo included prohibition of hunting and harvesting through taboos to preserve stable animal populations (Houghton, 2017).

In East Africa, for example, the Kikuyu people in Central Kenya preserved sacred groves around their highland water sources through rituals that safeguarded their crops and livestock. They used these sites as water catchment reserve zones alongside their religious functions, indirectly helping preserve biodiversity through area management near key water sources (Karanja, 2002). Certain sacred wetlands within Southern Africa's regions maintained both spiritual significance and protected important aquatic species including fish and amphibians that served as essential nutritional resources for the community. The sacred wetlands in South Africa honored their honeybees because they played an essential role in the community's religious practices. Through their care for honeybees the community maintained an essential medicinal and dietary honey supply (Nyong *et al.*, 2007).

Similarly, among the Akamba (Kamba) of southeastern Kenya, sacred status was accorded to specific trees and forests which served as sites for religious ceremonies and offerings. The community viewed its sacred sites named *Ithembo* (singular) and *Mathembo* (plural) as fundamental centers for spiritual and cultural traditions. These sacred locations held religious significance to the community and functioned as vital ecological zones which supported sustainable natural resource management. The combination of eco-cultural beliefs and practices protected such sacred areas from anthropogenic activities using taboos and myths together with customary laws and formalized rules and regulations.

The fig tree species were accorded a high sacred status because local beliefs held that these trees contained ancestral or divine spirits (Himberg, 2011). Customary law strictly forbade the cutting or harvesting of these trees because of their sacred nature. Community beliefs expressed through folklore reinforced protection of the sacred sites by connecting tree destruction to bad fortune and sickness within the community. Therefore, cultural beliefs established a protective framework which maintained both spiritual and ecological health by preventing damage to sacred forests (Wanjiru *et al.*, 2022).

1.2 Sacred Natural Sites (SNS) as *Biodiversity Arks* in the Anthropocene.

Anthropogenic disturbances create an unprecedented crisis for biological diversity through multiple human-caused factors, such as habitat degradation, fragmentation of ecosystems, pollution, overexploitation of resources, invasive species introduction, and climate change. Urbanization and expanded agriculture have led to widespread deforestation, thereby transforming natural ecosystems into human-dominated landscapes (Laurance *et al.*, 2014). This change ultimately results in fragmentation of habitat isolates species and disrupts essential ecological processes. Additionally, industries release pollutants into the environment i.e. air, soil, and water, adversely affecting the survival of species survival and the health of the ecosystem. Besides, wildlife species are threatened with extinction due to overfishing, poaching, and overexploitation (Maxwell *et al.*, 2016). Changing climate worsens these existing threats by altering temperature and precipitation regimes leading to habitat shifts, species migration, and increased susceptibility of ecosystems to extreme weather events.

Within these changing land uses, a substantial amount of biodiversity has persisted within fragmented patches of habitats regarded as sacred natural sites. These spaces are a quintessential example of the long tradition of habitat conservation which predates modern conservation efforts. Over the world, these sacred landscapes are important to many cultures and are refuges for biodiversity amidst anthropogenic pressures such as deforestation, and land conversion for urbanization and agricultural activities (Yuan *et al.*, 2019; Dudley *et al.*, 2009). Unlike the conventional protected areas, they are maintained through communally-initiated efforts that do not necessarily require governmental involvement. According to Bhagwat & Rutte (2006) and Kamalahar (2021), this traditional approach to biodiversity conservation reinforces bonds between local communities and their natural environment.

The incorporation of traditional knowledge systems is an integral component of biodiversity conservation efforts. Kamalahar (2021) noted that the Convention on Biological Diversity (CBD) and other international agencies emphasize the importance of traditional knowledge in conservation efforts and sustainable management of resources. Therefore, sacred sites make up an important model of biodiversity conservation through their community-managed nature, which employs indigenous conservation practices.

1.3 The Context of Biocultural Conservation within the Global Biodiversity Framework

The Strategic Plan for Biodiversity 2011–2020, adopted under the Convention on Biological Diversity (CBD), aimed to combat biodiversity loss through the Aichi Biodiversity Targets, which are 20 global goals focused on conservation, sustainable use, and ecosystem restoration. Unfortunately, the Global Biodiversity Outlook 5 confirmed that all Aichi Biodiversity Targets failed to reach their goals by 2020 as biodiversity decreased 69% on average due to habitat destruction, climate change and unsustainable resource exploitation (WWF, 2022). A more actionable framework with enforceable commitments beyond 2020 became necessary after observing this failure.

In response, the Post-2020 Global Biodiversity Framework emerged as a solution to overcome previous framework deficiencies by establishing precise measurable targets. The parties to the Convention on Biological Diversity (CBD) formally adopted the framework as the Kunming-Montreal Global Biodiversity Framework (GBF) during their meeting in 2022. The Aichi Targets faced difficulties because they lacked specific implementation strategies that resulted in inconsistent progress between nations. The GBF enforces this through tracking and enforcement by integrating national commitments with measurable indicators alongside accountability mechanisms.

The GBF expands the 2050 Vision for Biodiversity to establish societal equilibrium between human activity and environmental preservation. The global biodiversity framework contains 23 ambitious targets for the coming decade (2030) with special emphasis on the 30x30 target to safeguard at least 30% of terrestrial and marine areas worldwide. The GBF's Target 3 (30x30 Initiative) requires protecting 30% of terrestrial, freshwater, and marine areas through protected areas alongside Other Effective Area-Based Conservation Measures (OECMs) (Guidance on OECMs, 2024). OECMs are conservational areas outside traditional protected forests that enhance biodiversity outcomes at the same time ensuring sustainable land use practices such as sacred sites.

Park and Heo (2023) noted that OECMs play a fundamental role in reaching the 30x30 target because they are appropriate in regions where formal protected areas are limited. The conservation value of these areas emerges from their role in protecting biodiversity while maintaining ecological connections and enhancing the provision of ecosystem services (Paterson, 2023). Sacred groves function as natural OECMs which serve as fundamental elements for biodiversity conservation. These sites protect endangered species through habitat preservation and promote traditional ecological knowledge (TEK) and Indigenous conservation practices while maintaining biodiversity corridors to boost ecosystem resilience for climate adaptation and sustainable land management.

The Global Biodiversity Framework acknowledges the need for different approaches to conservation practices, highlighting sacred groves as vital conservation instruments. Policymakers need to integrate sacred groves into national biodiversity plans as OECMs and integrate Indigenous and community conservation approaches into biodiversity conservation plans. Sacred groves and OECMs are examples of community-based conservation models that enable GBF objectives. The recognition of sacred groves in Target 3 (30x30 Initiative) and Target 18 (Integration of Indigenous and local knowledge) mirrors their central role in building biodiversity resilience while promoting sustainable ecosystem management. The GBF's success depends, in part, by integrating these non-traditional conservation areas into their national targets.

1.4 The Contribution of the Project toward Kenya's Priorities

In response to the conserving threatened biodiversity, this project sought to align itself to the national priorities of the country. It supports Kenya's National Biodiversity Strategy and Action Plan (NBSAP, 2019-2030) through multiple alignment points. The integration of traditional knowledge systems alongside participatory governance frameworks with local community action is an important biodiversity conservation strategy, as noted by NBSAP. Through its citizen-science approach, this project supports the implementation of Strategic Target 26 from the NBSAP by engaging communities to monitor biodiversity and protect local practices while upholding indigenous knowledge.

The project contributes to the Strategic Target 27 by establishing community-led governance systems to protect Key Biodiversity Areas (KBAs) and other important ecological sites. By engaging citizens in the protection of sacred natural sites, the project promotes local stewardship that supports sustainable management approaches. Also, this effort supports Strategic Target 28 by encouraging the development of biodiversity knowledge and technology advancement through participatory research and data collection activities. Through the use of citizen science, the project enhances biodiversity monitoring further strengthening Kenya's ability to track biodiversity trends effectively. Moreover, this effort contributes to Kenya's biodiversity conservation objectives by encouraging the involvement of locals in protecting the county's ecological heritage.

Additionally, the project advances the objectives of Kenya Vision 2030 which strives to make Kenya a newly industrialized middle-income nation by 2030. It contributes to developing a nation where everyone can enjoy high standards of living while living in a safe environment that is free of pollution. The Kenya Vision 2030 establishes economic, social and political pillars to create sustained economic growth and equitable social development while establishing a stable governance system. The project finds its foundation in the social pillar that prioritizes environmental sustainability.

1.5 Relevant Policies, Legislation and Institutional Frameworks

This initiative supports the National Policy on Culture and Heritage (2009) which establishes an elaborate framework to protect Kenya's diverse cultural heritage. The Kenya Cultural Centre and National Museums of Kenya function as institutional frameworks under the Kenya Cultural Centre Act Cap 218 (2012) and the National Museums of Kenya Act (2006) to support this mandate. These cultural institutions serve as vital coordination centers for heritage protection initiatives while promoting Kenya's diverse cultural legacy. To promote sector-specific cultural heritage, several legislatures towards safeguarding of cultural heritage have been developed. The Copyright Act (2001) protects creator intellectual rights and the Kenya Heroes Act (2014) identifies individuals whose actions shaped Kenya's history and culture identity.

The Protection of Traditional Knowledge and Traditional Cultural Expressions Act (2016) gives power to county governments to create registries for the protection and promotion of traditional knowledge and cultural expressions ensuring their protection, conservation, and promotion. This devolved governance has also institutionalized national values in public administration by establishing a county cultural database to document and promote cultural activities. The Constitution of Kenya (2010) grants the County governments permission to develop policies on culture including building cultural centers, museums, and art galleries for the local communities. As a way of promoting the preservation of cultural values, they are required by law to hold cultural exhibitions and conferences. Pursuant to these provisions, the Makueni county government though the count assembly has developed the Makueni County Culture and Heritage Act (2016) and Makueni County Arts, Culture, and Heritage Policy (2021). Therefore, the initiative seeks to first make known what constitutes a cultural heritage within the Nzaui-Makuli area since one cannot protect and promote an unknown.

Similarly, there are international conventions and agreements that seek to protect and promote biocultural heritage. The main aim of the project aligns with the objectives of the Convention on Biological Diversity (CBD) by encouraging sustainable management of biodiversity. Further, it promotes the objectives of Convention on International Trade in Endangered Species (CITES) which regulates trade of threatened biodiversity. Our project has sought and incorporated key components of UNESCO conventions that protect heritage sites of global importance under the 1972 World Cultural and Natural Heritage Convention. This project complements the 2003 Convention on the Safeguarding of Intangible Cultural Heritage by promoting the preservation of traditional knowledge, cultural practices, and indigenous expressions. The incorporation of international frameworks within Kenya's biodiversity strategy adds value to conservation efforts through systematic progress reporting as well as consolidating national accountability and international commitments on biodiversity.

Domestically, it aligns with several key legislations that underpin Kenya’s commitment to biodiversity conservation and cultural preservation. Article 69 of the Constitution of Kenya (2010) binds both the government and citizens to protect biodiversity, while also stressing on the conservation and sustainable management practices. The Wildlife Conservation and Management Act (2013) gives way to a consolidated legislation that aims to conserve wildlife and allow for sustainable use through community-based solutions and human-wildlife conflict mitigation. The National Museums and Heritage Act (2006) plays a central role in the protection of Kenya's cultural heritage and natural resources, by promoting research activities and conservation efforts. All these statutory interventions cumulatively aid Kenya in meeting her national development goals while addressing international conservation standard requirements.

Though numerous attempts are being made to safeguard tangible cultural heritage and enhance its condition, intangible cultural heritage such as rituals, indigenous knowledge, and oral traditions have not received adequate conservation interventions. Traditional farming practices that previously guaranteed the resilience of food systems now present formidable risks, causing soil degradation and environmental harm. Some cultural beliefs and practices occasionally cause tensions with conservation objectives since they entail the hunting of protected animals and the destruction of natural habitats. Therefore, a balanced approach between contemporary conservation practices and traditional knowledge systems is necessary to conserve biocultural heritage. The study highlights the need of creating broad strategies that harmonize efforts toward preserving heritage and conserving biodiversity to conserve Kenya's rich cultural and ecological resources.

1.6 Problem Statement and Justification of the Study

The increasing awareness of the existence of substantial biodiversity beyond officially established protected areas (Craigie *et al.,* 2010; Ogutu *et al.,* 2016), has highlighted the need for Other Effective Area-Based Conservation Measures (OECMs), in the fragmented *Combretum*-wooded grasslands of Makueni sub-county. The creation of additional protected areas in this landscape is not feasible due to intricate land ownership structures and various competing land use priorities. Luckily, though sacred groves within this region are often isolated within expansive agricultural landscapes, they serve as culturally protected refuges, where the *Akamba* traditional beliefs and spiritual reverence have historically preserved biodiversity some of which threatened.

Unfortunately, these remnant patches of natural vegetation are increasingly becoming more vulnerable due to cultural erosion and socio-economic changes. Increased urbanization as a result of devolved systems of governance, changes in religious practice and modernization have eroded traditional conservation values. The increasingly dwindling cultural significance, with respect to deviation from the taboos and traditional moral law, of these sacred groves among local people have played a key role in resource exploitation and encroachment. Munywoki *et al.,* (2023) noted that these groves are critical habitats for critically endangered and endemic species such as *Aloe ngutwaensis* and *Dorstenia arachniformis*. Other globally threatened plant species include *Pavetta teitana*, *Millettia vatkei*, *Afrocanthium keniense*, *Thunbergia napparae*, and *Euphorbia friesiourum*. A recent survey by the ornithologist from Nature Kenya and the National Museums of Kenya recorded the highest population of *Turdoides hindei*, a globally threatened Kenyan endemic bird, within a sacred Nzaui hill, beyond its distributional range.

Without doubt, these sacred sites within the study area are playing a crucial role to the persistence of threatened biodiversity. Securing them as Other Effective Area-Based Conservation Measures calls for the adoption of evidence-based conservation strategies. Since majority of the locals no longer attach value to them, baseline species inventories and participatory biodiversity monitoring are needed to portray their ecological significance. Further, this will reinforce policy recognition as well as the allocation of funds and legal protection initiatives.

Citizen-science hold the keys to sustainable conservation and management of biodiversity. According to Cooper *et al.*, (2007) collecting data using citizen-scientist promotes a sense of responsibility and enhances awareness among the participants. Majority of people especially the youth may not know the existence of sacred landscapes within their locality leave alone what they contain. This intergeneration knowledge gap has a negative implication on the conservation of these landscapes and therefore this approach creates an avenue through which cultural information is integrated in scientific inquiries. These programs have been found useful in encouraging local communities to participate in conservation beyond the traditional protected areas. Besides, promoting biodiversity-linked value chains such as ecotourism positively shifts the perception of local communities towards conservation.

1.7 General Objective

The main aim of the project was to harness the power of citizen science and the sacred natural sites to promote the conservation of threatened biodiversity within the Nzaui-Makuli landscape, Makueni, Kenya.

1.8 Specific Objectives

1. To map sacred natural sites within the Nzaui-Makuli landscape and develop a comprehensive checklist of plants, birds and butterfly species within them. This checklist will serve as baseline information for future biodiversity monitoring as well as determine the conservation plans for such sacred spaces.

2. To use the site-specific assessments to codesign a citizen-science driven conservation strategy for the sacred groves as well as for the biodiversity of the area. A tripartite model of citizen-science that stretched far beyond the traditional citizen-scientist framework was embraced pulling enablers such as government and other stakeholders into the process.

3. To undertake an evidence-based campaigns on the importance of protecting sacred groves. It entailed targeted awareness campaigns to sensitize the locals on the biodiversity potential within the sacred groves. Educational program tailored to the local context was developed, focusing on the sites' ecological, cultural, and spiritual values.

4. To strengthen the adoption of alternative nature-based livelihood sources. Community-based climate-smart agriculture, including modern beekeeping, hay production, and commercialization, were piloted as a restoration tactic to enhance biodiversity, improve livelihoods, and boost climate resilience, providing sustainable income while promoting adaptation to environmental changes.

1.9 The Study Area

Southeastern Kenya (comprising of Makueni, Machakos and Kitui counties) are arid and semi-arid lands (ASALs) in Kenya with a mesic-savannah type of vegetation. This area falls within the larger *Somali-Masai* phytogeographical region and between the central highlands and the Kenyan Coast. Characteristic of this transition zone is several inselbergs that play a refugial niche function for species unsuited for higher and lower elevations (Malombe *et al.,* 2020; Malombe *et al.,* 2015; Malonza *et al.,* 2006). Within this zone, numerous dryland hilltops have been described as outliers in arid areas (IUCN, 1996), because they host diverse and unique biodiversity due to their cooler temperatures and higher precipitation compared to the surrounding savannahs. According to Young (1984), the biodiversity uniqueness and narrow species endemism of this area compares to the bio-diverse Eastern Arc Mountains Hot-spot highlighting the urgent need for increased scientific research and urgent conservation initiatives.

In Makueni county, these moist hilltops stretch from Kathonzweni area in the south, through Nthangu in Wote, up to Mbooni hills, Makongo forest and Kilungu hills in the north and NE, with the highest point (1900m) in Nzaui and Makuli hills forest in the south east and east respectively. They are characterized by *Afromontane* vegetation above 1500 m and *Combretum* woodlands above 1000m a.s.l. Generally, the climate of the region is dry, showing semi-arid conditions. The area has a bi-modal rainfall distribution, with long rains between March to June and short rains from October to December. The seasonal shifts and the intensity of the Inter-Tropical Convergence Zone (ITCZ) and the El Niño Southern Oscillation (ENSO) greatly influence the rainfall patterns of the area. While the annual precipitation range is about 800-1200mm per year in the hilly areas, it is less than 500mm per year in the other regions. The average temperature is about 23°C. As one moves from Wote town (Makueni County headquarters), the altitude increases with lowering temperatures towards Nzaui-Makuli area.

The main economic activity among the locals includes crop farming, livestock keeping, sand mining, charcoal burning, brick-making, among others. The crop farming is carried out in rain-fed systems with patches of irrigation in some localities. As a result, the vegetation is highly fragmented, with most natural vegetation receding to the hilltops. Kimeu and others (2020) term this occurrence of natural vegetation within farmlands as vegetation ‘‘islands’’ or relics.

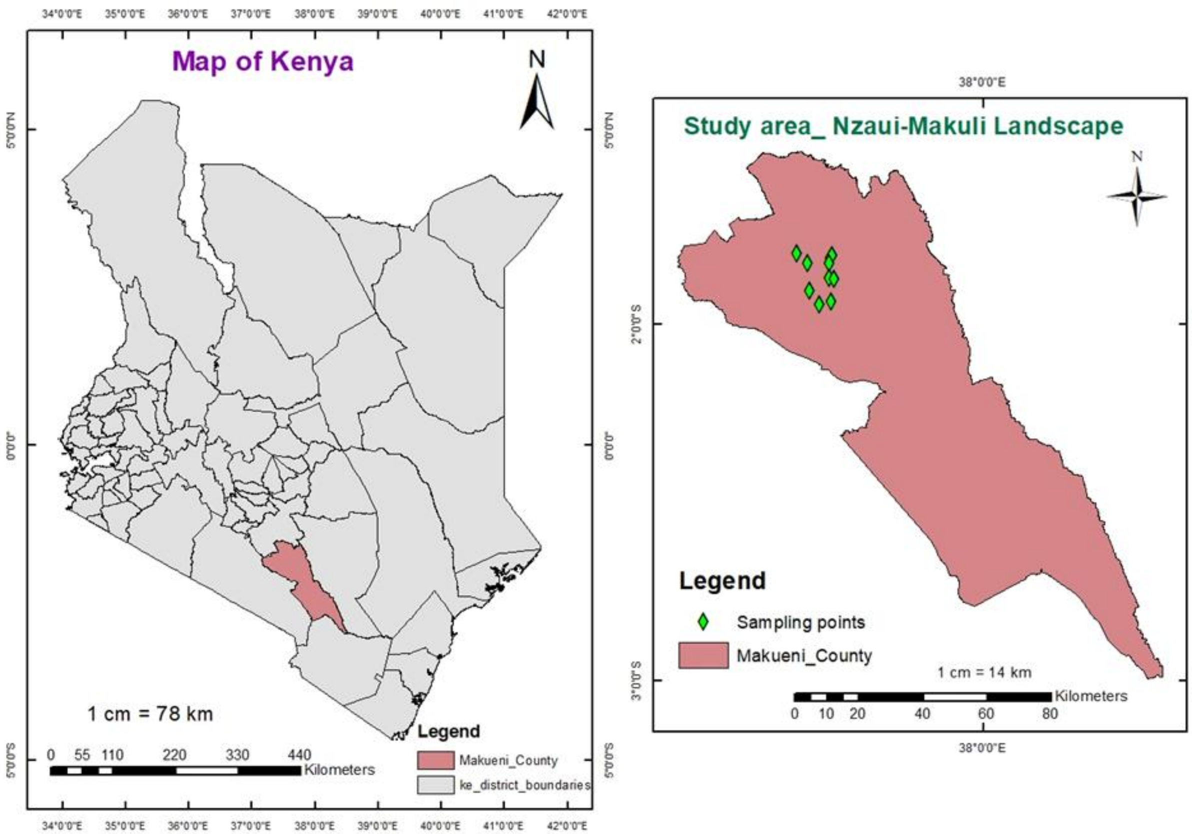

Figure 1.1: A map of the study area.

Our area of interest (AOI) under the present project was the Nzaui-Makuli landscape on the upper part of the Makueni County. Compared to the rest of the county, this region receives comparatively higher amounts of rainfall supporting a diverse range of vegetation. While Nzaui and Makuli hill forests are gazetted and predominantly exotic plantation, area between them are owned by communities and majority of the vegetation is indigenous.

CHAPTER 2: CONCEPTUAL FRAMEWORK

"It was the bees that showed me how to move between different flowers-to drink the nectar and gather pollen from both. It is this dance of cross-pollination that can produce a new species of knowledge, a new way of being in the world. After all, there aren't two worlds, there is just this one good green earth." **(Robin Wall Kimmerer, Braiding Sweetgrass p.47).**

1.1 INTRODUCTION

The vast Earth's biodiversity faces an urgent threat as species extinction rates surpass all previous human records (Día *et al.,* 2019). At least 1.2 million plant and animal species face extinction worldwide. According to Humphreys and others (2019), about 600 plant species have been recorded extinct since the onset of 16^{th} century and more disturbing is that such species loss is 10 to 1,000 times faster than the normal background rate of extinction, suggesting entry to the '*sixth mass extinction*'. The core drivers of biodiversity decline stem from economic systems that measure the material worth of nature without regard for its broader values. The dominant materialistic approach favors immediate personal gains over the traditional indigenous perspectives that value natural relationships through respect, sacredness and reciprocity.

The historical development of human civilization has produced various systems of knowledge that derive from natural ecological systems and cultural contexts. Within the natural world, there exist numerous concepts that influence the understanding of nature among the humans. Although, the conventional scientific methods are vital in understanding the ecological system, there are other approaches that can advance the understanding and protection of these systems we rely on.

Combining indigenous ecological knowledge with scientific approaches is analogous to grafting scion onto a rootstock. This comparison demonstrates the synergistic relationship in embracing two different knowledge systems when solving difficult environmental problems. Each of the knowledge systems harbors its share of an advantages and disadvantages which are optimized when combined. According to the grafting analogy both knowledge systems exist separately while remaining connected. The conservation of threatened biodiversity by promoting the protection of sacred sites heavily borrows from this *grafting concept* where indigenous knowledge serves as the rootstock by providing an adaptive framework founded in deep cultural and ecological practices.

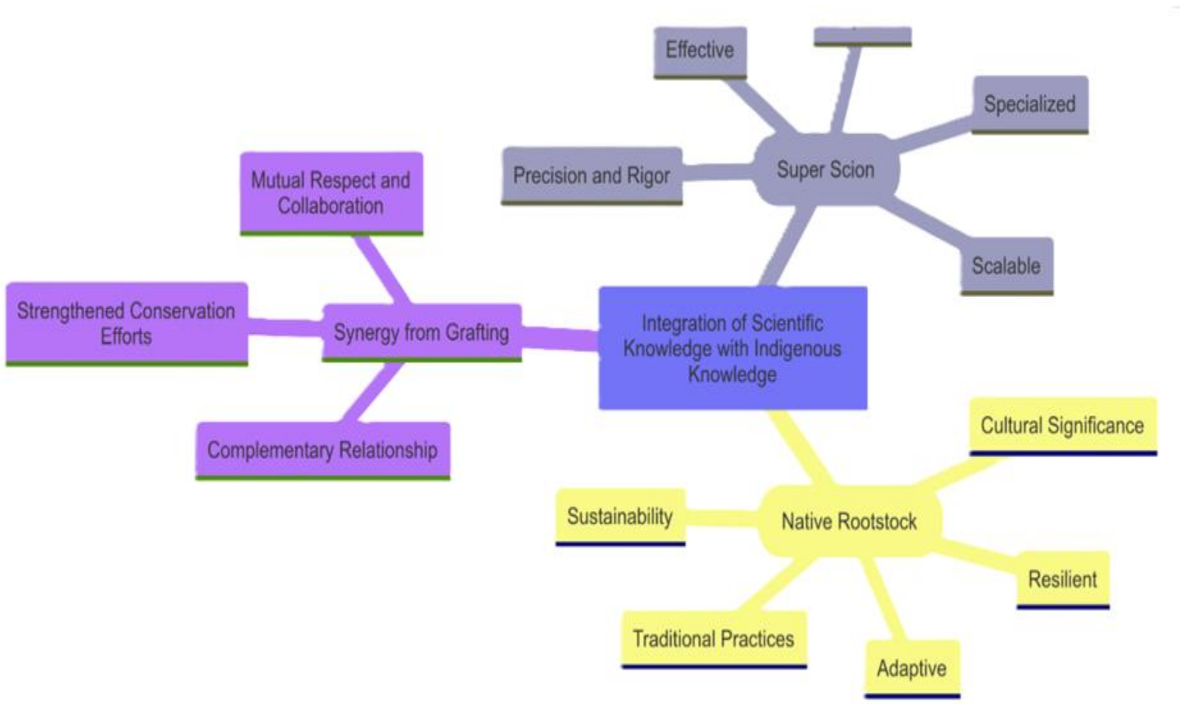

Figure 2.1: Diagrammatic representation of the adopted conceptual framework.

The scientific knowledge represents the introduced scion—an intentionally refined knowledge developed specifically to address particular challenges (Berkes *et al.,* 2000). The process of picking a super scion serves to increase desirable characteristics including productivity and disease resistance which parallels scientific adoption because of its accuracy, systematic approach and scalability. The project benefited from this concept through advanced ecological monitoring and innovative conservation methods. The conception of this conservation approach was based on empirical data and thus can to be adapted in other landscapes and settings. Indigenous ecological knowledge systems are normally developed from years of interaction with the environment. This concept of integrating two knowledge systems is key to the success of the project as it offers insights into sustainable resource management and culturally sensitive conservation.

Discussions on alternative solutions to species extinction such as indigenous perspectives have gained prominence. The exclusive focus on conventional scientific methods to address the "*Sixth Mass Extinction*" disregards potentially valuable traditional approaches to protect biological diversity. Therefore, the concept of citizen science-based conservation of threatened biodiversity, with emphasis on the protection of sacred natural sites is timely. It is hinged on the following two theories that borrow insights from environmental ethics, community engagement, biodiversity conservation, and knowledge sharing.

1.2 Two-Eyed Seeing Framework.

This theory by Mi'kmaw Elders Albert and Murdena Marshall was adopted and sought to integrate scientific findings and indigenous wisdom (Bartlett *et al.*, 2012). Here, we hypothesize that two-eyed seeing offers a way in which diverse perspectives work together to address the most disturbing challenges of our time; loss of biodiversity and ecosystem services. This concept bridges indigenous and mainstream knowledges to analyze the aforementioned complicated issues using multiple perspectives.

Mi'kmaw Elder Albert Marshall from the Eskasoni First Nation defined Two-Eyed Seeing as "*the learning to see from one eye with the strengths of Indigenous ways of knowing and from the other eye with the strengths of Western ways of knowing and to using both of these eyes together*" (Bartlett, Marshall, & Marshall, 2012, p. 335). Through this approach, the project pursued different perspectives to address the challenges facing threatened biodiversity within the study area. Here, the scientific and indigenous groups interacted leading to co-creation and co-designing of a citizen-science based conservation strategy. Importantly, the principle of reciprocity was also considered, guiding the project toward mutual gain through co-learning activities with local community members. The project initiatives were also aligned to match community-identified goals and needs. Besides, local elders and knowledge holders were also consulted to maintain respect for cultural protocols.

1.3 Epistemological Pluralism.

Epistemological pluralism theory encourages the inclusion of multiple knowledge systems, asserting that no single approach to understanding a complex issue is adequate. The application of this framework is appreciated in the context of engaging local communities to conserve threatened biodiversity by protecting sacred groves. Within the *Combretum*-wooded grassland of Makueni subcounty, these groves manifest as forest patches deemed sacred by local communities, and their preservation is often deeply embedded in traditional ecological knowledge (TEK) passed down through generations. According to Nadasdy (1999), sacred sites are critical biodiversity hotspots and are culturally significant, and this dual role makes them ideal subjects for a pluralistic approach to conservation.

Epistemological pluralism acknowledges that more than one system of knowledge—such as scientific, indigenous, and local—offers insightful perspectives (Berkes, 2009). Sacred groves' traditional ecological knowledge offers critical information regarding sustainable land use practices, species conservation, and climate resilience, aspects that are mostly overlooked by scientific knowledge. Local people equally possess critical knowledge about seasonal trends, plant identification, and animal behavior, all of which significantly contribute to maintaining ecosystem health (Miller *et al.,* 2008). According to Berkes (2009), scientists utilize conventional methods to monitor biodiversity and to enhance public understanding of ecological functions.

Protecting sacred groves through citizen science creates a link between indigenous knowledge systems and contemporary science approaches. Through this approach, local communities have an opportunity to engage in biodiversity monitoring and ecological data collection while scientists confirm indigenous knowledge through established scientific protocols (Hecker *et al.*, 2018). These knowledge-sharing processes between these systems promote a holistic conservation strategy (McKinley *et al.*, 2017). However, the practical application of epistemological pluralism faces various critical obstacles during implementation. For example, when monitoring biodiversity and managing natural resources, scientists embrace different approaches as compared to indigenous groups. While the scientific methods prioritize on protecting species, indigenous knowledge approaches biodiversity assessment through cultural and spiritual viewpoints (Nakashima *et al.*, 2000). The scientific and indigenous perspectives thus create an opposing reference framework that establish adversarial relationships. The ethical protection of traditional knowledge stands as a key issue that needs to be addressed when building pluralistic biodiversity conservation frameworks (Sillitoe 2004).

CHAPTER 3: LOCAL'S PERCEPTION TOWARDS SACRED GROVES

By Munyw'oki, J. Mulinge

1.1 INTRODUCTION

Today, the word is grappling with the twin threats of enhanced natural resource degradation and climate change. Poor agronomic practices worsened by ever changing climates is endangering the persistence of biodiversity, ecosystems and the provision of ecosystem services. Alarming rates of natural resource degradation are evidently reported in areas experiencing the highest socioeconomic disparities. This is because residents of such areas struggle to balance their daily needs with the protection of the environment. In Kenya, the Arid and Semi-Arid Lands (ASALs) are experiencing enhanced exploitation of natural resources making them among the most vulnerable regions in the country. This degradation is as a result of synergy from human population increase, deforestation, overgrazing and unpredictable climatic patterns. Consequently, the need for a broad-based conservation strategy is imperative.

A critical yet often overlooked form of conservation in these areas are the traditional, community-based form of *in-situ* conservation manifesting as sacred sites primarily preserved through cultural, religious, and spiritual practices. These forest relics serve threefold roles including religious worship, biodiversity preservation, and as watershed areas. They harbor unique floral and faunal species that sustain crucially important elements of the local ecosystems. Infact, traditional belief systems consider these sacred groves important because they promote cultural cohesion as well as enhance intergenerational knowledge transfer. Unfortunately, their persistence is increasingly threatened under the current changing cultural and climatic landscape. Rapid growth of human population, shifting land-use practices, and erosion of cultural values have increasingly led to encroachment and degradation of these sites (Bhagwat & Rutte, 2006). Expanded agriculture to feed the increasing population and urbanization have further fastened their decline, leading in the loss of cultural heritage and ecological stability (Ormsby, 2013).

Therefore, coming up with innovative and effective interventions to protect sacred groves call for first understanding the perceptions and attitudes of locals towards sacred groves and their preservation. These perceptions shape the way they interact with and value these landscapes. Conservation efforts that do not consider the locals' perceptions and attitudes, is susceptible to being misaligned with community beliefs, leading to resistance or disengagement. Conservation strategies yield fruits when local community's perception guide their development because cultural sensitivity and community ownership can be achieved through this method.

1.2 General Objective

The primary aim of this effort was to gain a deeper understanding of how the local communities within the *Combretum*-wooded grassland of Makueni sub-county perceive sacred natural sites within their surroundings. Recognizing that community beliefs and values significantly influence conservation efforts, this initiative sought to understand how these perspectives might influence active participation in co-creating and co-designing a sustainable conservation strategy for the sacred natural sites.

1.3 Specific Objectives

- To understand local's perceptions and attitudes toward the sacred natural sites within Nzaui-Makuli landscape and their conservation.
- To assess the level of awareness and the cultural, spiritual, and ecological significance that locals attribute to sacred natural sites.
- To identify and analyze the perceived threats to the sustainability and preservation of sacred groves within the Nzaui-Makuli landscape.

2.0 METHODOLOGY

2.1 Research Design and Sampling Technique

The study used a cross-sectional research design, integrating qualitative and quantitative methods to assess community perceptions, conservation needs, and monitoring strategies. Data collection included focus group discussions, key informant interviews, self-administered questionnaires, anecdotal narratives and observations. Purposive and snowball sampling (Chain referral) method was used whereby the process begun with a few known individuals (seeds), who then suggested others with relevant knowledge or experience, creating a recruitment chain.

2.2 Focused Group Discussions (FGD)

Two focused group discussions (one covering Nzaui Hill landscape and the other one Makuli and the surrounding areas) each comprising of 5 members to understand the perceptions and attitudes of respondents concerning sacred groves within their area. Question guide (Annex V) was used in the group discussions and probing questions used to get in-depth information and knowledge. To balance the groups diversity, age, gender and education were carefully considered.

2.3 Key Informant Interviews (KII).

Face-to-face key informant interviews were undertaken with elders of traditional worship and religious leaders. They were purposely selected on the basis of their first-hand knowledge on the local community or involvement conservation practices, traditional and mainstream worships. A total of 6 KII interviews were successfully conducted while the rest declined. A guide questions were used as tools for data collection (Annex IV).

2.4 Self-administered Questionnaire

To ensure standardized data collection, questionnaires were randomly distributed to 22 respondents after others declined participation. The survey covered key thematic areas, including demographic information, awareness and understanding of sacred groves, their cultural and spiritual significance, community perceptions and attitudes, existing threats and challenges, as well as recommendations and future perspectives. A questionnaire used for data collection is attached (Annex VI).

2.5 Anecdotes

A collection of vivid, insightful narratives and informal accounts was gathered from community elders, key informants, and local guides. These stories, deeply embedded in oral tradition, offered a profound understanding of the community's beliefs, myths, and taboos, shedding light on their cultural heritage and perspectives.

2.6 Data Analysis and Ethical Considerations

The research used thematic elements alongside content genotypes to identify common beliefs and fears about sacred groves existing among the community members. Descriptive statistics analyzed quantitative responses whose results were presented through pie charts. As a legal requirement in research involving human subjects, we first secured participant's consent before data collection. We promised the subjects secure data privacy along with protection of their cultural heritage and local traditions. Our research integrity and survey fairness remained crucial as we refrained from offering financial compensation to survey participants. This approach prevented possible biases while supporting our dedication to ethical standard operating procedures for all participants. Importantly, we adopted mixed-methods triangulation design following Creswell and Clark (2007) to enhance the credulity and validity of our research findings.

3.0 RESULTS AND DISCUSSION

The collaboration between contemporary scientific techniques and traditional conservation practices holds incredible promise for protecting sacred groves. As noted by Malhotra and his team in 2007, they skillfully integrated local beliefs with scientific methods to develop sustainable management plans for these significant areas in India.

3.1 Demographic Information of the Participants

We conducted interviews with 38 local community members, comprising 22 men (57.9%) and 16 women (42.1%), to better understand their perceptions on the sacred groves in the *Combretum*-wooded grassland of Makueni subcounty. Although our sample size was relatively small, we made sure it represented the community well.

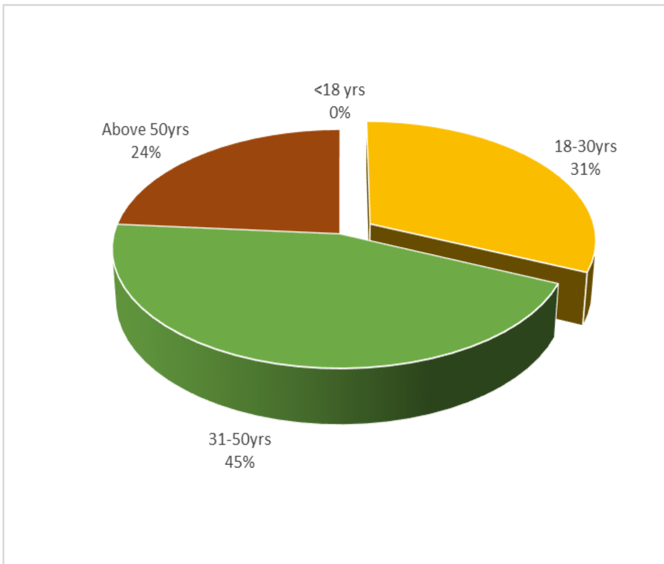

Figure 3.1: Categorization of respondents based on age.

Most respondents (44.7%) were aged 31-50, with none under 18 years. Additionally, 23.7% were above 50, and 31.6% were youth. Educationally, 15.8% had no formal schooling, while 39.5% had at least basic education. Farmers formed the largest occupational group (34.2%), followed by the unemployed (26.3%), mostly youth. Additionally, 33.3% had no formal community roles, mostly due to their youth status. The study highlighted that most respondents reside within a 0-5 km distance from a sacred grove suggesting that majority of locals know them.

The demographic breakdown shows that a significant portion of the population is between the ages of 31 and 50, which hints at possible generational differences in how people view and value these sacred natural sites. Older individuals might cling more to traditional beliefs (Githitho, 2003) as compared to the youth. Additionally, the fact that 26.3% of the youth are unemployed points to economic challenges in the area, which could influence their views on conservation priorities (World Bank, 2020). Furthermore, the finding that 33.3% of respondents did not have formal roles in the community—likely due to their age—highlights a lack of involvement in conservation governance, potentially impacting sustainability efforts. The close proximity of residents (0-5 km) indicates that many participants likely have direct experiences with the sacred groves.

Figure 3.2: Focus group discussion on locals' perceptions towards sacred groves.

3.2 Awareness and Understanding of Sacred Groves

A significant portion of the population (50%) demonstrated limited knowledge about the sacred groves within their community, while 16.67% were entirely unaware of their existence—likely corresponding to individuals residing more than 11 km away from these sacred sites. This lack of awareness may be attributed to changing societal values, declining oral traditions, and developments, which have collectively contributed to a weakening of traditional ecological knowledge (Rathore, 2024). Despite this, a strong cultural connection to sacred groves persists, as evidenced by the fact that 87.5% of respondents believe these sites have been integral to their community traditions for at least 50 years. This is consistent with previous studies that sacred groves are deeply rooted in indigenous belief systems, serving as ecological and cultural reservoirs passed down through generations (Khan & Evi, 2008).

3.3 Cultural and Spiritual Significance of the Sacred Groves

45.7% and 28.5% of the respondents believe religious worship and symbol of cultural identity respectively are the main cultural and spiritual significance of sacred groves within the project area. Interestingly, majority (83.3%) of the respondents do not know that sacred groves were established with specific reasons or events. On the contrary, 16.7% were aware that sacred groves were linked to certain events, rituals or festivals. They cite establishment for praying for rain, prevention of calamities such as drought, diseases, pests, thanksgiving for bumper harvest and for success in during tribal wars.

3.4 Local perceptions and attitudes towards sacred Groves

All the respondents (100%) perceive sacred groves within their area with great fear perhaps because of the taboos attached to them. It is interesting that none of the respondents expressed respect and reverence to the sacred groves. This discrepancy of fearing sacred groves rather than respecting them can be linked to cultural taboos, loss of traditional knowledge, religious influences, and modernization. These sites are perceived as dangerous due to deeply rooted superstitions, where violating their sanctity is believed to bring supernatural punishments. According to Słupecki (2022), it is this fear-based conservation approach that gives birth to avoidance rather than reverence.

The erosion of cultural values has been a major factor shaping these perceptions. Societies that go through or experience modernization commonly forget these sacred landscapes as places of worship while fear-based stories remain as the dominant narratives (Barik *et al.*, 2023). The combination of religious shifts and colonial influence caused by missionary activities has resulted into decreased respect for sacred groves because indigenous beliefs were labeled superstitions thus creating fear (Notermans *et al.*, 2016). Also, economic development and urbanization processes have further reconceptualized the sacred groves as unused space or idle land (Grace & Jeuland, 2018). Attitudinal change from fear to respect requires re-establishing cultural education that delivers information on the past spiritual-ecological significance of the sacred groves.

The awareness and adherence to prohibitions and taboos associated with sacred groves are rooted in environmental, religious, and cultural values. The large proportion of the respondents reporting prohibitions, such as prohibition on tree cutting, resource extraction, and unauthorized entry, is a reflection of traditional conservation by religious and social practices going back in history. According to Ahmed and others, (2023), sacred groves are usually protected through myths and taboos, which indirectly conserve rare plant species and biodiversity. The restriction of access to ordained persons only, as cited by 26.9% of the respondents, aligns with studies that sacred groves are viewed as spiritual sanctuaries where deities or ancestral spirits dwell, hence rendering them exclusive and sacred spaces (Lyubov & Nadezhda, 2017). In addition, the conviction that walking near sacred groves at night or the cutting down of trees might attract death is founded on fear of divine punishment, a psychological deterrence to conservation (Barre *et al.,* 2009).

Majority (83.33%) of the respondents recognized that the primary reason for sacred groves is their religious, spiritual, and cultural significance. Sacred groves are religiously consecrated sites where locals carry out religious and ritualistic practices under the protection of a deity (Rathore, 2024). Despite the role of sacred groves in conservation, the majority of respondents (62.5%) did not view this as their main function, hence the reason only a minority (16.7%) saw their role in environmental conservation. This observation corroborates existing literature that sacred groves are preserved due to religious and cultural reasons, and not for conservation (Rajesh, 2016). In addition, the respondents identified their role in water conservation, in comparison with biodiversity, as the most significant benefit, accounting for 31.8% of their views. Research confirms that many sacred groves play a crucial role in water conservation by regulating water flow, preventing flash floods, and ensuring water availability during dry seasons (Agarwal, 2016).

3.5 Perceived threats towards the sacred natural sites

The results reveal that 79.2% of respondents acknowledge cultural erosion, deforestation, and developments as the main threats facing the sacred groves in Makueni subcounty. The lack of interest among the youth is alarming, as intergenerational knowledge transfer is acknowledged essential for long-term conservation (Ormsby, 2013). While youth education (28.4%) and policy (25.7%) were the proposed solutions, ecotourism (45%) is perceived to offer an immediate incentive to engage youth through economic benefits and cultural experiences. Additionally, incorporating conservation into school curricula (22.5%) was believed to strengthen traditional ecological knowledge. Majority (20%) note that there are no specific management strategies within their communities to protect sacred groves and traditional practices and taboos are highlighted by 29.3% of respondents as the most elaborate management startegy currently existing within the community.

3.6 Traditional Beliefs, Myths and Taboos Promoting Biodiversity Conservation.

3.6.1 Plants

Across the Kamba community, clanship (*Mbai*) is among the key social structures whereby every clan identifies with a totem—commonly an animal or plant— that is revered. The totems are historically, physically, and spiritually significant, and are the representatives of the ancestors' spirits for every clan. As such, totemic animals and plants are safeguarded at all expense. For example, Amũumo (*Mũmũumo*) clan identify with the fig tree (*Kiumo*) that is sacred to them and cannot be felled due to cultural reverence and signifies source of water. Similarly, among certain Kamba clans, certain tree species, such as *Ximenia americana*, are never incinerated as firewood due to cultural taboos, and generally fruiting and shade trees are traditionally preserved.

Kamba mythology imbues symbolic significance in some plant species, as well. For instance, *Aspilia pluriseta* (locally *Muti*) is symbolic for beauty, as evidenced in the saying, *Anakavite ta ilaa ya muti* ("She is as beautiful as the flower of the *A. pluriseta* plant"). Importantly, sacred groves consist of one or more sacred plant species commonly ficus trees within the area. Although these sites were typically water points for the community, they were fiercely guarded by taboos, and beliefs that banned tree felling, hunting, firewood harvesting, or fruit gathering. Water could only be drawn using traditional calabashes, while modern containers (e.g. plastics) and structural modifications, such as cement walls, prohibited to maintain the natural flow. Disregarding these customs is believed to anger ancestral spirits, making the water turn into blood (Perhaps discoloration due to presence of iron). In addition, social peace was preserved near these water sources, as fights or arguments were thought to dry up springs.

There were also cultural taboos which strengthened traditional conservation practices. There was a taboo against women climbing trees, which promoted the conservation of trees through the adoption of the practice of pollarding—hacking off branches instead of felling the entire tree. Trees selectively valued for their shade were planted within homesteads and were never cut down thus attracting a lot of weaver birds that served as alarms for the household. Thus, the Kamba people were living in unity with their place in nature and culture in balanced condition.

3.6.2 Birds

Birds hold immense cultural significance among the Kamba people, and myths and beliefs have shaped human interactions with various species. Eagles are sacred and are never consumed since it is believed that a person consuming them will die of thirst. Owls are also associated with bad luck and are not killed or hunted. The red-and-yellow barbet (*Muututu*) is protected by local superstitions that deter individuals from peeping into its nest, which is said to be associated with the development of boils upon contact. The young men are also cautioned against the use of slingshots to disturb these birds, with the belief that the slings will get damaged if they do.

The Nubian woodpecker is culturally significant for weather and journey omens. Its call predicts the onset of rain season, but hearing it at the start of a journey is considered a bad omen, prompting travelers to return home. Interestingly, men are forbidden from consuming woodpecker meat, while women may eat it. This taboo has contributed to the bird's protection, as men, traditionally the primary hunters, saw little purpose in hunting it since they are not allowed to eat it.

The White-browed Coucal is associated with water sources, while the Hamerkop (*Nguni*) is linked to water-related superstitions. Swimming in pools where a Hamerkop is seen is believed to cause skin infections, a belief that sought to prevent drowning incidents while preserving aquatic habitats. Nightjars are considered taboo for consumption, while village weavers are respected as symbols of wealth and are never hunted. Their morning calls serve as natural alarms, reinforcing their protection. Birds such as the Common Bulbul and Drongos are valued for their ability to alert people to the presence of chicken predators like snakes and eagles. Additionally, Black-throated Honeyguides are believed to lead people to forest honey, making them both culturally and practically significant.

Certain bird species also serve as clan totems, reinforcing their protection. The Crested Francolin (*Kindile*) is sacred to the Anziũnĩ (*Mũnziũ*) clan, while the Hawk (*Mbolosya*) is a totem of the *Atangwa* subclan *Mbaa Mulela* and the *Akĩtutu* (*Mũkĩtutu*) clan. The *Akĩtondo* (*Mũkĩtondo*) clan honors the Pied Crow (*Ngunguu*), while the *Amũtei* (*Mũmũtei*) clan reveres the Secretary Bird (*Ndei*). Traditionally, clan members are forbidden from hunting or consuming their totem birds, ensuring their protection. However, as cultural values erode, birds are increasingly hunted, and habitats destroyed. These traditional beliefs once played a crucial role in biodiversity conservation, emphasizing the interconnectedness of culture and wildlife protection.

3.6.3 Butterflies

Butterflies hold a unique place in Kamba culture, particularly among herding boys. One of the most prevalent beliefs is that bagworms (*Ndolooto*) possess mystical abilities, guiding people to lost cattle and even revealing future spouses. Some locals also associate armyworm infestations with ancestral punishment, making the use of insecticides culturally inappropriate. Rituals of offerings of milk, honey, and meat are undertaken instead to appease the ancestors. Secondly, butterflies are also natural pointers to changing seasons. Their migration within the Nzaui-Makuli landscape coincides with the immediate onset of the rainy season, mirroring not just their ecological but also their cultural significance. Consequently, they are preserved not only due to their beauty but also because they serve as environmental forecasters. Aside from popular beliefs, butterflies hold a unique position in Kamba folklore as symbols of beauty. This is demonstrated in the saying *Anakavite na kimbalutwa*—"She is as beautiful as a butterfly." Because of this, butterflies are both admired and protected. Their aesthetic appeal is also manifested in traditional ornaments, where necklaces and headbands are created from strands of dead butterflies, especially for circumcision rites.

Apart from butterflies, animals feature significantly in the Kamba clanship system. The long-tailed monkey (vervet monkey) serves as a totem for the *Aombe* (*Mwĩombe*) clan, and the jackal (*Mbiwa*) for the *Anzaũnĩ* (*Mũnzaũnĩ*) clan. The *Akĩthumba* (*Mukĩthumba*) clan reveres the antelope (*Nthwaia*), the *Aewani* (*Mũewanĩ*) clan the leopard (*Kikoyo/Ngo*), and the *Asii* (*Mũsii*) clan the lion (*Munyambu*). The *Atangwa* (*Mũtangwa*) clan, divided into four subclans—*Mbaa Mulela*, *Mbaa Kateti*, *Mbaa Mũtheka*, and *Mbaa Mũkuva*—admires the baboon (*Nguli*), while *Mbaa Mulela* alone pays homage to the hawk.

Kamba kinship also has moieties and phratries and clans with the sharing of totems. For instance, while the *Atangwa* clan is symbolized by the baboon, its *Mbaa Mulela* subclan shares the hawk totem with the *Akĩtutu* clan. This sharing suggests historical clan divisions, either voluntary or involuntary, mirroring the way religious groups separate yet retain shared symbols and traditions. Migration and memory loss may also lead to shifts in identity while preserving ancestral totems as enduring cultural markers.

CHAPTER 4: PLANT DIVERSITY WITHIN SACRED GROVES

By Munywoki, J. Mulinge; Ngumbau V. Mutele and Malombe Itambo

1.1 INTRODUCTION

The international community recognizes Sacred Natural Sites as fundamental components for protecting cultural along with biological diversity. Indigenous people and local communities recognize some natural features to hold deep religious and cultural significance such as mountains, rivers, forests, trees, stones, caves. They contain spirits of their ancestors along with deities and supernatural beings according to their beliefs. Managers of protected areas together with modern conservationists and cultural anthropologists recognize sacred natural sites as essential institutions which protect nature through indigenous knowledge systems. Similarly, international organization such as UNESCO, WWF and IUCN recognize their role as repositories of biocultural heritage (Ramakrishnan, 1996; Dudley *et al.*, 2005 and Wild & McLeod., 2008). Sacred sites provide superior ecological protection than Protected Areas (PAs) do, which results in substantial contributions to worldwide conservation goals.

The official recognition of many of these sites as *Indigenous Community Conserved Areas* (ICCAs) recently highlights the active participation of local communities in environmental governance. The 10th Conference of the Parties to the Convention on Biological Diversity (CBD 2010) established these sites as *Other Effective Area-Based Conservation Measures* (OECMs) to emphasize their role as alternative conservation models which support conventional protected areas. This increasing acceptance shows that conservation efforts need policies which embed cultural and spiritual heritage values for maintaining biodiversity protection.

The *Combretum*-wooded grassland of Makueni sub-county contains numerous sacred natural sites in the form of groves, ancient trees, hills, springs, mystical caves and legendary rock formations which function as essential repositories of the community's biocultural heritage. Safeguarded by traditional taboos and totemic beliefs, these sites not only preserve cultural identity but also function as vital sanctuaries for threatened biodiversity. They provide essential resources, including herbal medicine, nutritious wild fruits, food supplements, and clean water, sustaining both ecological balance and local livelihoods. However, these remnants of natural and cultural heritage face growing threats from shifting societal attitudes, cultural erosion, and a lack of awareness. Without urgent mapping, documentation, and formal recognition by both landowners and the county government, these sacred landscapes—and the ecological and cultural wealth they embody—risk being irreversibly lost.

1.2 General Objective

The primary objective of this survey was to assess the botanical richness and ecological significance of sacred natural sites within the Nzaui-Makuli landscape.

1.3 Specific Objectives

1. To systematically identify, document, and map all sacred natural sites within the Nzaui-Makuli landscape, capturing their geographical distribution, ecological attributes, and cultural significance.

2. To compile a comprehensive checklist of all plant species, present within the surveyed sacred sites, detailing their growth form, classification, and species within them.

3. To assess and identify plant species of conservation concern, including those classified as endemic, endangered, or vulnerable, while also highlighting species of cultural significance among the local community.

4. To investigate and profile the various threats facing these sacred natural sites, including environmental degradation, habitat loss, cultural erosion, climate change, and unsustainable human activities, while proposing potential mitigation strategies.

2.0 METHODOLOGY

2.1 Floristic Survey

Several field expeditions were carried out in 17 sacred sites between the months of March 2024 to January 2025. The various forest fragments hosting sacred sites were surveyed in both the wet and dry seasons with an effort put to expand geographical coverage to areas where threatened plant species targeted by this project were previous collected. General walk-over surveys were carried out targeting plant species in each sacred site and around. Plant species observed were thereafter photographed, tagged, and collected. Information on the plant species which had a significant role in the cultural practices were gathered from the key informant and local community. Additionally, the local guides helped identify the species in the field for accurate identification later. The species, habit, habitat, elevation, location, and collector's details were recorded in a note book. Opportunistic sightings of forms of disturbances such as illegal logging, overgrazing, expanded agriculture were also recorded.

2.2 Plant Collection, Identification and Processing

The standard operating procedures for the collection and preparation of voucher plant specimens were followed. Fertile plant specimens were collected, dried and deposited in the East African Herbarium (EAH). Identification of pressed specimens and databasing was conducted. Identification of species followed the field guide "*Kenya Trees, Shrubs and Lianas*" (Beentje 1994) and *The Flora of Tropical East Africa* (FTEA 1952-2012), *Upland wild flowers* (Agnew 2013) as well as all verifications being made using the material available at EAH. Images of specimens which proved challenging were sent to specialists for identification. 300 specimens were collected in total. Identification had a 99% success rate with only several samples being identified only to genus level. Previous collections recorded from the Makueni County were collated to supplement records from the field surveys.

2.3 Nomenclature and Conservation Status

Taxonomic status for families follows the classification of Angiosperm Phylogeny Group IV system (APG IV). The current taxonomic circumscription, as well as the authorities for each taxon were determined through the Plants of the World Online (POWO 2019) (http://www.plantsoftheworldonline.org), African Plant Database (http://africanplantdatabase.ch) (African Plant Database 2021), Tropicos (http://www.tropicos.org) (Tropicos 2021). Correct authorities were listed, mainly derived from TROPICOS as they agree with the current nomenclature, in some cases this was double-checked against the World Flora Online and the star ratings for tropical Africa databases. The conservation status of all plants recorded was determined using the International Union for Conservation of Nature criterion (IUCN 2025) (https://www.iucnredlist.org).

3.0 RESULTS AND DISCUSSION

A total of 17 sacred natural sites were mapped and surveyed within the Nzaui-Makuli landscape. However, this was not an exhaustive effort, as additional sites were identified with the assistance of local communities. Due to time constraints, the project was unable to survey all the recognized sites as supported by the species accumulation curve.

Figure 4.1: Botanical assessment and documentation of the identified sacred groves.

3.1 Species Accumulation Curve

The species accumulation curve represents the cumulative count of plant species across 17 sacred sites. Its asymptotic nature indicates that while species discovery slows with additional sampling, it has not fully plateaued (*see* Figure 4.2), suggesting that more species remain unrecorded. This implies that the survey did not achieve full sampling adequacy, and the recorded species richness underestimates the true diversity within the sacred sites. To capture rarer or habitat-specific species, increased sampling efforts are needed, particularly in underexplored areas. Future surveys should focus on additional plots or seasons to enhance completeness and provide a more comprehensive understanding of plant diversity in these sacred sites.

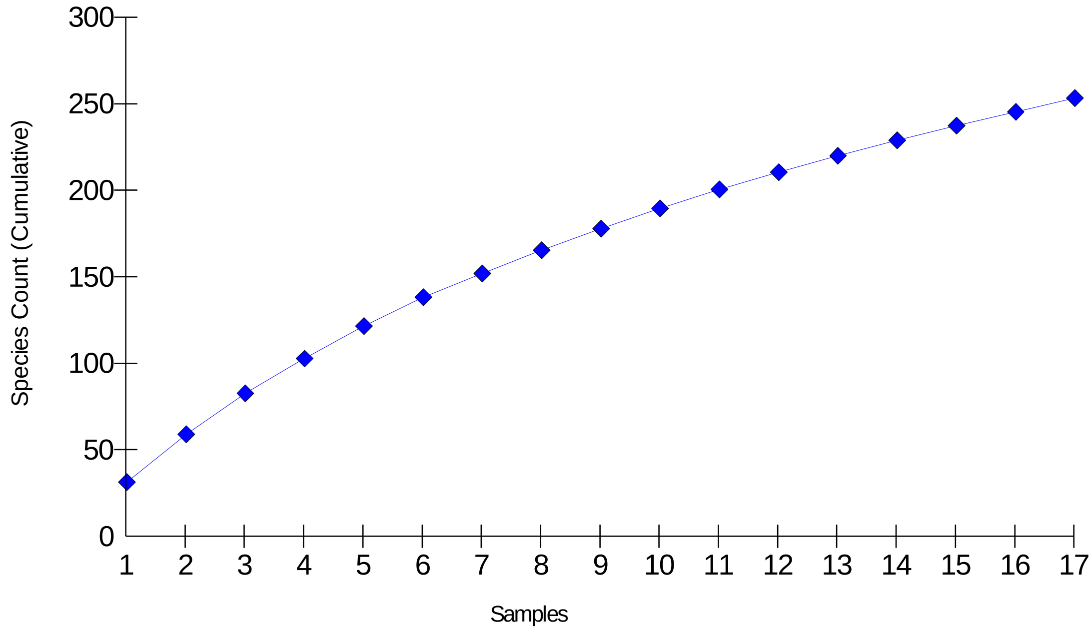

Figure 4.2: Plant species accumulation curve for the 17 sampled groves

A total of 253 vascular plant species (Annex I), including infraspecific taxa (subspecies and varieties), were recorded from the sacred groves across the Makuli-Nzaui landscape in Makueni County. These species belong to 162 genera and 61 families, representing 24.44% of species and 58.10% of plant families documented in the Kaiti watershed assessment (Malombe *et al.*, 2012). This highlights the critical role of sacred sites in plant conservation. The five most species-rich plant families are Fabaceae (31 species), Lamiaceae (21), Rubiaceae (20), Malvaceae (16), and Euphorbiaceae (14) (Figure 4.3). The most species-rich genera include *Ficus* (8 species, Moraceae), *Acacia* (7, Fabaceae), *Grewia* (5, Malvaceae), *Combretum* (5, Combretaceae), and *Vangueria* (4, Rubiaceae), demonstrating the high botanical diversity within these sacred groves. *Ficus* being the richest genera resonate with the cultural norm that most sacred sites were established under *Ficus* species.

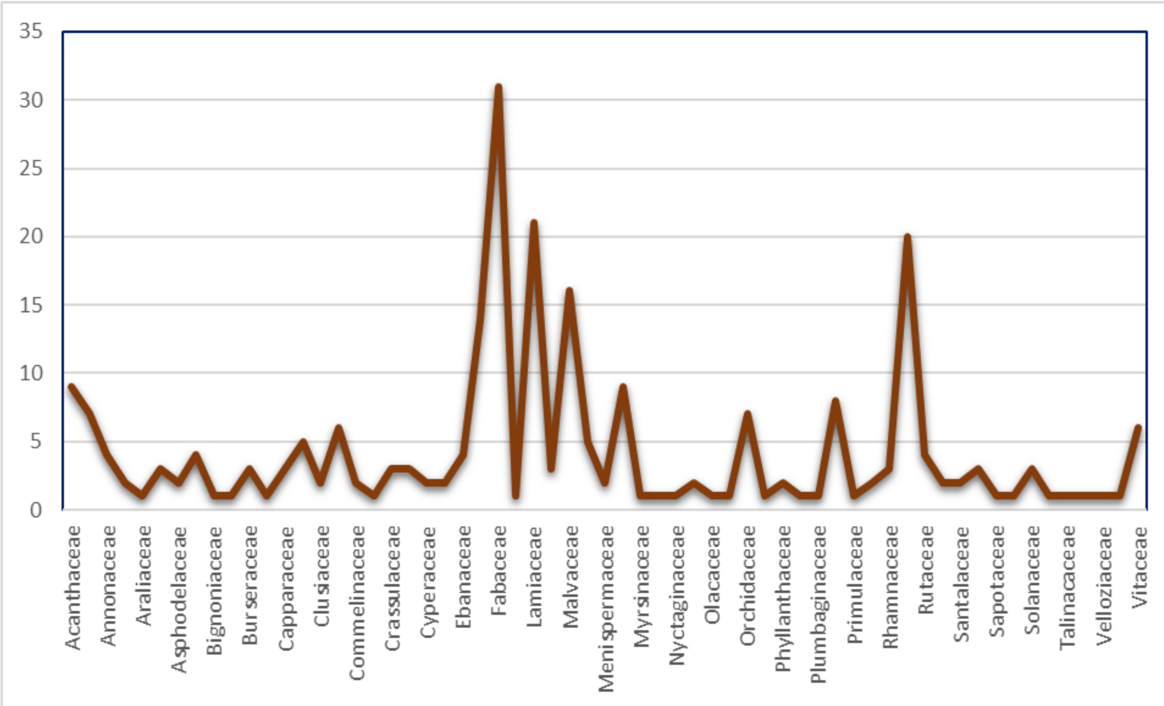

Figure 4.3: A graphic representation of plant families and species

3.2 Species richness

The five most species-rich sacred groves were Matooi (97 species), Kavyiu (47), Sammy (46), Mutweiti (38), and Syuvinda (37) (Figure 4.4). In contrast, the least species-rich groves among the 17 surveyed were Lilya (9 species), Kimiisya (11), Nzii (13), Nthukuni (18), and Kalinde (21). This variation in species richness has significant ecological and conservation implications. The groves with high species diversity indicate relatively well-preserved habitats, characterized by minimal human disturbance, favorable climatic conditions, and, in some cases, the presence of effective indigenous conservation practices. Conversely, species-poor groves like Lilya (9 species) reflect environmental degradation, often resulting from deforestation, agricultural encroachment, or climate-related stressors. The decline in species richness is largely attributed to habitat destruction and the erosion of traditional cultural values associated with these groves. Therefore, increased conservation efforts should focus on protecting the species-rich groves while implementing targeted restoration initiatives to rehabilitate the degraded, species-poor sites. Additionally, raising awareness about the ecological and cultural significance of these sacred groves will be essential in ensuring their long-term preservation.

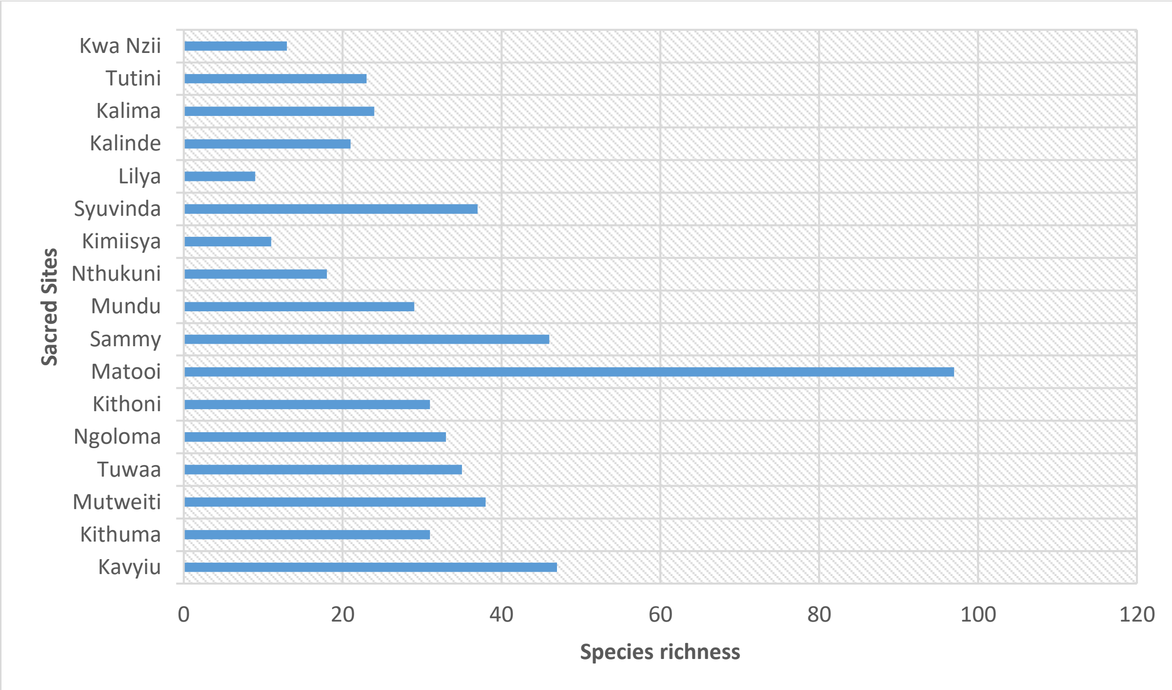

Figure 4.4: The number of documented species per sacred grove.

3.5 Species Similarity between Sacred Groves

Species similarity was conducted within 17 sacred natural sites across Nzaui-Makuli landscape. Four (4) distinct clusters of sacred natural sites were identified (Figure 4.5). Interesting three sacred groves Kimiisya, Nthukuni and Kwa Nzii were grouped as one enclave. These groves fall within protected forests Makuli and Nzaui Hill Forests. The elevation of these groves goes up to 2000 m a.s.l and have established *Afromontane* climatic conditions that support plant species suited to higher elevations. They are all surrounded by exotic trees especially *Eucalyptus* sp. and *Cypress* species.

The clustering of the four sacred groves; Lilya, Tutini, Kalinde, and Kalima is driven by their shared plant species composition, shaped by environmental and anthropogenic factors. Located in a severely degraded landscape of abandoned farmlands, these groves serve as crucial biodiversity refuges, as the surrounding area, affected by overgrazing and unreliable rainfall, lacks diverse vegetation. Studies indicate that plant species similarity among these groves results from common climatic conditions, soil properties, and human disturbances. Dominant plant families—Fabaceae, Combretaceae, Lamiaceae, and Poaceae—characterize secondary vegetation typical of disturbed habitats (Sharma & Patel, 2018). These groves play a vital role in conserving local flora, mitigating biodiversity loss, and maintaining ecological stability in an otherwise degraded region.

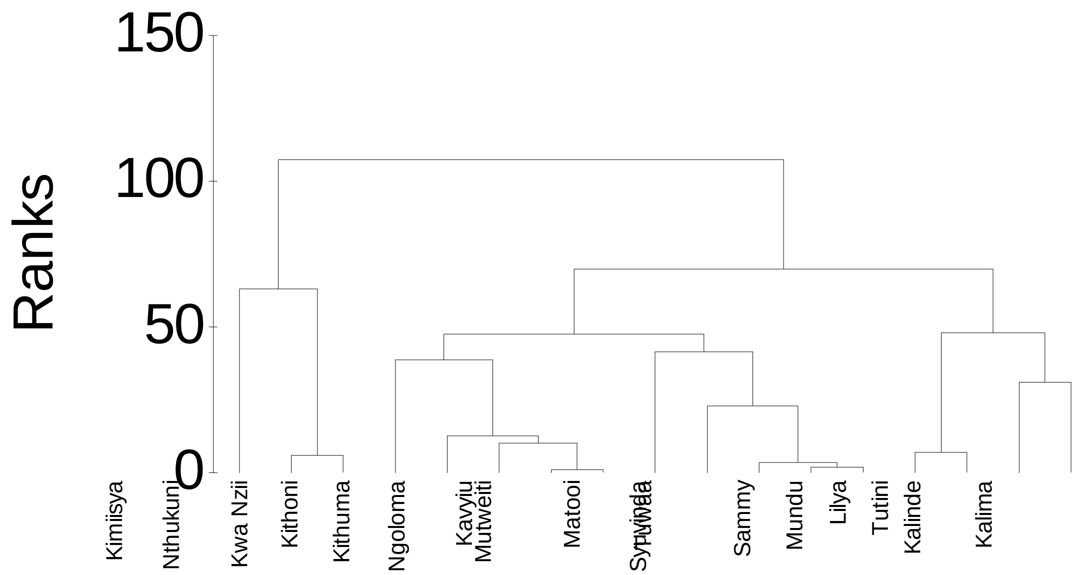

Figure 4.5: Cladogram of species diversity similarity among the sacred groves

Ngoloma, Kithuma, Kavyiu, Mutweiti along with Kithoni sacred groves cluster together (Figure 4.5) because of shared plants occurrences influenced by topographic elements, such as elevation, aspect, and position. The sacred groves exist at elevations above Kwa Lilya (low elevation) but below Kwa Nzii because here altitude greatly influence temperature, soil conditions and humidity which directly influence plant distribution. The plant families Euphorbiaceae, Fabaceae, Lamiaceae, Malvaceae, Vitaceae and Rubiaceae dominate this ecological zone because they have adapted to the prevailing conditions. The close proximity to each other together within established connectivity, though degraded, facilitates cross-pollination and seed spread while the isolated position of Kithoni restricts natural exchanges that create species dissimilarity. The plant diversity in this area is also influenced by human activities that combine cultural preservation with selective protection measures since most sacred groves in the study area we found to be active.

Matooi, Tuwaa, Syuvinda, Sammy, and Mundu sacred groves group is explained by species composition patterns owing to altitude, spatial distribution, and the size of the grove. Mundu and Sammy, despite being in proximity to one another, enabling species exchange, Matooi, despite being in proximity, has fewer species in common owing to its elevated position on Matooi Hill. This identifies elevation as one of the main drivers of plant distribution, as seen in Makuli and Nzaui hill forest, where elevation controls temperature moderation, soil moisture content, and soil type. Notably, Tuwaa and Syuvinda are more distant in the cluster (*see* Figure 4.5), indicating other variables are in play besides distance and elevation, i.e., the size of the grove. More extensive groves, such as in this group, harbor more varied habitats, buffering edge effects and increasing species richness. Their large interiors sustain stable microclimates that provide habitat for shade-adapted species, while disturbance-tolerant species on the edges create ecological gradients that ensure long-term biodiversity resilience.

3.3 Plant Growth Forms.

The growth forms of plants such as trees, shrubs, lianas, and herbs exhibit distinct mechanical architectures that can also vary phenotypically in response to environmental conditions (Rowe & Speck, 2005). In the Makuli-Nzaui landscape sacred sites, shrubs and trees dominate, accounting for 36% and 27% of the recorded plant life, respectively. Herbs follow closely at 26%, while herbaceous climbers and lianas make up 6% and 5%, respectively (Figure 4.6). These sacred sites support a diverse range of plant life forms, yet, unlike many other ecosystems, trees and shrubs prevail. This dominance aligns with cultural beliefs that sacred sites should be characterized by tree cover. Overall, woody taxa (trees and shrubs) constitute 68% of the recorded species, whereas herbaceous forms make up the remaining 32%.

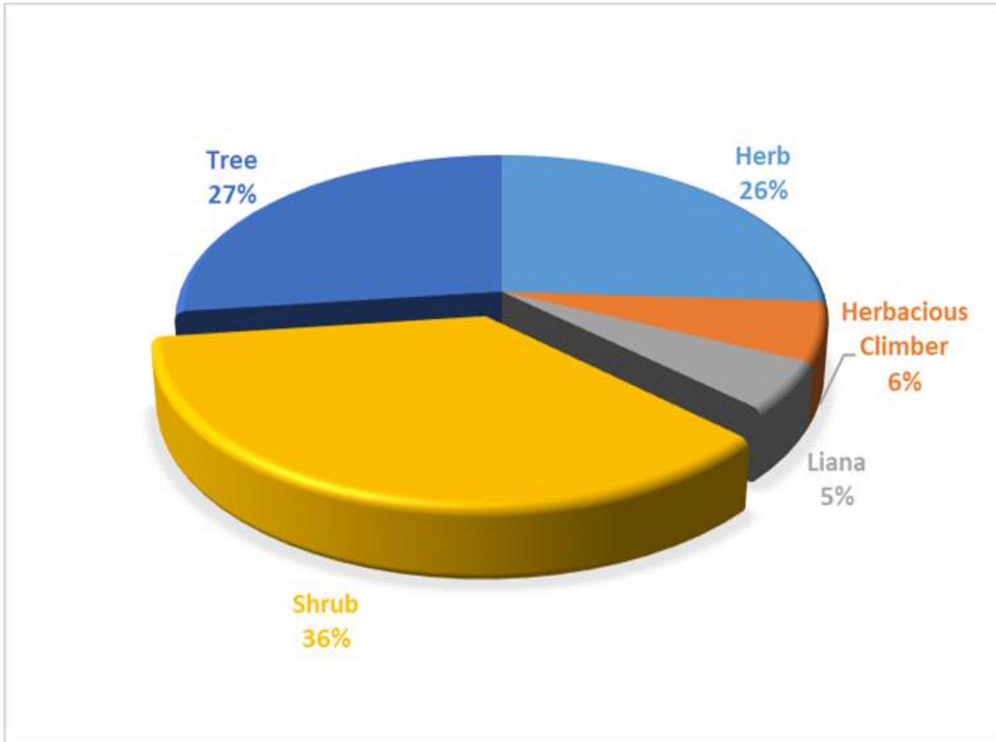

Figure 4.6: Representation of growth forms across the documented plant species.

These forms define ecosystems by influencing biodiversity, habitat structure, and ecological processes. Each plant form exhibits unique biomechanical adaptations that determine their ecological roles. Trees, with their rigid trunks and extensive root systems, offer structural stability and microhabitats for other organisms (Niklas, 1992). Shrubs, with multiple woody stems, provide understorey cover and play a vital role in soil stabilization (Givnish, 2002). Herbaceous plants, in contrast, grow rapidly and serve as pioneer species in disturbed areas (Grime, 2001). Lianas and herbaceous climbers rely on other vegetation for support, thriving in competitive environments by maximizing vertical growth while minimizing structural investment (Rowe et al., 2004). The Makuli-Nzaui sacred sites exhibit a higher prevalence of woody taxa, aligning with cultural and ecological functions. The dominance of trees and shrubs suggests minimal human disturbance, enabling late-successional species to establish and thrive (Mbile *et al.*, 2005). Such sites contrast with other ecosystems, where disturbance regimes favor herbs or lianas.

The prominence of trees and shrubs in sacred landscapes supports the theory that cultural beliefs shape plant community structures (Ormsby & Bhagwat, 2010). Sacred groves across Africa, Asia, and South America are preserved through traditional knowledge, often serving as biodiversity hotspots (Bhagwat & Rutte, 2006). In Makuli-Nzaui, this cultural preference likely influences species composition by discouraging deforestation and promoting natural regeneration. However, environmental conditions such as soil fertility, water availability, and anthropogenic activities also play a role in shaping vegetation patterns. Sacred sites with high canopy cover may limit light penetration, favoring shade-tolerant species over sun-loving herbs (Chazdon, 2008). Moreover, historical land use and climate change can alter species dominance over time.

3.4 Plant Species of Conservation Concern

The Red List and Red Data species system is an approach developed by the IUCN for evaluating the conservation status of species, and in particular for identifying and documenting species in need of conservation attention (IUCN 2025). According to this system, 11 taxa from the sacred sites of Makuli-Nzaui landscape, belonging to 6 families were categorized as, Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Near Threatened (NT). This represents 4.35 % of the total taxa recorded from the sacred sites of Makuli- Nzaui landscape. Of the 11 species recorded, two taxa were recorded as Critically Endangered, two Endangered, four Vulnerable, and 3 Near Threatened (Figure 4.7). *Cola greenwayi* though not assessed under IUCN red list, according to the finding of this study is not commonly distributed. Therefore, following the threats that befit their habitat we consider it threatened. The top three families which had most of its members threatened were Rubiaceae commonly known as coffee family, Fabaceae (Pea family) and Asphodelaceae. This study notes that most of the species documented within the sacred sites of Makueni County are evaluated as least concern (44%) and others are not evaluated (42). Most of this assessment was done many years ago and does not reflect the current status of the species following the rampant threat experienced in the region.

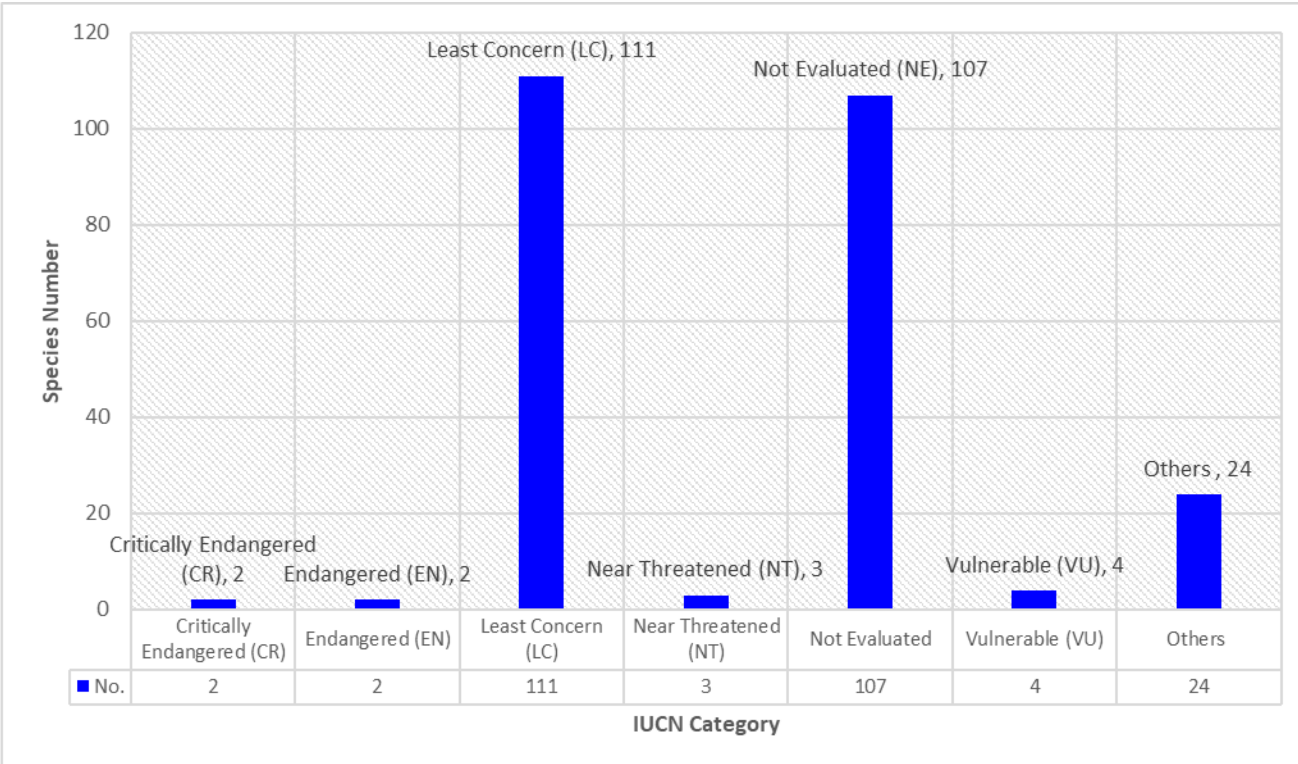

Figure 4.7: Conservation status (IUCN) of the plants within the sacred sites

Similarly, numerous species (3.95%) documented within the sacred groves were also listed in Appendix II of CITES, which includes species not currently facing extinction but at risk if trade is not strictly regulated. Notable among them are *Osyris lanceolata*, *Aerangis confusa*, *Angraecum affine*, *Bonatea steudneri*, *Eulophia petersii*, *Eulophia streptopetala*, *Rangaeris amanuensis*, *Dalbergia melanoxylon*, *Aloe deserti*, and *Aloe ngutwaensis*. We observe with concern that the Nzaui-Makuli landscape has recently experienced a troubling surge in plant poaching, particularly targeting *Osyris lanceolata* and various species of *Aloes*, threatening their persistence within the landscape.

3.6 Cultural Keystone Species

The Kamba traditional stories and folklore place greater cultural value on certain plants than others (Table 4.1). Among them are the *Ficus sycomorus* (Mukuyu) that have high cultural and spiritual value. Traditionally, where it grows is regarded a good site for establishing sacred groves as it represents strength, protection, and divinity. Its occurrence is perceived to be a water source or where the water table is close to the surface. Their widespread roots are claimed to draw water closer to the surface, and this results in the formation of streams, demonstrating its value as a source of water. This myth reinforces the determination of the people to preserve these trees because it is forbidden to destroy them. Other plants enveloped in protective myths, beliefs and taboos are those utilized in preparing purificatory media (Ng'ondu) such as *Dorstenia arachniformis*. It is common belief that interference with these plants, would lead to hand deformities, acting as a deterrent to their abuse. Such cultural narratives are traditional conservation practices, protecting valuable plant species that form part of the Kamba rich biocultural heritage.

Table 4.1: Culturally Important Species recorded within the sacred groves.

S/No	Species Name	Local Name
1.	*Commelina benghalensis*	Mukengesya
2.	*Kalanchoe lanceolata* (Forssk.) Pers.	
3.	*Kalanchoe densiflora* Rolfe	
4.	*Bauhinia taitensis* Taub.	Mulima
5.	*Ocimum kilimandscharicum* Baker ex Gürke	Mutaa
6.	*Strychnos henningsii* Gilg	Muteta
7.	*Ficus natalensis* Hochst.	
8.	*Ficus bussei* Warb. ex Mildbr. & Burret	
9.	*Ficus glumosa* Delile	Kikelenzu
10.	*Ficus ingens* (Miq.) Miq.	
11.	*Ficus stuhlmannii* Warb	
12.	*Ficus lutea* Vahl	
13.	*Ficus sycomorus* L.	Mukuyu
14.	*Ficus thonningii* Blume	Kiumo
15.	*Dorstenia arachniformis*	Ngondu ya Kitumbi/Itumbi
16.	*Cynodon dactylon* (L.) Pers.	Ikoka
17.	*Hymenodictyon parvifolium* Oliv.	Mulinditi
18.	*Psychotria kirkii* Hiern.	Ngondu ya Muthumba
19.	*Solanum renschii* Vatke	Kitongu tongu
20.	*Lantana rhodesiensis* Moldenke	Kivisavisi
21.	*Aloe deserti*	Kiluma
22.	*Aloe ngutwaensis*	Kiluma

A total of 22 plant species (8.7%) was recorded within the 17 surveyed sacred groves of the Nzaui-Makuli landscape, all of which held significant cultural value among the local communities (Table 4.1). Broadly, these species were either favored for the establishment of sacred groves or played an essential role in Kamba cleansing rituals. Among them, species of the *Ficus* genus were particularly preferred for sacred grove establishment, as they are symbolically associated with peace (*Muti muvoo*). Other plants were integral to the preparation of herbal medicinal mixtures or served as purifying agents, locally referred to as *Ng'ondu*, used in traditional purification rituals. Notably, three plant species were widely recognized across the Nzaui-Makuli landscape for their role in such practices: *Dorstenia arachniformis* (Ng'ondu ya Kitumbi/Itumbi) which is critically endangered, *Hymenodictyon parvifolium* (Ng'ondu ya Mulinditi), and *Psychotria kirkii* (Ng'ondu ya Muthumba).

The root infusion of *Bauhinia taitensis* was reported to be used for cleansing homes just as root ash from *Solanum renschii* is administered for ritual impurity. Similarly, leaf infusion from *Lantana rhodesiensis* is used as ritual infusion. Also, *Commelina benghalensis*, *Cynodon dactylon*, *Ocimum kilimandscharicum*, *Kalanchoe lanceolata*, *Kalanchoe densiflora* were used for cleansing rituals. Another cultural keystone species identified by the study was *Aloe deserti* and *Aloe ngutwaensis* (homonymously named *Kiluma* by locals). These species have a ritual application among the Kamba community as it was used to pronounce curse upon someone.

3.7 Threats to Plants within Nzaui-Makuli Landscape.

Vegetation in the study area is under serious threat due to rapid population growth, leading to extensive land clearance for farming and settlements (Figure 4.8). Expanding orchards demand frequent pesticide use, harming insects and wildlife. Illegal logging for charcoal and construction further depletes vegetation. Invasive species like *Lantana camara*, *Dodder cuscuta*, and *Dodonaea angustifolia* outcompete native plants, altering the ecosystem. Poaching of wild plants such as *Aloe* species and *Osyris lanceolata* has intensified, reducing their numbers. The introduction of fast-growing *Eucalyptus* species has led to monoculture plantations supporting limited biodiversity. Additionally, land subdivision fragments habitats, limiting genetic exchange among plant populations. Combined, these factors accelerate biodiversity loss and ecological imbalance.

Figure 4.8: Some of the documented threats towards biodiversity in the area.

Conclusion

A total of 17 sacred natural sites were mapped and surveyed within the Nzaui–Makuli landscape. Across these sites, 253 plant species were documented, providing the first-ever comprehensive checklist of flora associated with sacred groves in this region. This baseline inventory underscores the critical role that sacred natural sites play in in situ plant conservation. Notably, the occurrence of species such as *Cola greenwayi* var. *keniensis* Brenan, *Oxyanthus goetzei* subsp. *keniensis* Bridson and *Craibia brownii* Dunn is reported here for the first time from this area, representing new regional records. These findings suggest that further rigorous and systematic botanical surveys could yield additional species discoveries, potentially including taxa new to science an assertion supported by recent floristic discoveries within the county such as *Dorstenia arachniformis* Matheka, Malombe, T. Mwadime & Mwachala and *Aloe ngutwaensis* T. Mwadime & Matheka.

Of the species recorded, 22 held pronounced cultural and ethnobotanical significance to the local communities, affirming the socio-ecological value of these sacred groves. Furthermore, 11 taxa belonging to six families were classified under various IUCN threat categories, including Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Near Threatened (NT), representing 4.35% of the total flora documented. However, this figure likely underrepresents the actual number of taxa of conservation concern within the landscape. Many species occurring in the Makuli–Nzaui area exhibit narrow geographical ranges and are subjected to escalating anthropogenic pressures, suggesting that a greater proportion may meet the criteria for threatened status upon detailed assessment. For instance, *Cola greenwayi* is confined to limited distributions, with extremely restricted Extent of Occurrence (EOO) and Area of Occupancy (AOO), indicating a high risk of extinction. Consequently, there is an urgent need for targeted conservation assessments and the development of informed conservation strategies to prevent further species extinction and halt biodiversity loss.

The presence of multiple plant species listed under CITES Appendix II within these sacred groves such as *Osyris lanceolata*, *Dalbergia melanoxylon*, various orchids, and *Aloes* further emphasizes their conservation significance. Although these species are not currently classified as endangered, they remain susceptible to overexploitation, particularly due to unregulated trade. The inclusion of such taxa within sacred groves positions these sites as critical refugia for flora under threat, highlighting the imperative for their continued protection and the promotion of sustainable management practices. Ecological clustering of the sacred groves revealed four distinct groupings, reflecting environmental heterogeneity and geographical diversity across the landscape. In particular, the grouping of Kimiisya, Nthukuni, and Kwa Nzii into a single enclave is indicative of shared biocultural and ecological attributes. These sites, situated within the protected Makuli and Nzaui Hill Forests at elevations around 2000 m a.s.l., are characterized by Afromontane climatic conditions that support a unique assemblage of high-altitude flora. This elevates their importance as reservoirs of montane biodiversity and reinforces the role of sacred natural sites in conserving ecologically specialized plant communities.

CHAPTER 5: BIRD DIVERSITY WITHIN SACRED GROVES

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1.1 INTRODUCTION

Kenya is home to a variety of forest ecosystems, including montane rainforests, savannah woodlands, dry forests, mangroves, and coastal forests, all of which play essential ecological, cultural, and socio-economic roles (Kenya Forestry Service, 2012). However, these natural forests are increasingly being cleared for agriculture, while the rising demand for wood products is leading to the widespread expansion of monoculture plantations. As a result, the landscape has been transformed into a mosaic of human-modified habitats, such as agricultural lands, agroforestry systems, remnants of old-growth forests, logged areas, secondary forests, and plantations (Chazdon, 2014). These human-driven agroecosystems often differ substantially from native forests in both structure and composition, altering key ecological and functional processes.

In the highly-fragmented *Combretum*-wooded grassland of the Makueni Sub-County, these remnants of old-growth forests manifest as small, isolated patches mostly as sacred natural sites. They constitute the least studied habitats of these modified habitats. Despite the growing pressures from anthropogenic activities, these sacred groves have mainly persisted because of traditional beliefs and taboos attached to them. Although these sacred sites are critical habitats for biodiversity, there has been no comprehensive study to document their biodiversity value. Although substantial attempts have been made to document plants in the area, information about avifaunal diversity is notably lacking.

1.2 General Objective

The main aim of the study was to document the diversity of bird species within the various sacred groves within the fragmented *Combretum*-wooded grassland in Makueni subcounty, raise awareness of and enhance the appreciation of the local community regarding the critical role these sites play in biodiversity conservation.

1.3 Specific Objectives

1. To determine the avifaunal diversity within sacred sites across Nzaui-Makuli landscape.
2. To determine the avian feeding and forest-dependent guilds of the documented species.
3. Highlight species of conservation concern within the sacred groves.
4. To profile threats facing birds and their habitats within Makuli-Nzaui area.

2.0 METHODOLOGY

2.1 Timed Species Count (TSC)

This method was employed to document bird species in the more extensive sacred groves within the Nzaui-Makuli landscape. Initially designed for savannah habitats (Pomeroy & Tengecho, 1986), it was later modified and validated for use in forested environments, particularly for surveying birds in the mid and upper canopy (Bennun & Waiyaki, 1992a, 1993). The long-term protection of these sacred groves, driven by cultural and spiritual beliefs, led to the formation of dense canopies, enhancing habitat suitability for a diverse range of bird species while allowing for greater mobility during observations. Surveys were conducted twice daily, from 6:30 AM to 11:30 AM, when bird activity peaked, and in the evening, from 5:00 PM to 6:00 PM. Observers followed a predetermined route, moving slowly and quietly to ensure complete coverage while minimizing disturbances. Each 60-minute survey involved frequent stops to document all birds seen or heard (Waiyaki, 1995; Bennun & Howell, 2002). Data was analyzed using PRIMER software, and species were categorized as forest specialists, generalists, or visitors (Bennun *et al.*, 1996). The recorded bird species were classified into guilds according to habitat and diet preferences.

2.2 Point Count

The sacred groves varied significantly in size, necessitating a tailored approach for bird documentation. For smaller groves measuring less than 50 meters in radius, a single fixed point was strategically selected at the center of each grove. Observations were conducted for a total of 60 minutes per grove, ensuring comprehensive species documentation. Each point count survey included an initial 10-minute habituation period, allowing bird activity to normalize by minimizing disturbances. This was followed by 50 minutes of systematic observation, a duration identified as optimal for obtaining reliable species richness estimates (Mattos & Peris, 2008). During the observation period, all individual birds detected visually or acoustically were recorded. To ensure broad coverage, the direction of observation, initially chosen at random, was rotated clockwise by 90 degrees every 12.5 minutes. Olympus Trooper 8×40 DPS I Binoculars and a field guide facilitated visual identification, while bird call recordings assisted in confirming vocalizations. Species identification was based on *Birds of Kenya and Northern Tanzania* (Zimmerman *et al.*, 1996). Classification into habitat-preference guilds followed forest-dependence classification of Bennun and others (1996). Diet classification for African birds was used to group birds according to their diets (Kissling *et al.*, 2007).

2.3 Opportunistic Observations of Disturbance Indicators

Opportunistic observations were used to identify and document signs of disturbances within the sacred groves. These included charcoal kilns, livestock dung, grazing animals, agricultural encroachment, and infrastructure developments such as expanding roads and urbanization. Each disturbance was systematically recorded to profile potential threats to the birds and their habitat.

3.0 RESULTS AND DISCUSION

An ornithological survey was undertaken in 13 sacred groves within the Nzaui-Makuli landscape including Kwa Syuvinda, Nthukuni, Ka Ndoo, Kimiisya, Kwa Sammy, Matooi Mystical Cave, Kwa Mundu, Kwa Ngoloma, Kwa Kavyiu, Kwa Mbaa Kithuma, kwa Mutweiti, Kwa Nzii, and Tuwaa sacred groves. Of the above sacred sites, only four were found within the protected forests of Nzaui (Kwa Nzii) and Makuli (Nthukuni, Kimiisya, and Ka Ndoo).

3.1 Species Accumulation Curve

A total of 109 species and 680 bird individuals were recorded across 13 sacred groves within the study site. The species accumulation curve was generated to determine the sampling adequacy in the study area (Figure 5.1). The species accumulation curve using the 13 sites sampled did not reach an asymptote. This indicates that the survey did not adequately capture the total diversity that occurs in the sacred groves across the Nzaui-Makuli Landscape. With additional sampling, more species are likely to be recorded.

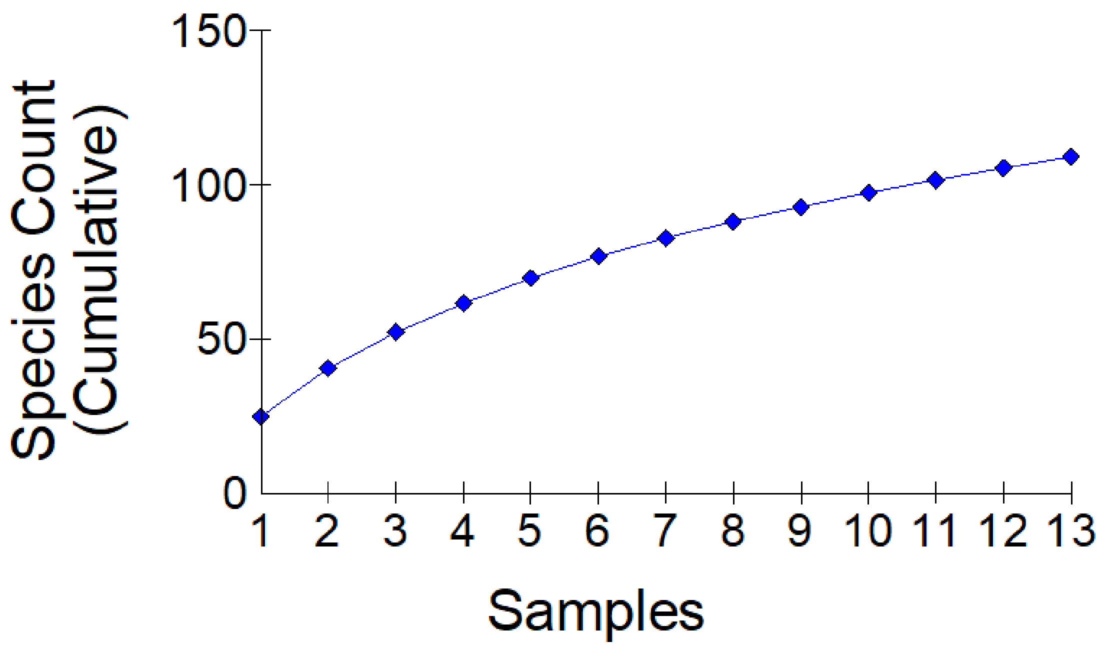

Figure 5.1: Species Accumulation Curve for the Sampled Sites.

3.2 Bird Species Composition.

All the species recorded belonged to 41 bird families. The most dominant bird families included Columbidae, Malaconotidae, Pycnonotidae, and Estrildidae, each with seven species (6.4%). On the other hand, Numididae, Threskiornithidae, Scopidae, Falconidae Musophagidae, Meropidae, Upupidae, Bucerotidae, Picidae, Platysteiridae, Laniidae, Oriolidae, Dicruridae, Monarchidae, Corvidae Timaliidae, Turdidae, Motacillidae, and Emberizidae were the least dominant (0.92%) each with one species (*See* Figure 5.2).

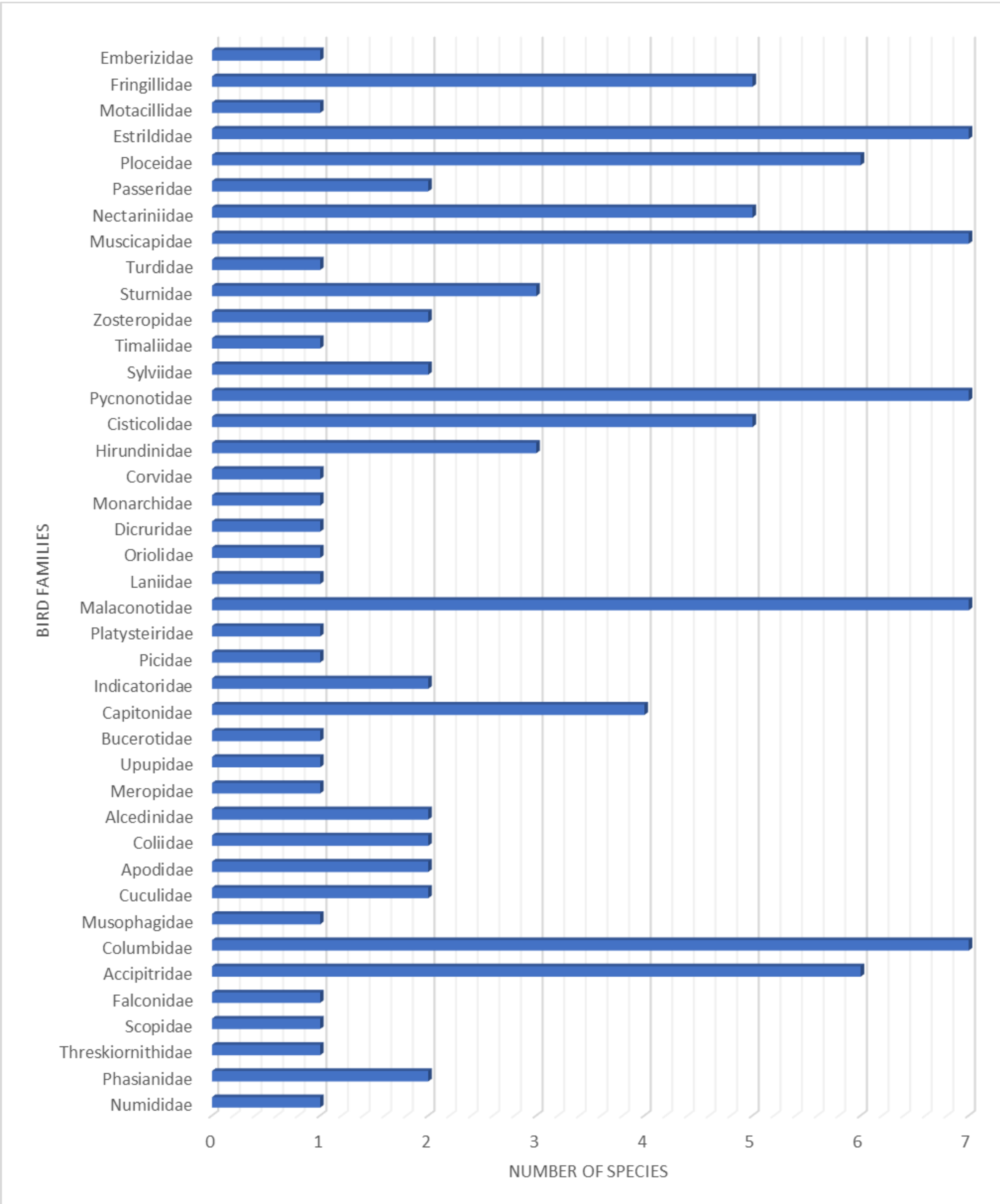

Figure 5.2: The number of species across bird families.

3.3 Bird Species Richness

A total of 109 bird species were documented across the 13 sacred groves within the Nzaui-Makuli landscape. The highest number of bird species were recorded in Matooi at 40, Kwa Sammy 33, Syuvinda 32, Kwa Mutweiti 29, Tuwaa and Ngoloma each at 28, Kwa Mbaa Kithuma recorded 27, Kwa Mundu 24, Kwa Nzii 22, Kwa Kavyiu 19, Nthukuni 17, Kimiisya 10, and Ka Ndoo recorded the least bird species at 8 (Figure 5.3).

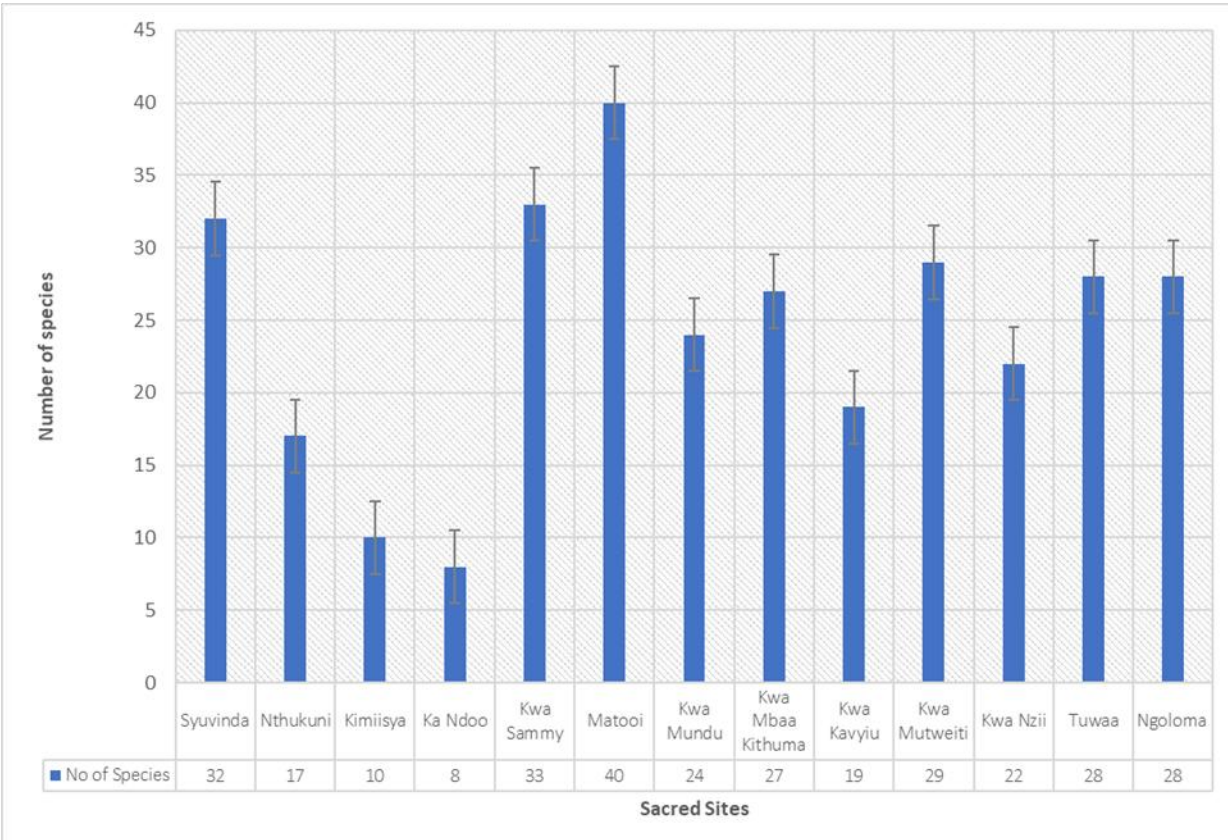

Figure 5.3: Number of bird species documented across the 13 sacred sites.

From the results, the species richness varied from one sacred grove to another. Matooi (40 species) and Sammy (33 species) had the highest richness, indicating favorable conditions such as habitat heterogeneity and food availability, which support more bird species. The higher richness in Matooi and Sammy suggests structurally diverse vegetation. Ka Ndoo grove (8 species) had the lowest richness, possibly due to habitat degradation and limited food resources. The main reason why this grove had the lowest species richness is because of habitat quality dominated by exotic *Eucalyptus* species. Higher species richness enhances ecosystem stability and resilience (Tilman *et al.,* 1997). Groves like Matooi and Sammy serve as biodiversity hotspots and should be prioritized for conservation initiatives.

Table 5.1: Diversity indicess across the 13 sacred groves.

		Diversity Indices			
S/No	Sacred Grove	Total Abundance (N)	Species Richness (s)	Shannon-Wiener Index (H' loge)	Pielous Evennes (J')
1.	Syuvinda	109	32	3.11	0.9
2.	Nthukuni	27	17	2.66	0.94
3.	Kimiisya	18	10	2.17	0.94
4.	Ndoo	14	8	1.77	0.85
5.	Sammy	56	33	3.34	0.96
6.	Matooi	127	40	3.25	0.88
7.	Mundu	55	24	2.84	0.89
8.	Kithuma	39	27	3.15	0.96
9.	Kavyiu	42	19	2.69	0.91
10.	Mutweiti	49	29	3.17	0.94
11.	Nzii	35	22	2.9	0.94
12.	Tuwaa	48	28	3.09	0.93
13.	Ngoloma	61	28	2.9	0.87

Bird species abundance (the total number of individuals) varied significantly across the sacred groves. The results indicate that Matooi (127 individuals) and Syuvinda (109 individuals) had the highest abundance. In contrast, Ndoo (14 birds) and Kimiisya (18 birds) had the lowest abundance (*See* Table 5.1). Such variations highlight the influence of ecological and anthropogenic factors on bird populations. Habitat quality plays a crucial role in supporting high bird abundance. Groves with diverse vegetation structures tend to harbor more birds due to the availability of foraging and breeding resources (Tews *et al.*, 2004). The high abundance in Matooi suggests a well-preserved habitat with rich flora, whereas lower counts in Ndoo indicate habitat degradation as the dominant vegetation was exotic *Eucalyptus* species. Additionally, the low abundance in certain groves may be a direct consequence of such pressures, reducing habitat suitability for many bird species. Furthermore, ecological factors like predation and competition can influence abundance levels, as high predator presence or resource competition can limit population growth (Newton, 1998).

A high number of bird individuals enhances ecosystem functions such as seed dispersal, pollination, and pest control (Şekercioğlu, 2006). However, high abundance alone does not necessarily indicate a healthy ecosystem, as dominance by a few species can lead to reduced overall diversity (Gaston, 2000). The relatively even distribution of birds across most groves suggests a balanced ecosystem. Therefore, conservation efforts should focus on maintaining the high-abundance groves while restoring degraded ones to sustain bird populations and ecological integrity (Sodhi *et al.,* 2011).

3.4 Species Evenness

According to Magurran (2004), this ecological metric evaluates the distribution balance between species' individuals in a community. Evenness values range from 0 to 1, where higher values suggest an even distribution with no single species dominating the community (Pielou, 1966). The bird communities in all the sacred groves demonstrated excellent species evenness, with values ranging between 0.85 to 0.96 (*See* Table 5.1). The bird communities in Sammy (0.96), Kithuma (0.96), and Kimiisya (0.94) displayed the most balanced species distribution because they showed minimum dominance patterns and equal individual distribution. The evenness index values of Ndoo (0.85) and Ngoloma (0.87) were the lowest among all sacred groves, which indicate potential species dominance possibly caused by habitat disturbance, resource scarcity, or predation.

The stability of ecosystems relies on species evenness because it prevents species competition, thus maintaining biodiversity sustainability (Tilman *et al.*, 1997). Systemic suppression from dominant species against other species leads to the breakdown of ecological functions, which further causes ecosystem stability to fail (Gaston, 2000). Sodhi *et al.* (2011) established that ecosystems become more environmentally resilient when they preserve higher evenness because species share resources evenly. The low evenness witnessed in Ndoo and Ngoloma groves points to an ecological stress condition resulting from habitat decline, insufficient food resources, and a growing human population. The preservation of ecological integrity, together with the functional stability of avian communities in sacred groves, requires the maintenance of species evenness.
While larger groves like *Matooi* provide extensive habitat space, some smaller sacred groves, such as *Kithuma*, *Sammy, and Mutweiti*, still exhibit high species evenness (J' > 0.90) (Table 5.1). This suggests that factors beyond grove size contribute to maintaining balanced bird populations. The edge effects and habitat diversity are some of the plausible explanations.

The high edge-to-core ratio of smaller groves means that they have both forested and open habitats in a limited space, creating a range of microhabitats that support diverse bird species without encouraging competition (Murcia, 1995). This diverse habitat structure enables different ecological bird species to share the same space, which results in balanced population distributions. The existence of keystone resources, including fruiting trees, water sources, and nesting sites, acts as a vital factor for maintaining diverse bird populations within small grove areas (Tews *et al.*, 2004). The presence of these critical resources at Kithuma, Sammy, and Mutweiti likely led to their high evenness. Although Nthukuni, Ndoo, Kimiisya, and Nzii are smaller groves, they fall within protected areas with stable environmental conditions that help preserve species distribution balance in them.

The more extensive *Ngoloma* grove demonstrated less species evenness (J' = 0.87) than the smaller *Kithuma* (J' = 0.96) (*See* Table 5.1). The observed difference demonstrates that bigger size does not necessarily translate into higher species evenness when habitat quality differs across the grove. The human disturbances manifesting in selective logging, overgrazing, and resource extraction within *Ngoloma* grove create conditions that favor few generalist species while eliminating specialists, ultimately lowering evenness (Bhagwat & Rutte, 2006). In contrast, *Kithuma* faces less human disturbance, which enables their bird population to develop naturally without human intervention. According to *Island Biogeography Theory*, the limited size of *Kithuma* does not hinder species balance because its connection to nearby habitats allows continuous bird immigration (MacArthur & Wilson (1967). The conservation strategy should prioritize protecting bigger groves while simultaneously preserving smaller ones because they both maintain essential roles in preserving balanced bird populations.

3.5 Species Similarity between the Sacred Groves

The clustering pattern observed in the dendrogram indicates that Ndoo, Nthukuni, and Kimiisya form a distinct group (all in Makuli Forest), separate from the other sacred groves (*See* Figure 5.4). These three hilltop groves are characterized by the dominance of exotic species, primarily *Eucalyptus* sp. and *Cyperus*, and are managed under a protected land tenure system. Similarly, Nzii also falls under the same land tenure category and is a hilltop grove with a predominance of exotic plant species- *Eucalyptus*). However, despite these shared characteristics, Nzii is clustered separately, suggesting notable differences in bird species composition. The main difference between these two cluster groups stems from vegetation composition because *Ndoo, Nthukuni,* and *Kimiisya* consist mainly of exotic species, while *Nzii* retains substantial indigenous vegetation coverage. The combination of native flora with exotic species at *Nzii* probably creates a diverse bird community, which explains its distinct position in the dendrogram.

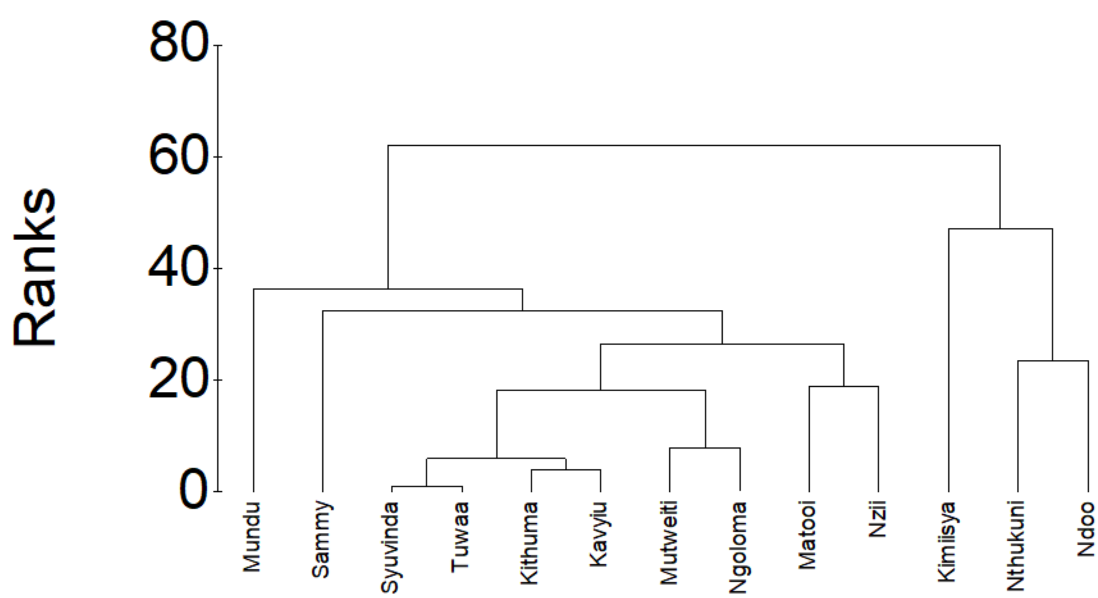

Figure 5.4: Hierarchical clustering dendrogram

The native vegetation at *Nzii* sacred grove allows different bird species to coexist, including species that depend on indigenous tree species, thus creating a distinct bird community that is different from that of exotic-dominated groves. According to Brockerhoff *et al.* (2008), exotic tree plantations support fewer native forest-dependent bird species than both natural and mixed forest communities. Further, according to Jose *et al.* (2009), many bird species have evolved relationships with native vegetation for food (e.g., insects, fruits, nectar) and nesting sites, something which is reduced in exotic plantations. The clustering pattern of Nzii differs from Nthukuni, Kimiisya, and Kandoo, possibly because native vegetation remnants in Nzii sustain bird species that avoid the exclusive exotic vegetation found in other sites.

The clustering of *Nthukuni*, *Kimiisya*, and *Ndoo* suggests that these groves share comparable ecological aspects that create suitable environmental conditions for specialized bird populations. The pattern could result from ecological niches that support particular species, according to Sekercioglu (2012), who demonstrated that habitat complexity determines bird assemblages. The presence of two forest specialist bird species, namely Grey-olive Greenbul and Lemon Dove, at Nthukuni sacred grove strengthens the supporting evidence (Table 5.2).

The *Syuvinda, Tuwaa, Kithuma,* and *Kavyiu* cluster indicates a high similarity in species composition, likely due to comparable habitat structures or landscape connectivity. Studies by Laurance *et al.* (2012) show that bird species diversity is strongly influenced by habitat continuity, as fragmented landscapes often lead to species loss and community shifts. These groves are part of a relatively undisturbed corridor, allowing species movement and maintaining high similarity in bird populations.

Though near each other, Kwa Mundu is not closely related to Sammy probably because of historical land use differences, particularly the past clearance of Mundu for farmland, which led to the development of secondary vegetation. The fact that Mundu was previously cleared and later regenerated means that its vegetation structure, tree species composition, and canopy cover differ from the rest and closely relate to the three (Nthukuni, Kimiisya, and Ndoo) which previously faced the same disturbance. Secondary forests often have lower tree diversity, a more open canopy, and denser undergrowth, which favor different bird communities than mature forests (Chazdon, 2014). Studies show that secondary forests tend to attract more generalist bird species and fewer specialist species, as the latter often rely on the complex structures of primary forests (Barlow *et al.,* 2007). Primary forests offer stable microhabitats, continuous canopy cover, and rich food resources that particular species require (Sodhi *et al.,* 2011). In contrast, Mundu may have lost some of these specialists when it was cleared, leading to a shift towards more adaptable, edge-dwelling, or open-habitat species.

Since Sammy is relatively undisturbed, it likely retains more forest-dependent specialist bird species. The time since Kwa Mundu was abandoned as farmland plays a key role in determining which species have recolonized. Studies indicate that the full recovery of bird communities in secondary forests can take decades or even centuries, depending on the landscape context and proximity to intact forests (*See* Dunn, 2004). Although Kwa Mundu is still in an early successional stage, it may not yet support the same bird species richness and composition as Sammy.

3.6 Forest Dependency

We assessed forest dependency by classifying the 109 bird species documented in the sacred groves into three categories, following Bennun *et al.,* (1996): forest specialists (FF species), forest generalists (F species), and forest visitors (f species). While both forest specialists and forest generalists rely on forest ecosystems to varying degrees, forest visitors do not exhibit such dependency. Forest specialist species are highly dependent on undisturbed, intact indigenous forests and serve as key indicators of a healthy forest ecosystem. They are actual forest birds, rarely utilizing alternative or surrogate habitats. Forest generalists, though often found in pristine forests, possess the adaptability to survive in modified or fragmented forest landscapes. In contrast, forest visitors (f species) are present in forests but are primarily associated with other habitat types, making their presence in forested areas incidental rather than essential.

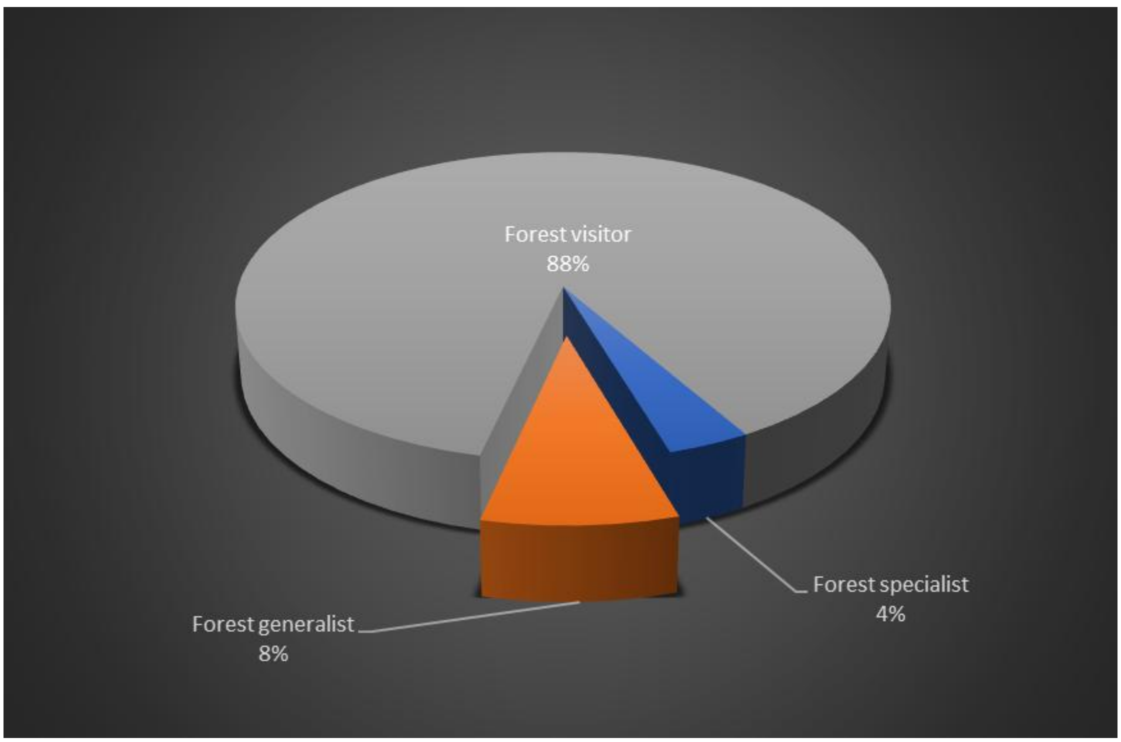

Figure 5.5: Proportion of each species category based on forest dependency.

Among the 109 bird species documented, only 4% were forest specialists, 8% were forest generalists, and the overwhelming majority (88%) were forest visitors (Figure 5.5). The scarcity of forest specialists suggests significant habitat degradation or fragmentation, as these species depend on intact, undisturbed forests (See Table 5.2). Their limited presence points to potential habitat loss, canopy thinning, or ecological disturbances that have rendered the forest unsuitable for sensitive, habitat-dependent species.

Table 5.2: List of forest specialists and forest generalists documented within the groves

S/No	Common Name	Scientific Name	Forest Dependency
1.	Crowned Eagle	*Stephanoaetus coronatus*	FF
2.	Lemon Dove	*Aplopelia larvata*	FF
3.	Grey-olive Greenbul	*Phyllastrephus cerviniventris*	FF
4.	Cabanis's Greenbul	*Phyllastrephus cabanisi*	FF
5.	Great Sparrowhawk	*Accipiter melanoleucus*	F
6.	Emerald-spotted Wood Dove	*Turtur chalcospilos*	F
7.	Yellow-breasted Apalis	*Apalis flavida*	F
8.	Sombre Greenbul	*Andropadus importunus*	F
9.	Northern Brownbul	*Phyllastrephus strepitans*	F
10.	Abyssinian White-eye	*Zosterops abyssinicus*	F
11.	Cape Robin Chat	*Cossypha caffra*	F
12.	Rüppell's Robin Chat	*Cossypha semirufa*	F
13.	Collared Sunbird	*Hedydipna collaris*	F

The low proportion of forest generalists (8%) further underscores the ecosystem's declining health. Typically, generalists can adapt to both pristine and moderately disturbed environments. However, their scarcity suggests that the forest is either highly degraded or lacks transitional habitat features such as secondary growth, diverse vegetation layers, or edge habitats. This indicates a severe reduction in habitat quality, restricting the survival of even moderately adaptable species. The dominance of forest visitors (88%) signals a shift toward a more generalist-dominated avian community, which is often a hallmark of ecosystem degradation. This suggests that the sacred groves may no longer function as thriving forest ecosystems but rather as highly altered landscapes that predominantly attract species from other habitats.

From a conservation perspective, these findings highlight the urgent need for habitat restoration and protection. Reversing this trend demands active forest management, including reforestation, minimizing human disturbances, and preserving native vegetation. Strengthening habitat connectivity between fragmented forest patches is also crucial to support both generalist and specialist species, fostering a more resilient ecosystem. For ecosystem health, the low number of specialists signals a decline in biodiversity and essential ecological functions. The dominance of forest visitors over specialists reflects the forest's reduced capacity to sustain native wildlife, underscoring the critical need for targeted conservation efforts. Restoring ecological integrity is essential to revive habitat quality and support species that serve as indicators of a thriving forest ecosystem.

3.8 Birds feeding guilds and their implication

After analysis, six foraging guilds, as described by Gray *et al.* (2007), were identified across the 109 bird species documented within the 13 sacred sites. The documented bird species displayed a range of feeding behaviors, including carnivores (which feed on vertebrates), nectarivores (specializing in nectar), frugivores (primarily consuming fruits), insectivores (which feed on insects), granivores (feeding on seeds), omnivores (which consume both insects and leaves) (Ndang'ang'a *et al.*, 2013). The most frequent were insectivores and omnivores, comprising 37.6% and 32.1% of the species recorded, respectively. Conversely, frugivores (5.5%) and nectarivores (4.6%) were the least frequent, whereas granivores (11%) and carnivores (9.2%) were moderately represented (Figure 5.6).

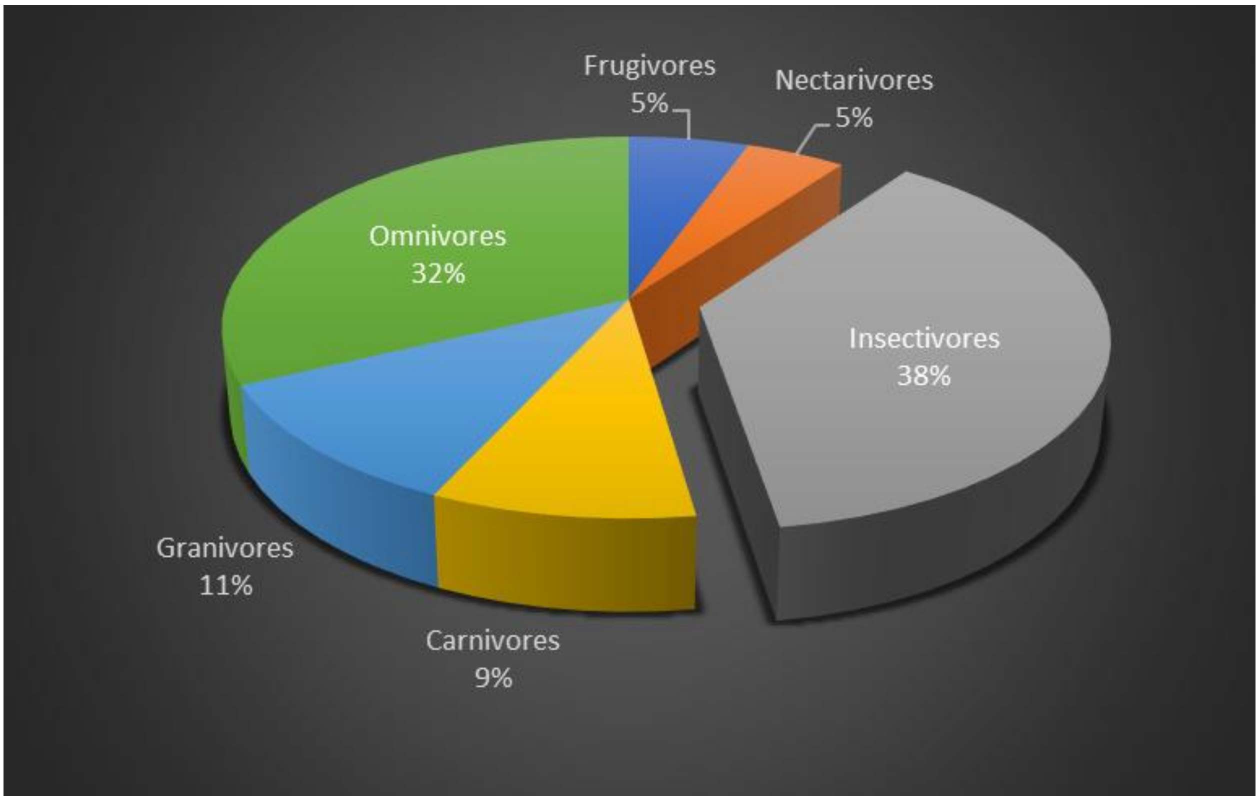

Figure 5.6: Proportion of feeding habits across the documented species.

The composition of the feeding guilds was ecologically significant within the realms of ecosystem balance, resource availability, and biodiversity conservation. Both insectivorous (37.6%) and omnivorous species (32.1%) accounted for almost 70% of the documented species, indicating that the groves form a vital habitat for invertebrate fauna and reservoirs of diverse food resources. Birds that prey on insects are known to be natural control agents as they regulate insect populations, which is key to ecological balance (Şekercioğlu, 2006). The presence of a high number of omnivores indicates that the groves harbor multiple floral and faunal food resources, demonstrating that they are able to sustain bird populations through different seasonal cycles (Kissling *et al.*, 2012).

Conversely, the low frugivore (5.5%) and nectarivore (4.6%) populations are an indication of low fruiting and flowering plant species within the sacred groves. According to Schupp and others (2010), frugivores are significant seed dispersers that further promote plant diversity and forest regeneration. On the other hand, nectarivores form key pollinators, and their representation in low numbers across the sacred groves indicates scarcity of nectar-producing flora, potentially affecting plant reproductive success and long-term forest sustainability (Bawa, 1990). The limited representation of these two guilds suggests that while the sacred groves provide habitat for birds, they may be experiencing habitat degradation, deforestation, or reduced plant diversity due to human activities such as selected logging and agricultural encroachment.

A moderate representation of granivores (11%) and carnivores (9.2%) indicates a moderately diverse ecosystem with available seeds and small prey species. Granivores play a key role in seed predation and, therefore, affect vegetation dynamics and plant species recruitment (Forget *et al.*, 2007). On the other hand, carnivorous birds are apex predators within avian communities and thus indicate trophic integrity and habitat quality (Thiollay, 2006). However, their moderate numbers indicate that the ecosystem may not be able to sustain more significant predator numbers due to lesser prey abundance or habitat fragmentation.

In conclusion, the dominance of omnivorous and insectivorous taxa indicates a working, albeit possibly fragile, ecosystem in which the food webs are intact; however, these could be threatened by habitat degradation. The comparative scarcity of nectarivores and frugivores highlights the necessity for conservation initiatives to restore plant diversity and the long-term ecological stability of sacred groves. Minimizing these imbalances by habitat restoration, afforestation, and ecologically sustainable land-use management can serve to increase bird diversity and ecosystem stability (Şekercioğlu *et al.*, 2004).

3.9 Bird Species of Conservation Concern

The study identified only one species of conservation concern, *Turdoides hindei*, commonly known as the Hindes Babbler. The species was sighted in Matooi Mystical Cave and Kwa Kithuma Sacred Grove. Apart from being a Kenyan endemic, this species is globally threatened and classified as Vulnerable according to the IUCN criteria. Its stronghold is central Kenya, but it has scattered pockets in lower eastern Kenya, though it is thought to have become extinct beyond Machakos Valley and Kitui. The recent avifauna survey has established its presence in Makongo, Makuli, Nthangu, and Nzaui forests in Makueni County. Notably, its sighting in Kithuma Sacred Grove, Miaani Village, marks its southernmost documented range, extending its known distribution. This result underscores the role of these sacred groves in the preservation of Kenya's endemic and endangered bird species.

3.10 Common Threats to the Bird species in Makuli-Nzaui Landscape.

Bird populations within the study sites face the most severe threat from the expansion of agriculture, which destroys their habitats. The natural vegetation exists in fragmented patches surrounded by extensive farmlands. The selective removal of mature trees for charcoal production and construction purposes equally poses a significant threat to the persistence of bird communities within the study sites. These trees provide essential habitats for nesting birds while also serving as their food source. For example, the survival of *Ficus sycomorus* faces extinction because people are targeting it for timber and charcoal production. Similarly, it is a host plant species for numerous plants, such as *Ansellia africana*, which is indiscriminately being destroyed.

Additionally, the establishment of monoculture *Eucalyptus* plantations is having a significant impact on the integrity of the natural habitats for bird communities. This reduces habitat diversity, thus supporting a limited number of bird species. Monoculture plantation forests have low level of biodiversity than surrounding native forests, and some of them have considered exotic monocultures as “biological deserts” (Brockerhoff *et al.,* 2013; Bremer and Farley, 2010). This ecological imbalance has created a path for the spread of invasive species such as *Lantana camara*, which is further disrupting the ecosystem. Moreover, some members of the community continue practicing outdated beliefs, such as burning forests to induce rainfall, leading to severe habitat destruction and possibly loss of species. A conservation agenda assuming three fundamental approaches of habitat protection, sustainable land-use practice, and enhancement of community awareness will ensure the long-term survival of bird species within the region.

CHAPTER 6: BUTTERFLY DIVERSITY WITHIN SACRED GROVES

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1.1 INTRODUCTION

Although drylands are ecologically significant areas, scientific explorations have directed more attention to *Afromontane* vegetation ecosystems. The *Combretum*-wooded grassland in Makueni subcounty represents a typical dryland ecosystem that has suffered ecological degradation over the past decade. A wide geographical area that once supported the local livelihoods now encounters mounting disruptions because of rising human settlements and poor farming practices. This important natural resource faces enhanced deterioration because of climate change effects. The vegetation of this ecosystem has receded to hilltops and along seasonal rivers or exists as isolated pockets within agricultural landscape.

Habitat loss or degradation in Makueni subcounty occurs mainly through four key driving factors including human population increase, agricultural land expansion, resource overexploitation and climate change impacts. These disturbances have depleted key resources adversely impacting food security and increasing poverty in the entire region. The expansion of fruit farming requires higher pesticide usage that has caused severe damage to pollinating insects which previously supported agricultural production. Food systems together with ecosystem stability continue to experience severe risks due to the combination of unreliable climate, encroachment and other losses from suppressed insect diversity. This is also linked to deterioration of traditional ecological knowledge that used to guide sustainable practices among the community.

Before the industrial era, indigenous knowledge-based weather forecasts (IKBFs) used the behavior of insects to make forecasts about seasonal variations (Chengula & Nyambo, 2016). The usage of excessive pesticides alongside monocropping by farmers has eliminated these crucial biodiversity signals from the environment. This biodiversity loss is simultaneously accompanied with the collapsing of traditional values that once safeguarded natural resources such as community water sources (Parween and Marchant, 2022). The sustainable land management practices which were essential for sustainable development has declined thus creating a cultural gap in the face of expanding modern agriculture.

Despite the great biocultural losses in the *Combretum*-wooded grassland in Makueni subcounty, remnants of this heritage persist in the form of sacred groves, which continue to support relatively higher biodiversity than the surrounding areas. These sacred spaces serve as critical refuges for several threatened species such as *Millettia vatkei*, *Pavetta teitana*, *Dorstenia arachniformis*, *Euphorbia friesiourum* and *Aloe ngutwaensis* among others. While the floral diversity has received substantial attention within the area, the role of butterflies remains largely understudied. This study is one of its kind since there has been no study on butterfly conducted within these sacred spaces despite their critical ecological role.

1.2 General Objective

To undertake a rapid butterfly survey within sacred groves within Nzaui-Makuli landscape in the larger *Combretum*-wooded grassland of Makueni subcounty.

1.3 Specific Objectives

a) To establish an inventory of butterfly species within the sacred groves.
b) Determine the diversity of the butterfly fauna that exists within these areas.
c) Identify the threats facing scared groves and the biodiversity within them.
d) Assess the potential for alternative nature-based livelihood options for the local communities.

2.0 METHODOLOGY

2.1 Butterfly Sampling

Baited butterfly traps were used to capture fruit-eating invertebrates alongside fast-flying butterflies that prefer to inhabit in forest canopies. Fermented pineapple and banana mixtures were used as trap baits because tropical and subtropical butterflies are commonly frugivorous (feed on fruits) (Sánchez-Bayo & Wyckhuys, 2019). Fermenting fruit has been shown to be an effective attractant for these butterflies, as it mimics natural food sources and draws them into the traps (Basset *et al.,* 2013). The traps were placed for a 24-hour duration before analysis of the captured specimens was done. Eardley and Smit (2007) recommend that this sampling approach works well in obtaining hard-to-capture species including canopy-dwelling and fruit-feeding organisms. The sampling traps were placed 10 meters apart and set at a height of 2 meters above the ground under sunlight to better attract flying species (Klein *et al.,* 2007).

The study adopted time-limited searches using 1-meter sweep net to sample flying butterflies or those visiting flowers. The method offers efficient interception because butterflies usually visit flowers to obtain nectar or move between plants (Klein *et al.,* 2007). Sweep net has been recommended effective for capturing butterflies during foraging or flying activities according to Vanbergen *et al.*, (2013), something hard to achieve using other approaches.

Two personnel performed general searches at designated sampling areas for two hours by working together. This method provides broad coverage of the study site by collecting different butterfly species especially those in flight or in foraging activities (Bates *et al.,* 2011). The sampling schedule focused on butterfly peak activity times that span from 7:00 AM to 10:00 AM and from 4:00 PM to 6:00 PM according to Zarim & Ahmed (2014) and Ojianwuna (2015). These time frames match active butterfly periods during which they search for nectar and complete reproductive activities (Kerr *et al.,* 2015).

2.2 Butterfly Handling and Identification

The collected butterfly specimens were stored in a well-labeled envelope for specimen identification and tracking purposes. The identification of the collected butterflies followed the authoritative butterfly taxonomy book "*Butterflies of Kenya and Their Natural History*" by Torben B. Larsen (1991). Additionally, voucher specimens were pinned and preserved which became part of the National Museums of Kenya's Invertebrate Zoology Collection. Through museum collection, these specimens serve as permanent references which enable future researchers to verify and cross-reference the findings (Larsen and D'Abrera, 2007). Specimen collection, identification and preservation serves both short-term population surveys and continuous biodiversity monitoring and conservation efforts (Sternberg *et al.*, 2018).

2.3 Opportunistic Observations

These research teams conducted spontaneous field observations to detect signs of human disturbances in forests particularly by examining visual indicators such as charcoal kilns and tree stump remains. Butterflies experience major population decline when their natural habitats become disturbed. According to Kerr *et al.* (2015) and Fiedler *et al.* (2017), forest clearing and degradation destroys both the habitat areas and nectar plant resources of these species. The research documented these disruptions to contribute to identification of prevailing environmental stress while exposing future risks to habitat loss and fragmentation along with human-induced land-use changes within the region. Opportunistic data collection remains crucial when studying biodiversity responses to multiple stressors because it enables researchers to monitor ecosystem changes occurring in rapidly developing human areas (Winfree *et al.,* 2009).

3.0 RESULTS AND DISCUSSION

3.1 The Role of Butterflies

Butterflies, part of the Lepidoptera order, are easily recognized by their scaly wings, which form distinct patterns. With about 19,000 species worldwide, Africa hosts 4,325 species, and Kenya alone has 903 species across five families (Williams, 2015; Kioko *et al.,* 2021). Butterflies are vital for pollination, supporting food security by aiding the production of nutrient-rich crops like fruits and vegetables. They also contribute to biodiversity through habitat regeneration. As a crucial part of the food chain, their life stages are preyed upon by various animals. Butterflies are excellent ecological indicators due to their sensitivity to environmental changes, making them useful for monitoring habitat health and assessing biodiversity loss (Kioko *et al.*, 2021; Devictor *et al.*, 2012).

3.2 Species Accumulation Curve

A total 57 species and 387 butterfly individuals were recorded from 8 different sacred groves within the *Combretum*-wooded grasslands of the Makueni sub-county (Annex III). The completeness of the invertebrates sampling was assessed using species accumulation curve derived from PRIMER multivariate analysis software (Clarke and Gorley, 2001). In this program, the accumulation curve is based on iteratively re-sampling of raw data 999 times and averaging the results. The average species accumulation curve for invertebrates revealed a typical rapid increase in number of species with increased sampling. However, the curves did not level even after the last samples were incorporated (Figure 6.1). The species accumulation curve shows an upward trajectory and not hitting a plateau phase signaling more and more species would be sampled over time in the various sampling points. This phenomenon could be attributed to heavy rains that fall on the first day and, very sunny and hot two last days of sampling hence making the climatic conditions unfavorable because butterflies are active at temperatures between 13°c and 30°c, with no rain or strong winds while temperatures over 30°c reduces the activity of some species (Swaay *et al.*, 2015).

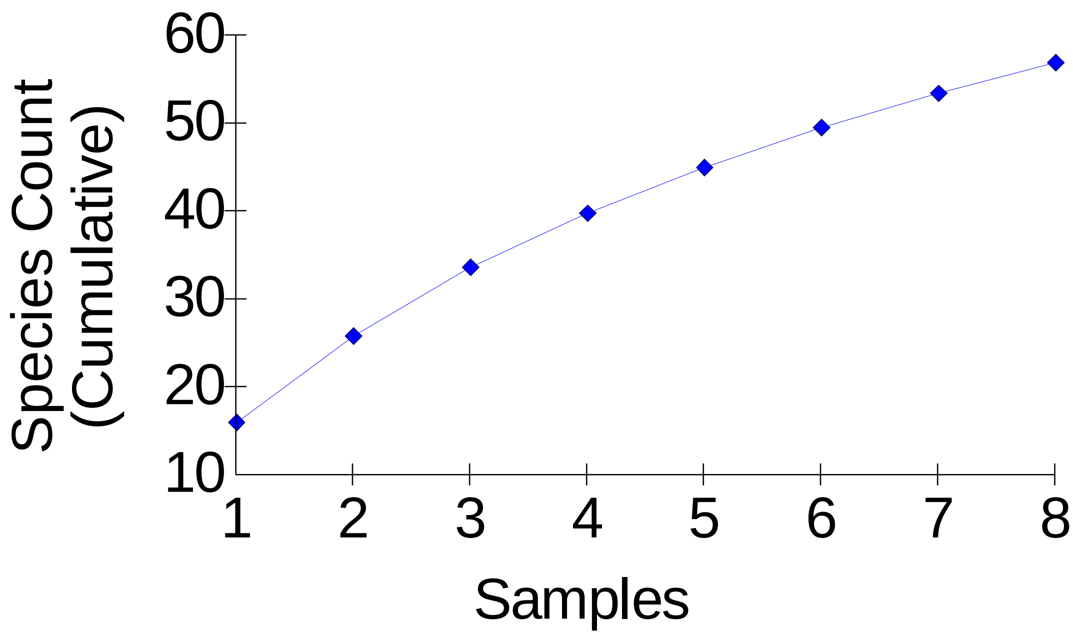

Figure 6.1: Species accumulation curve for all sampled sites.

3.3 Butterfly Species Composition

All the species recorded belonged to the five butterfly families known from Kenya including Nymphalidae (37%) which had the highest species composition, followed by Pieridae (26%), Lycaenidae (16%), Hesperiidae (14%) and the least Papilionidae (7%) (Figure 6.2). The abundance of butterfly families in Kenya generally mirrors their distribution in nature, with Nymphalidae and Pieridae being the most abundant, followed by Lycaenidae and Hesperiidae, while Papilionidae is the least abundant family in butterfly records (Kioko *et al.,* 2021a; Larsen, 1996). Fermented fruit feeders, however, performed poorly in the study, likely due to unfavorable weather conditions (Swaay *et al.,* 2015). Despite this, *Charaxes candiope* was recorded, suggesting that, with the right timing and weather conditions, stable populations of this species could be found, as its larvae feed on *Croton* trees, which are abundant in the area (Kioko *et al.,* 2021b). This indicates the potential for increased presence of these fruit-feeding species under more favorable environmental conditions.

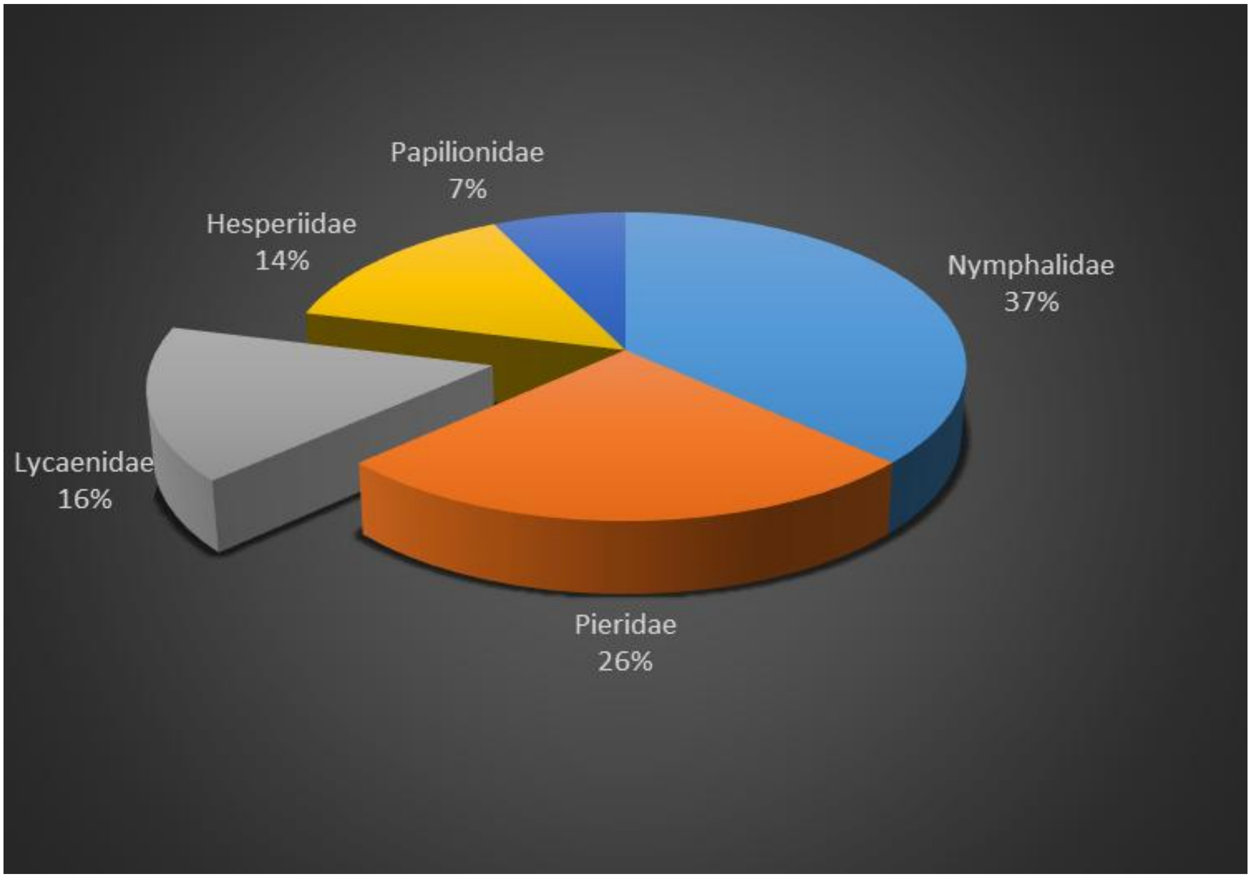

Figure 6.2: Butterfly species composition.

3.4 Species Richness, Diversity and Abundance.

Overall, the species richness across the sacred groves varied notably, with Matooi mystical cave (s = 24), Syuvinda (s = 23), Kwa Sammy & Kwa Mundu (s = 17), Kwa Kavyiu (s = 16), Kwa Lilya (s = 14), and Mutueti (s = 12) exhibiting substantially higher species richness, while kwa Kalinde (s = 5) had the least species richness (Table 6.1). Diversity levels also differed among the sacred groves, with Syuvinda (H' = 2.9481), Kwa Mundu (H' = 2.6162), Kwa Sammy (H' = 2.5898), and Matooi mystical cave (H' = 2.5694) being the most diverse. Kwa Lilya (H' = 2.4454), Mutueti (H' = 2.3779), and Kwa Kavyiu (H' = 2.2838) exhibited moderate diversity, while Kalinde (H' = 1.5595) was the least diverse.

In terms of abundance, Matooi Mystical cave (n = 100) was the most abundant sacred grove, followed by Kwa Kavyiu (n = 61), Kwa Mundu (n = 52), Syuvinda (n = 50), Kwa Sammy (n = 42), Mutueti (n = 40), Kwa Lilya (n = 34), and Kalinde (n = 8), which had the lowest abundance (Table 6.1). The Pielous Evenness Index was used to assess how evenly species were distributed across the sacred groves. Kalinde (J' = 0.969) and Mutueti (J' = 0.9569) exhibited nearly perfect evenness, while Matooi (J' = 0.8085) displayed the least evenness (Table 6.1).

Table 6.1: Diversity indices across the 8 surveyed sacred groves.

Indices	Sacred Grove							
	Matooi	**Mundu**	**Sammy**	**Syovinda**	**Lilya**	**Kalinde**	**Kavyiu**	**Mutueti**
Total species (s)	24	17	17	23	14	5	16	12
Abundance (n)	100	52	42	50	34	8	61	40
Pielous' Evenness Index (j')	0.8085	0.9234	0.9141	0.9402	0.9266	0.969	0.8237	0.9569
Shannon Weiner Index {h'(loge)}	2.5694	2.6162	2.5898	2.9481	2.4454	1.5595	2.2838	2.3779

The species richness (n=57) observed in this survey is consistent with another survey done in 2019 on Nzaui-Makuli water catchment by Musyoki and Mwakodi (2019). However, the recorded richness was lower than the one documented by Kioko and others in 2012 whereby they recorded 69 species with the Kaiti watershed. This difference may be attributed to the increasing habitat loss occasioned by expanding farmlands and heightened usage of pesticides.

The high richness and abundances in Matooi and Syuvinda can be attributed to the large habitat area at Matooi while there could be outflow of species from the larger Makuli Forest that is adjoined by Syuvinda grove. This is because larger areas are associated with positive biodiversity effects as documented by Chase *et al*., (2020) and some species have been shown to have tolerance in new habitats and high mobility in tandem with a study by Lens *et al.,* (2002). However, though Mutweiti had an extensive area, it had farming and intensive grazing activities taking place thus affecting the state of the habitat and hence lowering the richness and abundance of the butterflies.

On the other hand, the least richness and abundance in Kalinde and Kwa lilya could be attributed to area size and habitat degradation occasioned by overgrazing. This is because these sacred groves are very small in size due to conversion of native vegetation into farms and overgrazing. These agricultural factors have been noted elsewhere to drastically affect populations of insects including butterflies (Sanchez-bayo and Wyckhuys, 2019). On the contrast, at kwa Mundu natural sacred site, there was moderate richness and abundance because the area had receding farms where formerly-farmed areas are now been turned into grazing areas and the existing grass, shrub and vines vegetation offered excellent habitat for Lycaenidae butterfly species (*see* Kioko *et al.*, 2021b).

3.5 Species Similarity between the Sacred Groves

The Non-metric Multidimensional Scaling (nMDS) Ordination of the 8 sampling sites based on presence/absence transformation and Bray-curtis Dissimilarity was used. To visualize the dissimilarities amongst the sampled sites, nMDS ordination plot was constructed with the best 3-D configuration stress level at 0.03 occurring 5 times and best 2-D configuration stress level at 0.09 occurring 2 times (Figure 6.3). Stress value less than 0.1 is considered fair. There was a clear dissimilarity in species composition across the different sites with sharing of species occurring based on habitat types, conservation efforts and land use.

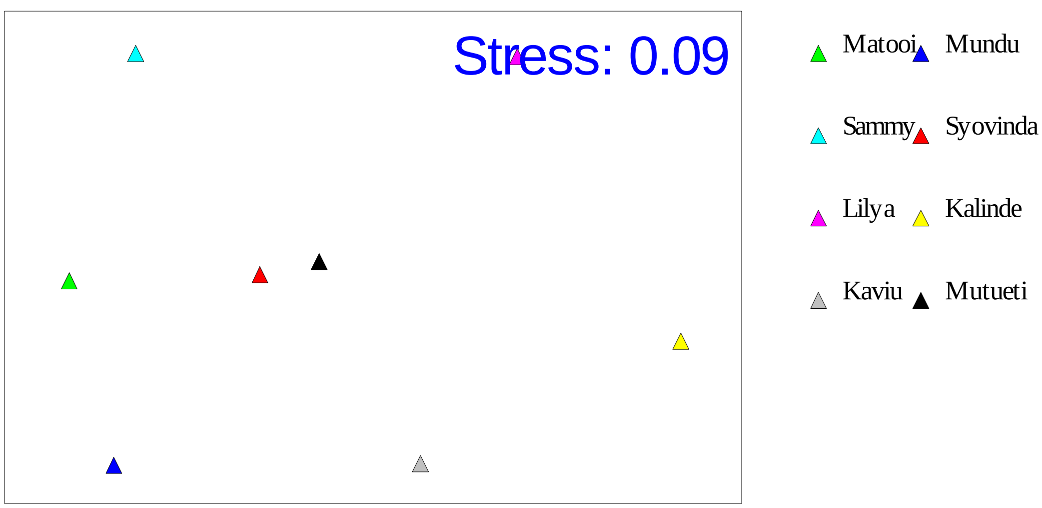

Figure 6.3: Non-metric Multidimensional Scaling ordination of the 8 sampling sites.

The majority of butterfly species recorded were generalists, although some exhibited specific habitat preferences. For instance, *Papilio dardanus* is primarily found in riverine forests, while *Graphium leonidas* is a transition species, inhabiting the boundary zone between forest and savanna ecosystems. Similarly, *Junonia natalica*, typically considered a forest species, was unexpectedly recorded in open areas, far from its usual forest habitat. This phenomenon, where forest-dependent species are found in more open or disturbed areas, can be attributed to the species' mobility and their ability to tolerate habitat disturbance (Lens *et al.*, 2002). Such behavioral flexibility allows these species to persist and adapt to changing environments, reflecting their resilience in response to ecological changes.

3.6 Common Threats Facing the Persistence of Butterfly species in the area.

1. Livestock Grazing

Majority of the sacred groves were degraded as a result of livestock grazing (See Figure 6.4) Although cultural values attached to these sites has deteriorated, still substantial vegetation persist within them. This phenomenon has led to increased grazing especially in times when pasture for livestock is limited. Similarly, some of the sacred groves are within water sources and thus animal find their way into these sacred sites clearly demonstrating declining protection unlike previously.

Figure 6.4: Portion of a degraded sacred grove due to overgrazing.

2. Expanded Agricultural Activities.

The majority of sacred groves are located at the edges of farmlands, where human activities such as pesticide use, clearing of host plants, and other forms of anthropogenic interference are prevalent. The erosion of cultural values, evident in the growing neglect of these sacred sites, has led to their gradual clearance to make room for agricultural expansion and human settlement. This ongoing transformation is having a detrimental impact on the biodiversity that resides within the sacred groves, particularly on populations of butterflies and other native species.

3. Invasion by Invasive Species.

Lantana camara has been found to have aggressively colonized native plant species in the sacred groves of Kwa Mutueti, Kwa Kavyiu, Kwa Mundu, and Kwa Syuvinda (See Figure 6.5). This invasion is largely attributed to the plant's ability to thrive in disturbed environments, which is characteristic of many sacred groves. Notably, *Lantana camara* is dispersed by birds that seek refuge in these remaining forest patches. There is growing concern that if this invasive species is not effectively controlled, it could displace vital indigenous host plants and disrupt the availability of floral resources for invertebrates, including bees and butterflies, thereby threatening local biodiversity.

Figure 6.5: *Lantana camara* thickets within sacred groves.

5. **Illegal Logging**

Large trees continue to thrive in the majority of sacred groves and along riverine ecosystems within the study area, but this very persistence has made them prime targets for illegal logging activities. These trees are frequently felled for charcoal production and for construction purposes, significantly depleting vital forest resources. The loss of these mature trees has a significant impact on the floral resources available to pollinators, including bees and butterflies, that rely on a diverse range of native flora for nectar sources and habitat.

Figure 6.6: Evidence of Charcoal burning within sacred grove.

The loss of these trees also fragments the ecosystem as a whole, reducing the integrity of the habitat and further endangering the survival of other species. With fewer trees to feed on and take shelter in, the population of plants and animals in such groves keeps dwindling. This is a possible danger to pollinators and environmental health in general. In addition, the loss of these trees greatly increases soil erosion, disrupts the water cycle, and renders the ecosystem vulnerable.

3.7 The Potential for Alternative Nature-based Livelihoods

1. Lepidoptericulture

The study recorded several host plants in connection with various species of butterflies, a notable case being *Clausena anisata*, a key host plant to butterflies in the Papilionidae family. This specific plant was found in abundance in Matooi, Kwa Sammy, and Mutueti sacred sites. Notably, the Papilionidae butterflies recorded in the areas included *Papilio nireus*, *Papilio demodocus*, and *Papilio dardanus*. The large and visually striking features of these butterflies appeal many individuals. Elsewhere, local communities in Arabuko Sokoke Forest, Gede, have ventured into butterfly farming with great economic rewards. Introduction of such a project in the study area can go a long way in ensuring sustainable alternative livelihood opportunities for the local community that will deter them from destructive activities such as illegal logging and forest clearance. This would preserve the butterflies and their food plants as well, since *Clausena anisata* naturally occurs in the transitional belts surrounding forests and agricultural lands.

Figure 6.7: A fruiting *Clausena anisata* and wildings within Matooi mystical cave.

Additionally, *Clausena anisata* has provided added value to individuals in the area, as most parts of the plant are used in local medicines for the treatment of diseases like rheumatism, malaria, heart ailments, toothache, and mouth infections. The plant also serves as a source of toothbrushes, underlining its multipurpose use within the community. Encouraging of butterfly farming, along with conservation of these essential plants, has the potential to enhance both biodiversity and livelihoods for local communities, thus promoting a win-win situation between conservation and local community well-being (Lawal *et al.,* 2015).

Salvadora persica L (Mswaki) is another larval food plant of butterfly genus *Colotis* observed at Kwa Lilya sacred grove. This plant is found in plenty in the area and has many uses by the locals. It is used for making toothbrushes locally and commonly sold in many urban areas across Kenya.

Figure 6.8: *Salvadora persica* L, a host plant for the Genus *Colotis*.

2. Cultural and Nature Tours

The sacred groves around Nzaui Hill have significant cultural value as the origin of the Kamba community. At the hill's base, near the Kwa Kavyiu and Mutueti sacred groves there is a legendary rock with the footprints of ancient Kamba people and their livestock. Nzaui Hill stands at an elevation where the *Afromontane* climate creates a unique blend of natural beauty. By combining these natural wonders with the rich cultural heritage, this particular area presents a compelling and diverse tourism opportunity for visitors interested in both environmental exploration and local traditions. Just a short distance away, Kalamba houses Kenya's first African Inland Church (AIC), further enhancing the area's cultural and historical appeal. These attractions could create a well-rounded tourist circuit that connects to the coastal tourism route, positioning the region as a distinctive eco-tourism destination. Additionally, this would attract bird watchers, nature enthusiasts, and those seeking to learn about indigenous practices. By linking these sites, the region can generate sustainable income while fostering the conservation of its unique biodiversity.

3.8 Recommendations

- Some of the species recorded within the sacred groves have great potential for income generating activities like butterfly farming and ecotourism which can further stimulate sustainable utilization and management of these valuable ecosystems and curb current challenges of illegal logging, over-grazing, deforestation and forest encroachment.

- There is need for more research to enhance understanding of the diverse butterfly population dynamics, ecology and seasonality in order to conserve butterflies and their habitats within the area.
- Support communities to start selective propagation of some of the host plants for butterflies such as the *Clausena anisata* along boundaries with the adjacent forests for enhanced pollination services.
- There is need for awareness campaigns within the community as well as local schools for enhanced understanding on the importance of butterflies to the ecosystem and our livelihoods.

CHAPTER 7: EVIDENCE-BASED CAMPAIGN FOR SACRED SITES PROTECTION

By Munyw'oki J. Mulinge

1.1 INTRODUCTION

For generations, the Kamba community of southeastern Kenya has maintained a deep connection with nature, viewing it as an integral part of their existence. They believe in a monotheistic, invisible, and transcendental God known as *Ngai* or *Mulungu*, who they revere as the ultimate creator. To the Kamba, nature is a sacred gift from Ngai, entrusted to them for protection and stewardship. Like many other communities in Kenya, the Kamba have a traditional creation story that speaks to their deep spiritual ties with the land. It is believed that *Mulungu* created the first man and woman and placed them on a rock at Nzaui Sacred Hill. Even today, the footprints of these ancestors and their livestock are visible on the rock, serving as a testament to their origins. Within the community, the spirits of the departed, known as *Maimu* or *Aimu*, are regarded as intercessors between the living and their God. These ancestral spirits are honored through ritual libations and offerings conducted in sacred groves, locally called *Mathembo* or *Ithembo*.

Sacred groves have persisted within this community due to the taboos and traditional beliefs that safeguard them. While these customs have long functioned as effective conservation tools, the gradual weakening of customary governance systems is now threatening their survival. As a result, both the rich cultural heritage and the biodiversity these groves protect are at risk of being lost. The sacred sites found within the *Combretum*-wooded grasslands of Makueni provide crucial refuge for rare and threatened plant species, as well as forest-specialist animals, including diverse bird species. However, their ecological importance is largely unrecognized by local communities, as their benefits remain obscured or undervalued. Although these groves are widely acknowledged for their religious and cultural significance, their critical role in biodiversity conservation remains overlooked.

1.2 General Objective

The primary objective of the activity was to conduct an evidence-based campaign within the Nzaui-Makuli landscape, raising awareness among local communities about the importance of protecting sacred natural sites. Additionally, the campaign sought to advocate for the area's official recognition as a Key Biodiversity Area (KBA).

1.3 Specific Objectives

1. Document evidence of the rich plant diversity within the sacred groves, including recently discovered species that are at risk of extinction.
2. Highlight the critical role of these sacred groves in supporting bird communities, including species classified as globally threatened under the IUCN criteria.
3. Provide compelling evidence of the area's diverse butterfly population, demonstrating its potential as a pilot site for butterfly farming.

4. To showcase the progress made and the vital role of key stakeholders, including the Government of Makueni County, the Kenya Forest Service, the National Museums of Kenya and local communities, in preserving, promoting, and commercializing the region's rich biocultural heritage.

2.0 METHODOLOGY

To enhance awareness of the biocultural significance of sacred groves within the area, we adopted a mixed-method approach designed to engage a broad audience. First, we leveraged existing public forums (*Chief Baraza*) in collaboration with national and county government institutions to encourage local communities to take an active role in protecting sacred groves. Given the widespread skepticism about the importance of these sites, we employed a multidisciplinary, evidence-based approach to showcase their biodiversity potential and economic benefits. It combined scientific and traditional knowledge-sharing to create a holistic approach to biocultural conservation.

Further, successful case studies integrating customary management structures in conservation were highlighted and benefits accrued by the local communities exposed. In regards to this, the Kayas within the Coastal forests of Kenya were used as an example. As worst-case scenario of the ongoing destruction of sacred groves within the region, the meeting was strategically conducted in a sacred grove that had been cleared for development, offering a tangible example of this vice. During these sessions, elders played a key role in bridging the intergenerational knowledge gap, passing down invaluable experiential wisdom to counteract the ongoing destruction of sacred groves within the area. Additionally, the forum provided a critical space for policymakers and advocates to address sociocultural challenges facing the Makueni County. The Makueni County Government, represented by the Departments of Environment and Culture, sensitized the locals on ongoing county initiatives aimed at preserving the region's biocultural heritage.

To maximize outreach, a multimedia campaigns were launched through local FM radio and TV broadcasts, as well as social media platforms such as WhatsApp. Furthermore, guided site visits engaging key informants were undertaken across the groves and whose identified opportunities and challenges for sustainable management were passed on during the meetings. Recognizing the importance of early education in fostering environmental stewardship, sensitization programs in local schools, were also conducted in line with the current Kenya's Competency-Based Curriculum. This sought to ensure that younger generations develop a sense of responsibility for nature and its resources. All these strategies sought to integrate traditional and modern conservation methods, fostering community-led protection of sacred groves for future generations.

3.0 RESULTS AND DISCUSSION

3.1 The general overview of the project

The project lead, Mr. Munyw'oki, started by thanking the locals for attending the awareness meeting sparing time from their busy schedules. Importantly, he highlighted that Rufford Foundation has played a key role in conserving nature within the area for the last five years. Focusing on the present project, he mentioned that it is as result of previously funded projects under the same donor in the area that exposed the importance of sacred groves in the area in conserving threatened biodiversity. Linking this to the community and particularly traditional ecological values they hold, he appreciated and recognized their efforts. Unfortunately, he lamented that there are some members of community who do not appreciate these treasures and the potential they have in conservation and livelihood improvement.

Exposing this inherent potential, he started by describing the area as an emerging biodiversity hotspot within the southeastern Kenya and worthy recognition and collaborative conservation. Citing Young (1984), he compared its uniqueness to the Eastern Arc Mountains and coastal dry forests before highlighting how the numerous isolated inselbergs create a transition zone between the Kenyan Highlands and coastal plains, in supporting species favored by neither higher nor lower-elevation habitats. Evidently, he also noted that such inselbergs provide alternative habitats for rare species, such as *Afrocanthium keniense*, typically found in upland dry deciduous forests.

Further, he highlighted six new species had been discovered in the area, including recently discovered *Aloe ngutwaensis* (Kiluma) and *Dorstenia arachniformis* (Ng'ondu ya Kitumbi). These species hold cultural significance among the Kamba community and were found in a sacred site. Classified as critically endangered by the IUCN, their survival has been largely attributed to traditional Kamba beliefs and taboos. He urged attendees to actively protect sacred groves, emphasizing their vital role in conserving biodiversity and ensuring these culturally significant species (CSS) endure for future generations. Therefore, he explained that the project aimed to harness the potential of citizen science and the ecological significance of sacred groves to drive the conservation of threatened biodiversity within the Nzaui-Makuli Landscape.

3.2 Biodiversity Potential of the Nzaui-Makuli Landscape

Dr. Ngumbau from the Botany Department of the National Museums of Kenya expressed her gratitude to attendees before outlining the campaign's goal: fostering a shared vision for the critical role of sacred groves in biodiversity conservation. She noted that since 2020, the Rufford Foundation, in partnership with the National Museums of Kenya—the national repository of biocultural heritage—has implemented multiple projects in the region due to its rich biodiversity. Previous research revealed that these groves harbor a remarkable number of globally threatened plant and animal species, a preservation attributed, in part, to traditional beliefs and taboos. However, she lamented that these sites face rampant destruction due to the erosion of cultural values. Warning of irreversible loss without urgent action, she emphasized that "*one cannot protect* *what they do not know*," reinforcing the meeting's purpose: raising awareness and inspiring collective action to safeguard this invaluable heritage.

Figure 7.1: Dr. Ngumbau explaining the biodiversity potential of the study area.

3.2.1 Diversity of Plants Species within the Surveyed Sacred Groves

As a component of the current project, we successfully surveyed 17 sacred groves within the Nzaui-Makuli Landscape, focusing on three key taxa: plants, birds, and butterflies. Our botanical assessment recorded 253 plant species, across162 genera and 61 families. Notably, 11 of these species are globally threatened and listed on the IUCN Red List of Threatened Plant Species. Additionally, another 10 species are safeguarded under the Convention on International Trade in Endangered Species (CITES), ensuring protection from commercial overexploitation. Beyond their ecological significance, 22 plant species were identified as culturally important to the Kamba community, highlighting the deep connection between biodiversity and traditional heritage. Our botanical exploration within the sacred groves yielded remarkable findings, including the discovery of three new plant records for region, one of which is classified as Vulnerable under the IUCN criteria and another one locally threatened and in need of further reassessment.

3.2.2 Diversity of Bird Species within the Surveyed Sacred Groves

According to Alex Syingi, an ornithologist from the National Museums of Kenya, the survey was conducted across 13 sacred groves, where we successfully recorded 109 bird species from 41 families. Notably, we confirmed the presence of Hinde's babbler, a globally threatened and Kenyan endemic bird, at two of the surveyed sites, underscoring the critical role these groves play in its conservation. Furthermore, four forest specialist bird species were documented in sacred groves, meaning they are strictly dependent on forest ecosystems and cannot thrive elsewhere. Because sacred groves are protected from deforestation, they provide a rare and vital sanctuary for these birds. Beyond their ecological significance, bird species also serve as key climate indicators, helping scientists monitor habitat shifts and environmental changes over time, he finalized.

Figure 7.2: Mr. Mutati explaining the crucial role that sacred groves play to birds in the area.

3.2.3 Diversity of Butterfly fauna within the Surveyed Sacred Groves

Mr. Munywoki reported that they were able to document 57 butterfly species and 387 individuals from 8 different sacred groves within the Nzaui-Makuli landscape. He pointed out how butterflies were traditionally used to predict weather pattern. He lamented that the butterfly diversity has reduced due to poor agronomic practices. Importantly, he further exposed the potential of butterfly farming within the study area as the study recorded Papilionidae butterflies including *Papilio nireus*, *Papilio demodocus*, and *Papilio dardanus*. They are visually striking butterflies, an appeal to many individuals that can be harnessed to generate revenue to the local communities. He cited a successful case of butterfly farming among the local communities in Arabuko Sokoke Forest, Gede where they are generating additional income from the venture.

3.3 Youth inclusion in Promoting Biocultural Heritage Conservation

Bonface Kyalo, the Youth Champion for Culture, expressed deep gratitude to attendees for their dedication to cultural discussions. He highlighted sacred groves as vital "living museums" where students can connect with their heritage. However, he pointed out that youth lack incentives to support biocultural conservation, often leading them to contribute to the destruction of these sacred sites, as they see little value in preserving them. Noting the youth’s strong interest in income-generating ventures, Kyalo advocated for the commercialization of culture as a sustainable solution. By transforming sacred groves into sources of economic opportunity, he argued, local communities could benefit financially while fostering greater appreciation for their cultural and ecological significance. Encouraging innovative approaches, he called for policies that integrate economic incentives with conservation efforts, ensuring that youth become active participants in protecting and promoting their heritage.

Figure 7.3: Mr. Kyalo encouraging the commercialization of Kamba traditional culture.

Seeing the county's immense potential through the project, he swiftly identified key opportunities for youth in biocultural conservation, including tour guiding, avitourism, butterfly farming, and commercializing traditional foods. Before concluding, he expressed heartfelt gratitude to the National Museums of Kenya and Makueni County's Department of Culture for their commitment to preserving cultural heritage and supporting sustainable conservation efforts within the region.

3.4 Intergenerational Knowledge sharing in promoting preservation of Culture

Elder Mr. Mwikya expressed deep joy and gratitude for witnessing a gathering dedicated to cultural heritage, lamenting its growing misrepresentation and demonization. He identified the widening intergenerational knowledge gap as a key factor eroding cultural values. Emphasizing traditional methods of preserving sacred groves, he highlighted the protective role of deeply rooted beliefs and taboos, sharing compelling examples of individuals who defied these customs and faced dire consequences. With nostalgia, he recalled traditional foods and *Thome* (knowledge-sharing sessions in Kamba culture) stressing their role in strengthening communal ties. He passionately urged the county government to support cultural festivals, particularly those celebrating indigenous cuisines, as a means of revitalizing and safeguarding local heritage. Through these initiatives, he envisioned a future where cultural identity is preserved, respected, and passed down to future generations.

Figure 7.4: Mr. Mwikya explaining how sacred groves were preserved from destruction.

He concluded by emphasizing the immense power of today's youth, asserting that their innovative ideas could even influence the presidency to support cultural preservation. Comparing the youth to a dormant volcano and the older generation to an active one, he warned of the urgent need to teach young people their forefathers' ways while respecting their modern priorities. Building on previous speakers' points, he urged the Makueni County government to actively involve youth in policy formulation, cultural promotion, and the commercialization of culture, ensuring their inclusion in efforts to preserve and sustain the region's rich heritage.

3.3 Efforts by the Government of Makueni County

The CECM for Lands, Urban Planning & Development, Environment and Climate Change
Mr. Nicholas Nzioka started by appreciating the support from Rufford Foundation through the National Museums of Kenya. Further, the CECM highlighted that the government of Makueni county is restoring degraded forests and landscape within the County. According to him, a collaboration between the County Government and World Resources Institute (WRI) undertook a Restoration Opportunities Assessment Methodology study (ROAM) in 2018 and identified 7 restoration opportunities, among others, agroforestry, riparian land restoration, road buffer zone restoration, rangeland rehabilitation and rehabilitation of natural forests. This formed the basis for forest and landscape restoration in the county.

Figure 7.5: Mr. Nzioka (CECM Environment) sensitizing the locals on sacred groves.

Additionally, Mr. Nzioka added that Makuli- Nzaui Landscape is one of the areas benefiting from the implementation of the ROAM report where a restoration action plan 2021-2026 has been prepared and is so far being implemented. He once again took the opportunity to appreciate Rufford Foundation through the National Museums of Kenya for contributing towards the achievement of the plan. The protection of sacred natural sites is an innovative approach to conserving biodiversity and should be embraced, he remarked. To strengthen this protection of sacred groves, the county government of Makueni continues to recognize these sites within their county land use planning processes. Importantly, he reported that seventeen (17) sacred groves are in the process of being issued with title deeds further enhancing their protection for the benefit of our rich biocultural heritage.

1. **The CECM for Trade, Marketing, Industry, Culture and Tourism.**

Dr. Sonia Nzilani, thanked the donors and project team for the initiative citing great relevance in line with the Makueni county priority areas. She started by acknowledging that for long sacred groves were associated with sources of water. Erosion of cultural values is adversely impacting our environment, livelihoods and culture. Today, there is minimal respect accorded to these sites and people do not appreciate their role calling for innovative ideas to make local communities realize the significance of these sites in their lives, she added. She called for attendants to embrace traditional foods, terracing, rain water harvesting and mainstream restoration within their production systems (agroforestry).

Figure 7.6: Dr. Sonia explaining progress by the county in promoting culture and tourism.

She further emphasized that tourism presents a prime opportunity for economic growth, particularly through the promotion of cultural heritage. Despite the county’s immense tourism potential, it remains largely untapped, limiting economic benefits for local communities. Its strategic position within the coastal tourism circuit provides a competitive edge, which the county is actively leveraging. Additionally, proximity to major national parks like Tsavo and Chyulu Hills, vital infrastructure such as the Nairobi-Mombasa Highway and Standard Gauge Railway (SGR), and attractions like AIC Kalamba, Sikh Temple, Makongo recreational centers, and Mulatya Legendary Rock further boost its tourism appeal, she added. Having highlighted the county’s rich tourism potential, she further noted that her department has engaged the Kenya Tourism Board (KTB) to identify untapped opportunities and strengthen both local and international marketing strategies. By leveraging these efforts, the department aims to boost tourism growth, attract more visitors, and strategically position the county as a prime destination. Additionally, she emphasized the importance of identifying key focus areas and fostering partnerships to maximize the sector's economic benefits for local communities.

2. **The Makueni Director for Culture, Music, and the Arts**

Mr. Mulonzya, began by expressing gratitude to the project team and supporters for their dedication to the initiative. He then elaborated on the constitutional recognition of sacred groves, addressing misconceptions among locals. Mulonzya emphasized that culture is a fundamental pillar of the 2010 Constitution, which he acknowledges as the foundation of the nation, a reflection of Kenya’s cumulative civilization, and a driver of ethnic diversity, equality, and national cohesion. The Director emphasized that the Constitution mandates the State to actively foster national and cultural expression through literature, the arts, traditions, science, communication, media, publications, libraries, and heritage. He further highlighted the State’s duty to recognize science and indigenous technologies in national progress while safeguarding Kenyans' intellectual property rights.

He further emphasized that the 2010 Constitution supports the devolution of forest resources, citing Article 69(1)(d), which mandates the state to promote public participation in environmental management, protection, and conservation. Sacred groves serve as an innovative resource management strategy, integrating traditional communities into forest governance. Mr. Mulonzya highlighted that Makueni County has made significant progress in preserving Kamba culture and heritage through the enactment of the Makueni County Cultural Heritage Act, 2016, reinforcing cultural conservation efforts.

Figure 7.7: Mr. Mulonzya explaining the legal backing for the conservation of sacred groves.

3.4 Kenya Forest Service

Mr. Katana from the Kenya Forest Service started by thanking the project team and the Ruford Foundation for exposing the significance of sacred groves in forest resource protection and conservation. He plauded the co-management approach embraced in the management and protection of Nzaui and Makuli Forests where local communities are playing a crucial role.

Figure 7.8: Mr. Katana highlighting some of the user rights under the PFM framework.

Cultural ecosystem services are officially recognized and registered as user rights under Kenya's Participatory Forest Management framework. As a result, the local communities of Nzaui Sacred Hill Forest and Makuli Forest each have designated sacred groves within these forests, preserving their cultural and spiritual heritage, he remarked. These sacred groves, remnant of primary forest, harbor indigenous plant species protected by traditional beliefs and taboos and they are never cut as the trees are believed to be sacred. However, he urged the local communities to abandon destructive beliefs, such as the myth that burning the forest brings rain—an all-too-common practice in both Nzaui and Makuli Forests.

Mr. Katana emphasized that the erosion of cultural values is a key driver of the destruction of sacred groves. To illustrate a successful conservation model, he cited the sacred Mijikenda Kaya forests in coastal Kenya, where local communities have turned cultural heritage into a source of sustainable income through cultural tourism. He highlighted various nature-based enterprises, including an indigenous tree nursery, ecotourism initiatives as well as the production of traditional crafts and foods. He also gave another successful case of Nature based enterprise-the Kipepeo Initiative within the Arabuko-Sokoke forest where local communities are rearing butterflies for sale serving as alternative income stream for them. Encouraging similar ventures within the Makuli-Nzaui landscape, he underscored the potential for communities to benefit economically while preserving their sacred sites.

3.5 Restoration of degraded sacred natural sites

While the awareness campaign placed strong emphasis on the protection of sacred natural sites, active restoration of degraded areas was also essential to revive their ecological and cultural integrity. Restoration involved replanting native and culturally significant plant species that once thrived within these groves before destruction occurred. Notably, *Dorstenia arachniformis*, a culturally important species central to Kamba purification rituals (Ng'ondu), was used to restore the inner sections of the groves. Its presence reinforces both biodiversity and spiritual value. Around the boundaries, species such as *Pavetta teitana*, recognized by community elders as among those lost during past deforestation, were reintroduced to recreate natural buffers. Importantly, restoration efforts were carried out exclusively in areas where permission had been granted by the elders, as these sites are considered sacred. The Makueni County Government played a pivotal role in this process by officially recognizing these sites. They accomplished this by gazetting 17 sacred sites and issuing title deeds, thereby providing them with formal legal protection.

Figure 7.9: Restoration of sacred natural sites within the study area.

The County Executive Committee Members (CECMs) for Environment and Culture (Mr. Nzioka and Dr. Sonia) played a central role in creating awareness and leading the restoration of degraded sacred sites within the study area. Their leadership ensured that the restoration efforts were not only environmentally sustainable but also aligned with the cultural values of the local communities. Working in close collaboration with community elders and other local stakeholders, the CECMs coordinated efforts to rehabilitate these sacred areas, recognizing their importance for both ecological health and cultural heritage. Through their dedication, the restoration initiatives gained the necessary support, resources, and legal backing, underscoring the county's commitment to preserving these significant sites for future generations.

CHAPTER 8: CITIZEN SCIENCE-BASED STRATEGY FOR ENHANCED BIODIVERSITY CONSERVATION

1.1 INTRODUCTION

The present project undertook biodiversity exploration across 17 sacred groves across the *Combretum*-wooded grassland of Makueni subcounty which revealed their significant biocultural worth. The sacred groves contain a diverse collection of plants and animals together with a wealth of cultural heritage. However, this traditional heritage faces a severe threat due to the prevailing destruction within those sacred landscapes. The erosion of cultural values serves as the primary driving factor of this loss, worsened by widening intergenerational knowledge transfer.

The implementation of nature conservation through bottom-up approaches usually community-based and heavily relying on traditional knowledge leads to sustainable outcomes. Community involvement in environmental protection fosters compliance with conservation rules. According to Grilli *et al.*, (2019), the involvement of communities in Irish fisheries management decision-making led to sustainable resource preservation and better attainment of management goals. Unlike top-down conservation models, this approach does not encounter community resistance since they assist in developing these initiatives and thus fosters a long-term commitment. According to Rwekaza (2024), this model empowers locals with the knowledge that delivers affordable and adaptable conservation practices which respond to prevailing environmental changes. Bottom-up conservation approaches attain success by applying traditional wisdom and scientific procedures to protect biodiversity, supporting local livelihoods while implementing robust governance frameworks that deliver enduring socio-economic benefits.

The effective management of natural resources is increasingly recognizing long-term monitoring as an important ingredient (Noss and Cooperrider, 1994). Local communities demonstrate the best fit for biodiversity monitoring because they possess deep ecological understanding and quick detection abilities regarding environmental changes. Community-led conservation delivers extended monitoring systems which lead to sustainable outcomes along with adaptive management practices, greatly differing from short-lived externally controlled projects (Tang & Zhao, 2011). Moreover, social cohesion, governance and conflict resolution are enhanced through the strength of diverse stakeholder engagement (Reed and Ceno, 2015). Therefore, the sustainable conservation of sacred groves and their resources within the Nzaui-Makuli landscape requires the development of an effective management strategy. Such a strategy should integrate traditional knowledge with scientific approaches, encourage the involvement of local communities in ongoing biodiversity monitoring frameworks for future generations.

1.2 General Objective

The main goal of this initiative focused on co-creating a community-led action plan or management strategy which would safeguard sacred natural sites while conserving threatened biodiversity across the Nzaui-Makuli landscape. The action plan is heavily dependent on the active involvement of the local communities for a long-term sustainability.

1.3 Specific Objectives

This initiative specifically sought to co-design a management strategy that aligns with the priorities of all stakeholders, harnesses technology, supports community well-being, and strengthens the protection of sacred groves, all while safeguarding the threatened biodiversity within the Nzaui-Makuli landscape.

2.0 METHODOLOGY

2.1 Participant Recruitment

The management strategy development adopted a maximum variation sampling according to Patton (2002) for enhanced participant representation. The participant selection process targeted individuals from distinct ecological regions, carefully considering demographic segments based on age, gender, educational level as well as cultural backgrounds with diverse beliefs and traditions. Throughout the co-creation process, substantial efforts were made in balancing expert analysis from researchers and policymakers with traditional ecological understanding from elders. To achieve this, both referrals and snowball sampling were embraced to obtain participants with unique insights. The process generated enriched findings by combining focus group discussions alongside key informant interviews establishing a holistic approach for conservation through scientific and traditional ecological knowledge integration while maintaining cultural sensitivity.

2.2 Citizen Science Models

The development of a management strategy of the conservation of threatened biodiversity through protection of sacred groves adopted three models of citizen science described by Bonney and colleagues (2009) including contributory, collaborative and co-creation. Grounded in the principle that individuals are experts in their own lives, the project harnessed local knowledge to support conservation efforts. In the contributory phase, we designed the initiative upon recognizing the persistence of threatened biodiversity within sacred groves across the *Combretum*-wooded grassland of Makueni subcounty. Here, community members played a crucial role by providing observational data on sacred grove locations. The collaborative phase expanded engagement, enlisting community members as key informants in the exploration of selected groves. They identified Culturally Keystone Species (CKS) and documented traditional conservation mechanisms embedded in beliefs, taboos, and practices.

The co-created phase prioritized co-learning, where non-scientists and professional scientists collaboratively developed a citizen science-based action plan for biodiversity conservation. However, a key limitation of the three typologies was realized as the exclusive engagement of citizens and scientists. Given today's complex challenges, adopting a 'whole-of-society' approach is vital for fostering inclusive, sustainable, and impactful solutions. Recognizing the need for broader participation, a tripartite model was introduced to integrate additional stakeholders, ensuring a more comprehensive and effective framework for conservation efforts.

2.3 Tripartite Citizen Science Model

Today, we face complex challenges that threaten biodiversity, livelihoods, and informed decision-making. In response, projects are becoming increasingly interdisciplinary, fostering collaboration among diverse stakeholders. Acknowledging the roles and motivations of all participants is key to enhancing transparency, optimizing project outcomes, and maximizing impact. To achieve global environmental benefits (GEBs), our citizen science-based action plan embraced a tripartite model (Salmon *et al.*, 2021), which extends beyond citizens and scientists to include a vital third role—the ‘enabler’—who facilitates engagement, bridges knowledge gaps, and strengthens collaboration for more effective and inclusive conservation efforts.

3.0 RESULTS AND DISCUSSION

The accelerating loss of biodiversity calls for a unified, 'whole-of-society' approach that leverages scientific knowledge to anticipate challenges, adapt to changes, and implement innovative solutions for the conservation of threatened species. Achieving meaningful impact often requires collaboration beyond professional and scientific communities, engaging diverse stakeholders to encourage a more effective and inclusive action. Citizen science involves non-professionals and local communities in the design, implementation, monitoring, data collection, analysis, and evaluation of projects to generate scientific information and knowledge. It promotes diverse "ways of knowing" by providing pathways to engage Indigenous Peoples, local communities, and Indigenous and local knowledge.

3.1 Tripartite Citizen-Science Model: Citizens, Scientists and Enablers

Throughout preceding Rufford funded projects, we observed first-hand the disconnect between traditional ecological knowledge, science and the realities within the Makuli-Nzaui Landscape. Reviews led to the adoption of the tripartite model presented here. The model acknowledges everyone involved in the project, and the different roles that they play as citizens, scientists, and a third, facilitative role, we called the enabler (Figure 8.1). The individual(s) who filled the Enabler's role were often involved in our project as a mechanism to allow scientists to interact with members of the local community.

Our idealized tripartite model of citizen science, included participants, scientists, and enablers (Figure 8.1), each of whom had goals, skills and opportunities that were critical to the project's success. Our project sought to conserve threatened biodiversity within the Nzaui-Makuli landscape by promoting the protection of sacred groves. Erosion of cultural values, expansion of agriculture, population increase and climate changes were identified as the main drivers of this degradation. To achieve this goal, we harnessed various citizen science models from inception to decommissioning of the project. Throughout the implementation process, three roles were identified including Citizens (Community), Enabler and the scientists.

We note that some individuals within the idealized framework occupied more than one role. For example, the scientists were the initiators of project seeking to conserve threatened species, however, they also played a role of enablers by advocating for the protection of sacred groves, indirectly conserving threatened species within them. Similarly, Traditional elders and religious leaders are citizen who provided crucial information for the project as well as crucial in enabling behavioral change i.e. change of community's perceptions and attitudes towards sacred groves. Mainstream religions like christianity often view sacred groves as idol worship. Thus, spiritual leaders were encouraged to take an active role in reshaping this perception by promoting their cultural and environmental significance. By fostering awareness and appreciation, they were charged with inspiring congregants to respect and preserve these sacred natural spaces.

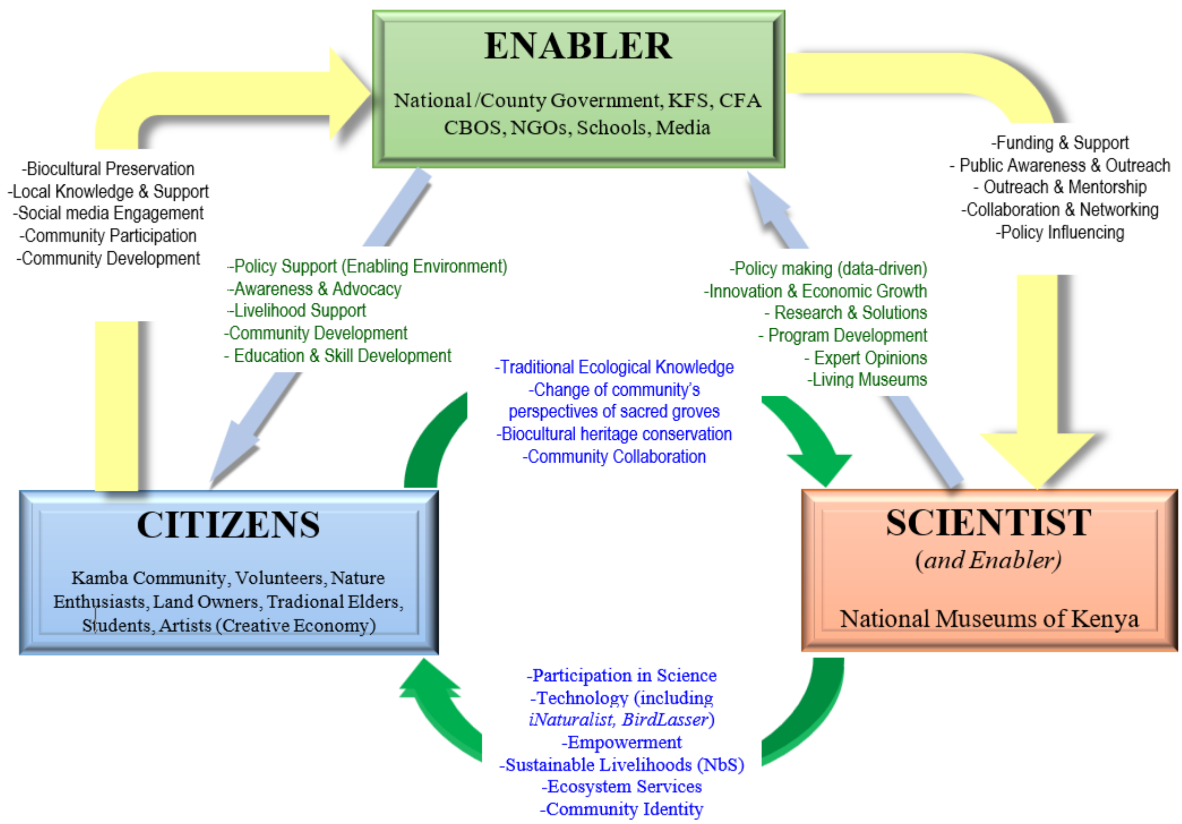

Figure 8.1: Idealized tripartite model of citizen science for biodiversity conservation.

(Adopted with modification from Salmon *et al.*, 2021). Boxes indicate different roles within the project. Arrows indicate what each role is providing to (or receiving from) for one another.

Initially, the project partly adopted a traditional two-party model involving only citizens and scientists. However, with each emerging issue came the realization that the success of the initiative can only be achieved by engaging multiple stakeholders each bringing its unique way of knowing to the project. The scientists sought the preservation of rich biocultural heritage inherent within the study area as the community benefit from increased ecosystem services, strengthened community identity, technology and also participation in scientific study. Besides, the potential for butterfly farming, apiculture, and hay production was confirmed and that are believed to contribute to community development and enhanced living conditions for the locals. This citizen-scientist relationship was feared to suffer a sustainability blow and therefore a third party, an Enabler, was introduced into the framework to facilitate and bridge the gap in knowledge. Our project identified the Makueni County Government, KFS, local schools, media, CFAs, NGOs and CBOs as the main enablers of the initiative.

Erosion of cultural values has contributed to the destruction of sacred groves and subsequently to loss of critical habitats for threatened biodiversity. Today, the locals do not see the importance of sacred groves in their lives and thus motivation to continue to destroy them. To reverse this trend, the county government has a key role in creating an enabling environment through policy support. Firstly, through making relevant policies driven by data generated by scientists. So far, the county government is in the process of issuing title deeds to 17 sacred groves. They too have the responsibility of coming up with innovative interventions surrounding conservation of biodiversity and sacred groves to spur economic growth and enhance recognition of the importance of sacred groves among the communities. In return, the scientists will benefit from the county government through collaboration and networking as well as policy influencing conservation.

3.2 Establishment of Long-term Monitoring

For the sustainability of the initiative, we trained 10 volunteer citizen scientists. The on-site training program focused on equipping them with the skills for long-term biodiversity monitoring using digital tools. Participants were introduced to *iNaturalist*, where they learned to record plant and animal observations, upload images, and engage with experts for species identification (Figure 8.2). They were taught how to take clear photos, input accurate location data, and contribute to global biodiversity databases. Trained volunteer citizen scientists will collaborate with knowledgeable community members, such as traditional medicine men, to locate and map populations of threatened species, leveraging their traditional ecological knowledge. They also received training to monitor environmental threats, including those affecting sacred groves and overall biodiversity.

Figure 8.2: Volunteer citizen scientist practicing making observations in *iNaturalist.*

Additionally, they were trained to use *BirdLasser*, a mobile app for logging bird sightings (*See* gigure 8.3). They practiced recording species in real time, marking geolocation points, and submitting data to national bird atlases such as the Kenya Bird Map. The training emphasized the importance of consistency, accuracy, and ethical wildlife monitoring.

Figure 8.3: A practical session on how to use *BirdLasser* app.

Facilitators explained how long-term data collection helps track biodiversity trends, detect environmental changes, and support conservation efforts. The participants expressed enthusiasm about using these tools to contribute to scientific research and environmental protection. By the end of the program, they demonstrated confidence in independently documenting local biodiversity and committed to continuing their monitoring efforts.

3.3 School outreach

School-going children are the next generation conservationists and if they are taught early in their childhood about the importance of conserving biodiversity, they will grow to be responsible people who care for nature and all that comes with it. Intergenerational knowledge gap was one of the challenges leading to the erosion of cultural values that protect biodiversity. Through collaboration with local schools and scientists working within the Nzaui-Makuli ecosystem,

Figure 8.4: Preparing the next generation of conservationists.

A Wildlife Club was collaboratively established at Ngutwa Primary School to promote continuous environmental awareness and responsibility among students. The club engages learners in hands-on environmental conservation activities such as tree planting, clean-up campaigns, and nature walks. This initiative is in line with Kenya's Competency-Based Curriculum (CBC), which emphasizes practical learning and recognizes environmental studies as an examinable subject. By nurturing environmental stewardship at an early age, the club aims to instill lifelong values of sustainability and ecological responsibility. Through active participation, learners not only gain knowledge but also develop essential competencies required for responsible citizenship and community engagement.

3.4 Restoration of destroyed sacred groves

This project actively involved local communities in the selective propagation of culturally significant and IUCN-listed threatened plant species. A total of 93 *Dorstenia arachniformis*, 112 *Ficus sycomorus*, and 846 *Pavetta teitana* individuals were propagated and restored within sacred natural sites across the study area. *D. arachniformis*, a cultural keystone species among the Kamba community, holds vital significance in purificatory rituals (Ng'ondu) and was recently discovered in a sacred grove within the study area. It has since been classified as Critically Endangered under IUCN criteria. *F. sycomorus*, another species of cultural value, is traditionally used in the establishment of sacred groves and protection of water sources.

Figure 8.5: Propagation of culturally important and agroforestry species.

Melia volkensii, locally known as *Mukau*, is a vital agroforestry tree valued for timber, fodder, and soil enhancement, and integrates well with crops under proper management. A total of 2,631 seedlings were propagated and distributed to farmers, schools, and churches to support landscape restoration, particularly within farmlands and along boundaries in degraded areas.

Figure 8.6: Community-led restoration effort within the study area.

As a way of mainstreaming landscape restoration within production systems, the project propagated and distributed 2,631 *M. volkensii* individuals to farmers to grow as agroforestry trees within their production areas. Additionally, 141 farmers benefitted from 4230 *Brachiaria* splits as a way promoting fodder production and commercialization within the Nzaui-Makuli landscape.

CHAPTER 9: PROMOTION OF NATURE-BASED LIVELIHOODS

Munyw'oki J. Mulinge

1.1 INTRODUCTION

The relationship between biodiversity, climate change, and human health remains poorly understood in the Kenya's Arid and Semi-Arid Lands (ASALs). These areas occupy a vast 89% of the country's land cover and sustain around 16 million individuals (Ministry of Environment and Forestry, 2020). Research has shown that approximately 20% of Kenya's semi-arid lands are degraded or in the process of degradation, outwardly characterized by increasing bare lands and decreasing vegetation cover (Burrell *et al.,* 2020; Song *et al.,* 2018). Coupled with these adversities, the frequency of drought has increased by 70% in the past three decades (UNDP, 2020), directly contributing to rising levels of malnutrition and recurring outbreaks of disease among native inhabitants. Despite extensive global research investigating links between biodiversity, climate change, and human wellbeing, there is scant research on Kenya's drylands, highlighting the necessity for targeted, on-the-ground action.

Southeastern Kenya exemplifies a fragile dryland ecosystem and an emerging biodiversity hotspot (Sebsebe *et al.,* 2017). The region's fast-rising human population heavily relies on nature assets, hence making food security of the utmost importance. Local people are facing an increasing threat as rainfall patterns become ever more erratic and temperatures increase, risking agriculture, livelihoods and exacerbating inherent vulnerabilities. Resource availability falls behind population growth, increasing pressure on already over-stressed ecosystems. In the face of changing climate, livelihood and biodiversity conservation has become increasingly difficult to sustain, necessitating adaptive strategies focused on enhancing resilience and long-term sustainability.

Nature-based Solutions (NbS) are increasingly being recognized for their potential to enhance ecosystem services while addressing pressing socio-economic and environmental challenges. NbS utilize natural processes and ecosystems to provide sustainable solutions that benefit both human well-being and biodiversity. Ecosystems deliver critical services to local communities due to the fact that their functions directly support livelihoods, water security, and climate resilience. By preserving, restoring, and sustainably managing natural environments, NbS play a pivotal role in biodiversity conservation and long-term sustainable development. With the aim to address these in a most efficient manner, climate-smart practice and technology such as climate-smart beekeeping and hay making and commercialization hold great promising areas for the purposes of improving agricultural productivity, raising resilience levels, and taking off the pressures exerted on threatened ecosystems.

1.2 General Objective

This initiative aimed to enhance the adoption of sustainable alternative livelihoods as a means of reducing reliance on environmentally destructive activities. By promoting nature-based economic opportunities, the research sought to empower local communities within the *Combretum*-wooded grassland of Makueni subcounty fostering resilience, biodiversity conservation, and long-term ecological sustainability.

1.3 Specific Objectives

1. To strengthened the Hay value chain within the Makueni subcounty.
2. To promote the uptake and adoption of advanced beekeeping technologies in the region.

2.0 METHODOLOGY

For the purpose of implementing this initiative, a mixed-method approach was utilized to obtain a balanced insight into local livelihoods and the prospects of adopting sustainable practices. Direct observation was first carried out to identify and evaluate the livelihood activities currently in place in the communities, giving an indication of how local populations maintain themselves and interact with their environment. Secondly, randomized interviews with farmers throughout the whole study area were made to evaluate how much they understood about the connectivity of biodiversity and climate change, as well as their livelihood. Also, this helped identify their perceptions and knowledge gaps on environmental sustainability. Finally, key informant interviews with experts and stakeholders on new technologies on beekeeping, hay production and commercialization were conducted. These consultations centered on crucial aspects of production, processing, and marketing to identify challenges and opportunities for scaling-up these climate-smart practices.

Building on the findings from these assessments, a targeted training program, in which multiple stakeholders were involved including the Government of Makueni County, Kenya Forest Service, business people among others. This campaign raised awareness to achieve higher appreciation of the local communities on the interlinked complexities between biodiversity, climate change, and their livelihood. Additionally, the region's rich cultural heritage was introduced as a key incentive, fostering a sense of ownership and motivation for adopting sustainable livelihood practices.

Household Questionnaire

We also collected data on costs and yields of planting one acre of maize, beans, green grams and *Brachiaria* from local farmers within the Nzaui-Makuli Landscape. Similarly, we also gathered production data (yields & costs) of investing in 10 langstroth hives and compared with the yields and costs of planting maize, beans and green grams which is the main activity conducted by the local farmers in the region.

3.0 RESULTS AND DISCUSSION

Hay production is a climate-resilient approach to ensuring feed security for livestock, particularly in the Kenya's ASALs). Following repeated droughts, which lead to pasture scarcity, organized hay farming ensures availability of animal feed throughout the year, reducing the pressure on fragile rangelands and preventing overgrazing (Mganga *et al.,* 2015). By integrating climate-smart approaches such as water harvesting, rotational grazing, and drought-tolerant fodder crops, hay farming enhances livestock resilience and productivity. Additionally, commercializing hay creates an economic incentive for local communities, enabling them to adapt to climate change while sustaining their livelihoods.

Within the *Combretum*-wooded grasslands of Makueni subcounty, many farmers are engaged in mixed farming, that is, growing crops and rearing livestock, though on small scale. Fruit farming especially pixie, orange and mangoes is intensively done. Due to limited space within their farms, intercropping is done, mixing more than one type of crop.

Figure 9.1: A pixie farm within Ngutwa Village, Makueni subcounty.

The primary challenge for farming in the area is unreliable rainfall, often resulting in insufficient moisture for crops. To address this, farmers construct terraces and divert road surface run-off to their farms to maximize water retention. One of the most effective techniques used is *Fanya Juu*, meaning "*throw the soil up*" in Kiswahili. This method involves building contour earth bunds by shifting soil upwards from trenches, gradually forming terraces that help conserve moisture and reduce erosion. They have proven beneficial to Small Scale Farmers (SSFs) within the area where sloped terrain and erosion pose significant challenges. Usually, the ensuing trenches are used to harvest water from roads (spate irrigation), supporting the growth of bananas and other fruit crops.

To maximize on the space the bunds are used as planting sites for fodder grasses, which provide valuable feed for livestock especially in times of drought.

Figure 9.2: Contour earth bunds locally called *Fanya Juu.*

3.1 Hay Value Chain within Nzaui-Makuli Landscape.

Within this area, diverse pasture species exist the major ones including *Eragrostis superba* (Mbeetwa), *Cenchrus ciliaris* (Ndata Kivumbu), *Panicum maximum* (Mbwea), *Enteropogon macrostachyus* (Nguu), *Chloris gayana*, and *Chloris roxburghiana* (Kilili). These ones constitute the lions share source of forage for free-ranging livestock. They present multiple benefits to local farmers apart from sustaining livestock, including controlling soil erosion. However, overgrazing and improper pasture management pose challenges to maintaining rangeland productivity and biodiversity. The Makueni subcounty lies within a high productivity zone within the county and therefore the area receives relatively higher rainfall as compared to other areas. Therefore, grass readily grow in plenty in the wild and also within farmlands. Livestock farmers from neighboring sub-counties and even counties constitute the market for this locally produced hay including crop residue. One of the greatest challenges of this hay value chain within the area is lack of standardization leading to exploitation of local farmers.

Importantly, other important grass in the area includes *Brachiaria brizantha*, *Brachiaria deflexa*, and *Brachiaria lachnantha* which occur naturally within open glades of the region's hills. Infact, locally collected *Brachiaria* varieties have been improved through selective breeding programs in Brazil, resulting in high-yielding hybrids now being cultivated to enhance fodder availability. It is highly valued for their rich protein content and their potential to enhance livestock productivity while building resilience to climate change. Notedly, improved *Brachiaria* varieties are rapidly gaining wider acceptance and has become a lucrative venture for many farmers in the area.

Figure 9.3: Improved *Brachiaria* grass propagated and promoted by project as pasture.

Leveraging of this already existing pasture farming, we promoted this initiative by actively collaborating with local communities to establish pasture nurseries, providing training on best practices for maximizing pasture cultivation including sale of high-quality seedlings/splits to other local farmers. Through this partnership, we established two community nurseries specifically dealing with pasture production.

3.1.1 Climate smart cropping systems for sustainable Pasture Production

Climate-smart cropping systems play a crucial role in ensuring sustainable pasture production by enhancing resilience to climate change while optimizing productivity. These systems incorporate drought-resistant forage species, crop diversification, and agroforestry to improve soil health and water retention. Efficient water management practices, including rainwater harvesting, road run-off support pasture growth during dry seasons. Within Nzaui-Makuli area, farmers are utilizing alley cropping systems whereby they are planting pasture in rows within their croplands to check on soil erosion and maximize space.

Figure 9.4: Incorporating pasture within croplands within Nzaui-Makuli Landscape.

As a component of this project, we established two pasture nurseries within the study area raising *Brachiaria* and *Chloris gayana* both of which are being grown though in small scale.

Figure 9.5: Established pasture nurseries within the Nzaui-Makuli area.

The establishment of pasture nurseries has assumed a communal approach whereby local community members play an active role in tending the nurseries. This initiative aims to ensure a steady supply of planting stock while fostering community collaboration in pasture management. After the sown grass reached transplanting size, it was harvested and distributed among community members with special consideration given to vulnerable members of the community such as widows. Each group member was tasked with the responsibility of planting in his or her farm first before extending the support to neighbors. Embracing the Training of Trainers (ToTs) approach, group members received specialized training with the goal of passing on their acquired knowledge to others in the community. This communal strategy not only enhances pasture security for livestock but also fosters continuous learning and collaboration in pasture management. By equipping members with the skills to train others, the initiative ensures the widespread adoption of best practices, creating a ripple effect that benefits the entire community. The established nursery serves as both a practical resource and an educational hub, where farmers actively exchange ideas, refine techniques, and explore other innovative solutions for effective pasture establishment and maintenance.

Figure 9.6: Members of Katituni Self-Help group attending to their pasture nursery.

Pasture farming in the area is gaining significant momentum, with farmers increasingly shifting from traditional maize cultivation to grass farming. This transition is driven by the recognition of pasture as a profitable and sustainable agricultural enterprise. By adopting a business-oriented approach, the initiative is attracting more farmers who see the economic and environmental benefits of pasture farming. As a result, demand for quality pasture has extended beyond the local community to drier regions such as Kathonzweni and Mbuvo, where livestock keepers are in urgent need of reliable fodder sources. Neighboring counties such as Kajiado, Kitui and Machakos are also part of ready market for the hay. This growing interest highlights the potential of pasture farming as a viable alternative to conventional crops, offering both financial stability and enhanced livestock productivity.

Figure 9.7: An established *Chloris gayana* and *Brachiaria* pasture farm.

We hasten to note that, the first and second Rufford grants were instrumental in sparking the idea to transform pasture farming into a commercial venture. Under this First Booster Grant, we visited beneficiaries whose successful pasture farming efforts were a direct outcome of Rufford's previous support.

Figure 9.8: Hay cutting, bailing and storage by project beneficiaries.

As we engaged with the project's target groups, the team got first-hand information on the significant effect of *Brachiaria* grass on animal productivity and farmers' lives. As they gave their testimonies describing the increase in milk yields, enhanced animal health, and the reduction in feeding costs, it was evident that *Brachiaria* is commercially viable. The demand for high-quality livestock feed is rising in the region, and farmers are eager for a reliable, nutrient-rich solution. This insight led to the idea of developing a business case for *Brachiaria* Hay—a scalable enterprise that meets market demand and also empowers local farmers. By promoting production, upgrading processing technologies, standardizing balling and linkages to markets, this project has the potential to transform *Brachiaria* into a profitable agribusiness venture from a mere forage alternative.

3.1.2 Hay Business Model

Table 9.1: Cost Benefit Analysis of food crops and pasture business cases.

ANNUAL YIELD AND INCOME COMPARISON FOR A 1-ACRE FIELD				
	Crop Types			**Grass Species**
Activity	**Maize**	**Beans**	**Green Grams**	**Brachiaria**
Cost of Procuring Inputs				
Land Preparation	4000	4000	4000	4000
Seed Purchase	4400	1500	5000	24250
Sowing Labour	4000	4000	4000	2500
Weeding Labour	5000	5000	5000	0
Chemicals/Pesticides	3000	3000	3000	0
Fertilizer/Manure	6000	1500	1500	0
Cost of Harvesting and Processing				
Crop Harvesting	2000	3000	4000	0
Post Harvesting Processing	2000	2000	2000	0
Hay Cutting and Bailing	0	0	0	4000
Cost of Gunny Bags (90kgs)	350	150	200	0
Total Input Cost (Ksh) for 1 season	30750	24150	28700	34750
Annual cost of Input	***61500***	***48300***	***57400***	***38750***
Output and Sales				
Hay in Bales	0	0	0	200
Cereals/Pulses in kgs	630	270	360	0
Annual output (kgs & bales)	***1260***	***540***	***720***	***400***
Sales (Ksh)				
Split sale Ksh 5/split	0	0	0	1000
Hay sale Ksh 300/bale	0	0	0	60000
Cereals/pulses sale	31500	29700	39600	0
Crop residue sale	5000	1500	1500	0
Total Sales (Ksh)	36500	31200	41100	61000
Annual Sales (Ksh)	***73000***	***62400***	***82200***	***122000***

TOTAL INCOME				
Annual Total Income in Ksh = (Total Sales-Total Input Costs)	**11500**	**14100**	**24800**	**83250**

3.1.3 Brachiaria Hay Return on Investment

Return on Investment (ROI) formula is:
ROI= (Net Profit/Cost of Investment) ×100
where:
Net Profit = Annual Total Income (Total Sales - Total Input Cost)
Cost of Investment = Annual Input Cost

1. Maize

- **Net Profit** = 11,500
- **Cost of Investment** = 61,500

ROI= (11500/61500) ×100=**18.7%**

Maize has the lowest ROI at 18.7%, making it the least attractive investment among the four. Despite an annual input cost of Ksh 61,500, its net profit stands at only Ksh 11,500, highlighting its low financial returns. The high costs of fertilizers, labor, and pesticides significantly reduce profitability, meaning that maize farming is a high-investment, low-return venture.

2. Beans

- **Net Profit** = 14,100
- **Cost of Investment** = 48,300

ROI= (14100/48300) ×100=**29.2%**

With an input cost of Ksh 48, 300, Beans had a ROI of 29.2%, and presents a moderate investment. While they can still generate income, they may not be the best choice for farmers aiming for high profits which depends more on favorable market prices.

3. Green Grams

- **Net Profit** = 24,800
- **Cost of Investment** = 57,400

ROI= (24800/57400) ×100=**43.2%**

With an ROI of 43.2%, input cost of Ksh 57,400 and a net profit of Ksh 24,800, Green grams were the second-best investment choice. They give a good balance between affordability and profitability.

4. Brachiaria (Pasture)

- **Net Profit** = 83,250
- **Cost of Investment** = 38,750

ROI= (83250/38750) ×100=**214.8%**

The above Cost-benefit Analysis (CBA) indicates that *Brachiaria* (pasture) offers the highest return on investment at 214.8%, and thus the most profitable choice. In simple terms, it means that for every Ksh 100 invested, the farmer realizes an additional profit of Ksh 214.8 after recovering the original amount. Despite having the lowest annual input cost of Ksh 38,750, it generates a good annual income of Ksh 83,250, primarily from hay sales. This suggests that pasture farming is a highly lucrative option, especially for farmers targeting the livestock industry. Investing in Brachiaria requires relatively low capital while yielding substantial profits, making it an ideal choice for those looking to maximize returns with minimal financial risk.

3.1.4 A SWOT Analysis for Brachiaria Hay Business

Strengths

- Multiple revenue streams (hay, seeds, split sales).
- High Return on Investment (ROI) – 214.8%
- Low input costs compared to other crops.
- Strong market demand for quality livestock feed.
- Drought-resistant and climate-adaptive.
- Improves soil health & prevents erosion.

Weaknesses

- High initial seed cost (Ksh 24,250 per acre)
- Slow initial growth phase before full productivity.
- Limited awareness & technical knowledge
- Processing & storage challenges (hay cutting, baling)

Opportunities

- Expanding demand of livestock feeds in neighboring counties.
- Government & NGO support for fodder farming
- Climate change adaptation and resilience projects

- Value addition possibilities (processed feeds)

Threats

- Climate variability (drought).
- Pest and disease risks affecting yield.
- Land use conflicts with food crop farming.
- Price fluctuations in the fodder market.
- Competition from alternative feed sources.

3.2 Promotion of Modern Beekeeping Technologies

According to Thorp (1943), beekeeping is an integral part of Kamba tribal culture, with the ownership of beehives being as essential as the possession of cattle and goats today. Honey, in its various forms—most notably as mead—held significant cultural and religious value within the Kamba community. For instance, raw honey was/is offered to ancestral spirits (*aiimu*) as a sacred tribute when seeking rain or food. The Kamba people carefully selected specific trees for crafting beehives, with the *Commiphora* species being highly valued for this purpose. Royal jelly was used as famine food among the Kamba community.

The Nzaui-Makuli landscape is characterized by *Combretum*-wooded grassland, providing an ideal environment for beekeeping. Along the roads, one can observe numerous traditional log hives suspended from trees, a testament to the deep-rooted practice of apiculture among local communities. It is as integral to their way of life as farming, with generations of residents having honed the skill of honey production over time. Historically, these communities have closely observed bee behavior, associating the migration of bee colonies with the onset of rainfall. Even today, there are farmers who use the flight of bees as a natural signal of approaching rains. Yet, like in other rural communities, the complex interdependence between pollinators and farm productivity continues to be greatly undervalued. Many locals report notable decline in bee colonies and agricultural productivity, raising concerns on the long-term agricultural and apicultural sustainability in the region (Klein *et al.,* 2007; Potts *et al.,* 2010). The reduction in farm yields has led to the locals resorting to environmentally degrading activities, such as illegal logging, expanded agriculture, and charcoal production. These unsustainable land use practices result in loss of forests, biodiversity and land degradation, thereby exacerbating environmental challenges in the Nzaui-Makuli region (FAO, 2021; IPBES, 2019).

Nature-based livelihood strategies have demonstrated extensive potential to promote environmental conservation and economic sustainability. Beekeeping, further, provides a potential sustainable solution to environmental degradation while offering benefits to the local communities (Bradbear, 2009). The Nzaui-Makuli Landscape has already an apiculture foundation, since some locals keep bees using the traditional log hives. However, this practice has limited economic gain since it tends to produce lower quality and quantity honey (Crane, 1999).

Figure 9.9: Traditional log hive with Nzaui-Makuli area.

Moreover, cultural norms have historically restricted beekeeping to men, limiting opportunities for youth and women's participation in this economically viable sector (Kiptot & Franzel, 2012). Addressing these challenges by promoting modern beekeeping practices, such as the use of Langstroth hives, improved hive management techniques, and inclusive participation, could enhance honey quality, increase yields, and create equitable economic opportunities within the community while fostering environmental sustainability.

Recognizing these challenges, the present project aimed to strengthen existing beekeeping practices by introducing and promoting modern beekeeping technologies. As part of the initiative, fifteen (15) langstroth hives, along with their accessories, were distributed to Katituni and Ngutwa self-help groups in Kathuma and Ngutwa villages respectively. The groups received training on critical aspects of modern beekeeping, including site selection, hive installation and inspection, harvesting techniques, and maintenance of a healthy colony.

Figure 9.10: Capturing swarming bee colonies using brood box.

We utilized brooders as catcher boxes, positioning them on tall trees along known bee routes identified by locals. After successful colonization, the brooders were relocated to stands two weeks later. The brooders underwent periodic inspections, and supering was done once most frames were fully honey-combed. To prevent ant and other insect attacks, we applied oil and wood ash around the base of the hive stands. To protect the hives from honey badgers, which are common in the area, the hives were securely fastened with wood to prevent vandalism.

Figure 9.11: Supered langstroth hives (Honey badger-proofed).

Remarkably, within the first week of installation, all fifteen hives were successfully colonized. As at the time of this report, (13) hives remain colonized, while two (2) have been absconded. Notably, Katituni Self-Help Group has already completed its first harvest, extracting a total of forty-eight (48) kilograms of honey from five (5) hives. Of this yield, eight (8) kilograms were consumed locally, while the remaining quantity was sold at the prevailing market price, generating a total revenue of Ksh 40,000. Half of the earnings were reinvested in the group to acquire additional hives, while the rest was allocated for routine operational activities.

Despite clear evidence that beekeeping offers significantly higher returns on investment compared to crop farming, we conducted a cost-benefit analysis to compare the profitability of maize, beans, green grams, and beekeeping. This analysis aimed to provide farmers with a data-driven perspective on which venture yields the best financial returns while requiring the least effort and resources.

3.2.1 Modern Beekeeping Returns on Investment

Return on Investment (ROI) formula is:
ROI= (Net Profit/Cost of Investment) ×100

where:
Net Profit = Annual Total Income (Total Sales - Total Input Cost)
Cost of Investment = Annual Input Cost

Table 9.2: Cost Benefit Analysis of food crops and beekeeping business cases.

ANNUAL YIELD AND INCOME COMPARISON FOR A 1-ACRE FIELD				
	Crop Types			Beekeeping
Activity	**Maize**	**Beans**	**Green Grams**	**10 Langstroth Hives**
Cost of Procuring Inputs				
Land Preparation	4000	4000	4000	0
Seed Purchase	4400	1500	5000	0
Sowing Labour	4000	4000	4000	0
Weeding Labour	5000	5000	5000	0
Chemicals/Pesticides	3000	3000	3000	0
Fertilizer/Manure	6000	1500	1500	0
Equipment (Hives and Accessories)	0	0	0	62000
Cost of Harvesting and Processing				
Crop Harvesting	2000	3000	4000	0
Post Harvesting Processing	2000	2000	2000	0
Honey harvesting	0	0	0	2500
Cost of Gunny Bags (90kgs)	350	150	200	0

Total Input Cost (Ksh) for 1 season	**30750**	**24150**	**28700**	**64500**
Annual cost of Input	**61500**	**48300**	**57400**	**67000**
Output and Sales				
Honey in Kgs	0	0	0	50
Cereals/Pulses in kgs	630	270	360	0
Annual output (kgs & bales)	**1260**	**540**	**720**	**100**
Sales (Ksh)				
Honey sale Ksh 1000/kg	0	0	0	50000
Other Bee Products	0	0	0	4000
Cereals/pulses sale	31500	29700	39600	0
Crop residue sale	5000	1500	1500	0
Total Sales (Ksh)	**36500**	**31200**	**41100**	**54000**
Annual Sales (Ksh)	**73000**	**62400**	**82200**	**108000**
TOTAL INCOME				
Annual Total Income in Ksh = (Total Sales-Total Input Costs)	**11500**	**14100**	**24800**	**41000**

1. Maize

- **Net Profit** = Ksh 11,500
- **Cost of Investment** = Ksh 61,500
- **ROI** (11,500 / 61,500) × 100 = **18.7%**
- For every Ksh 1 invested in maize farming, you earn only Ksh 0.19 in profit.

Maize has the lowest ROI at 18.7% and hence is the least profitable of the four investments. Its net profit is Ksh 11,500 with an annual input cost of Ksh 61,500, an indicator of its poor return on invested capital. The high costs of fertilizers, labor, and pesticides significantly reduce profitability, thus maize farming is a high-input, low-return venture. Farmers who are investing primarily in maize are not able to attain significant economic gains unless they intercrop it with more lucrative crops.

2. Beans

- **Net Profit** = Ksh 14,100
- **Cost of Investment** = Ksh 48,300
- **ROI:** (14,100 / 48,300) × 100 = **29.2%**

- For every Ksh 1 invested in beans farming, you earn Ksh **0.29** in profit.

Beans, having an investment potential of 29.2%, have a moderate investment potential. Though the input cost on beans (Ksh 48,300) is less in comparison to green grams and maize, the ensuing net profit (Ksh 14,100) is comparatively modest. This implies that while beans can still make money, they may not be the best for farmers who want maximum profitability. Their relatively lower return is such that profitability is highly dependent on good prices in the market and efficient management of costs.

3. Green Grams

- **Net Profit** = Ksh 24,800
- **Cost of Investment** = Ksh 57,400
- **ROI:** (24,800 / 57,400) × 100 = **43.2%**
- For every Ksh 1 invested in green grams, you earn Ksh **0.43** in profit.

Green grams rank second best with a 43.2% return on investment. Priced at an annual input cost of Ksh 57,400 and net profit of Ksh 24,800, green grams are a fair middle ground between profitability and affordability. This is to say that farmers who want a stable cash crop with reasonable input costs and modest returns are better off with green grams.

4. Beekeeping

- **Net Profit** = Ksh 41,000
- **Cost of Investment** = Ksh 67,000
- **ROI Calculation:** (41,000 / 67,000) × 100 = 61.2%
- For every Ksh 1 invested in beekeeping, you earn Ksh **0.61** in profit.

Beekeeping has the highest ROI at 61.2%, meaning that it is a profitable and sustainable venture among the four value chains. Its profit of Ksh 41,000 is close to almost double the profit of green grams and almost four times that of maize.

3.2.2 SWOT Analysis for Modern Beekeeping Enterprise

1. Strengths (Internal Advantages of Beekeeping)

Beekeeping has several key strengths that make it a profitable and sustainable investment.

- High Return on Investment
- Low Maintenance & Labor Costs.
- Resilience to Climate Change.
- Small Land Requirement.
- High Market Demand & Stable Prices.
- Environmental Benefits.

2. Weaknesses (Internal Challenges of Beekeeping)

Despite its advantages, beekeeping has some weaknesses that need to be addressed.

- Relatively high initial investment costs

- Requires Training & Technical Knowledge
- Risk of Bee Swarming & Colony Loss
- Limited Harvesting Seasons

3. Opportunities (External Factors That Can Boost Beekeeping)
Several external factors favor the growth and profitability of beekeeping.

- Growing Demand for Honey & Bee Products.
- Government & NGO Support.
- Integration with Other Farming Activities.
- Development of Value-Added Products.

4. Threats (External Risks That Could Affect Beekeeping)
Beekeeping is not without risks, and farmers should be aware of potential threats.

- Pests and diseases
- Environmental and climate changes
- Competition and adulteration of honey
- Theft and vandalism

The promotion of modern beekeeping and the production and commercialization of *Brachiaria* value chain within the Nzaui-Makuli Landscape hold significant potential for economic growth. However, several critical challenges must be addressed to maximize profitability. Standardizing bale sizes is essential to ensure uniformity and fair pricing in the market. Additionally, local farmers should organize themselves into cooperatives or groups to leverage economies of scale, enhancing their bargaining power and reducing production costs. In beekeeping, locals of the Nzaui-Makuli landscape measure honey in liters as opposed to kilograms. Importantly, ongoing training is crucial to improving hive management techniques and honey production efficiency. Furthermore, access to a reliable honey extractor is necessary to enhance productivity and maintain product quality.

CHAPTER 10: BIBLIOGRAPHY

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CHAPTER 11: ANNEXES

ANNEX I: Checklist of plant species documented within the sacred groves

S/No	FAMILY	SPECIES	LOCAL NAME	LIFEFORM	CONSERVATION STATUS
1	Acanthaceae	*Crabbea velutina* S. Moore		Herb	Not Evaluated
2	Acanthaceae	*Dyschoriste depressa* Nees	Mututi	Herb	Not Evaluated
3	Acanthaceae	*Hypoestes aristata* (Vahl) Sol. ex Roem. & Schult.		Herb	Least Concern (LC)
4	Acanthaceae	*Justicia diclipteroides* Lindau		Herb	Not Evaluated
5	Acanthaceae	*Justicia flava* (Forssk.) Vahl		Herb	Not Evaluated
6	Acanthaceae	*Justicia* sp.		Herb	
7	Acanthaceae	*Justicia striata* (Klotzsch) Bullock		Herb	Not Evaluated
8	Acanthaceae	*Thunbergia alata* Bojer ex Sims		Herb	Not Evaluated
9	Acanthaceae	*Thunbergia napperae* Mwachala, Malombe & Vollesen		Herb	Endangered (EN)
10	Anacardiaceae	*Lannea rivae* (Chiov.) Sacleux		Tree	Least Concern (LC)
11	Anacardiaceae	*Lannea schimperi* (A.Rich.) Engl.		Shrub	Not Evaluated
12	Anacardiaceae	*Lannea schweinfurthii* (Engl.) Engl		Shrub	Not Evaluated
13	Anacardiaceae	*Ozoroa insignis* Delile		Shrub	Least Concern (LC)
14	Anacardiaceae	*Rhus natalensis* Bernh. ex C.Krauss		Shrub	Least Concern (LC)
15	Anacardiaceae	*Rhus longipes* Engl.		Shrub	Least Concern (LC)
16	Anacardiaceae	*Sclerocarya birrea* (A. Rich.) Hochst.	Kiua	Tree	Least Concern (LC)
17	Annonaceae	*Artabotrys monteiroae* Oliv.		Liana	Least Concern (LC)
18	Annonaceae	*Monanthotaxis parvifolia* (Oliv.) Verdc.		Liana	Least Concern
19	Annonaceae	*Monodora grandidieri* Baill.		Liana	Least Concern
20	Annonaceae	*Uvaria scheffleri* Diels	Ngukuma	Liana	Not Evaluated
21	Apocynaceae	*Acokanthera oppositifolia* (Lam.) Codd		Tree	Least Concern (LC)
22	Apocynaceae	*Carissa spinarum* L.		Shrub	Least Concern (LC)
23	Araliaceae	*Cussonia holstii* Engl.		Tree	Least Concern (LC)
24	Asparagaceae	*Asparagus africanus* Lam.		Liana	Not Evaluated

25	Asparagaceae	*Asparagus falcatus* L.	Kavosya iteta	Liana	
26	Asparagaceae	*Sansevieria suffruticosa* N.E. Br.	Kyongoa	Herb	Not Evaluated
27	Asphodelaceae	*Aloe deserti* A. Berger		Herb	Near Threatened (NT)
28	Asphodelaceae	*Aloe ngutwaensis* T. Mwadime & Matheka		Herb	Critically Endangered (CR)
29	Asteraceae	*Aspilia mossambicensis* (Oliv.) Wild	Muti	Herb	Not Evaluated
30	Asteraceae	*Aspilia pluriseta*		Herb	Not Evaluated
31	Asteraceae	*Senecio* sp.		Herb	
32	Asteraceae	*Vernonia brachycalyx* O. Hoffm.	Museve	Shrub	Not Evaluated
33	Bignoniaceae	*Markhamia lutea* (Benth.) K. Schum.		Tree	Least Concern (LC)
34	Boraginaceae	*Cordia africana* Lam.		Tree	Least Concern (LC)
35	Burseraceae	*Commiphora baluensis* Engl.		Tree	Least Concern (LC)
36	Burseraceae	*Commiphora habessinica* (O. Berg) Engl	Mutungati	Shrub	Not Evaluated
37	Burseraceae	*Commiphora africana* (A. Rich.) Engl.	itula	Tree	Least Concern (LC)
38	Cactaceae	*Rhipsalis baccifera* (J.S. Muell.) Stearn		Herb	Least Concern (LC)
39	Capparaceae	*Capparis tomentosa* Lam.	Kitamba mboo	Liana	Not Evaluated
40	Capparaceae	*Maerua? angolensis* DC.		Shrub	
41	Capparaceae	*Maerua triphylla* var. *pubescens* (Klotzsch) DeWolf		Shrub	Least Concern (LC)
42	Celastraceae	*Mystroxylon aethiopicum* (Thunb.) Loes.	Ngongoo	Tree	Not Evaluated
43	Celestraceae	*Gymnosporia senegalensis* (Lam.) Loes.		Shrub	Not Evaluated
44	Celestraceae	*Maytenus heterophylla* (Eckl. & Zeyh.) N. Robson		Shrub	Least Concern (LC)
45	Celestraceae	*Maytenus putterlickoides*	Muthunthi	Shrub	Not Evaluated
46	Celestraceae	*Maytenus undata* (Thunb.) Blakelock		Shrub	Least Concern (LC)
47	Clusiaceae	*Garcinia livingstonei* T. Anderson		Tree	Least Concern (LC)
48	Clusiaceae	*Garcinia volkensii* Engl.		Tree	Not Evaluated
49	Combretaceae	*Combretum apiculatum* Sond.	Kiua Nzuki	Tree	Least Concern (LC)
50	Combretaceae	*Combretum collinum* Fresen.		Tree	Least Concern (LC)
51	Combretaceae	*Combretum molle* R. Br. ex G. Don		Tree	Least Concern (LC)
52	Combretaceae	*Combretum schumannii* Engl.	Kyaa sya usi	Tree	Not Evaluated
53	Combretaceae	*Combretum* sp.		Tree	

54	Combretaceae	*Terminalia brownii* Fresen.	Kiuuku	Tree	Least Concern (LC)
55	Commelinaceae	*Commelina benghalensis* L.	Mukengesya	Herb	Least Concern (LC)
56	Commelinaceae	*Commelina forskaolii* Vahl	Kikowe	Herb	Not Evaluated
57	Convolvulaceae	*Ipomoea kituensis* Vatke	Kiungu	Herb	Not Evaluated
58	Crassulaceae	*Kalanchoe citrina* Schweinf.		Herb	Not Evaluated
59	Crassulaceae	*Kalanchoe densiflora* Rolfe		Herb	Least Concern (LC)
60	Crassulaceae	*Kalanchoe lanceolata* (Forssk.) Pers.		Herb	Not Evaluated
61	Cucurbitaceae	*Momordica rostrata* Zimm.		Climber	Not Evaluated
62	Cucurbitaceae	*Momordica boivinii* Baill.		Climber	Not Evaluated
63	Cucurbitaceae	*Peponium vogelii* (Hook.f.) Engl.		Climber	Not Evaluated
64	Cyperaceae	*Cyperus* sp.	Kiindiiu	Herb	Not Evaluated
65	Cyperaceae	*Cyperus giolii* Chiov.	Ngaatu	Herb	Not Evaluated
66	Dracaenaceae	*Dracaena laxissima* Engl.		Climber	Not Evaluated
67	Dracaenaceae	*Dracaena steudneri* Engl.		Shrub	Least Concern (LC)
68	Ebanaceae	*Diospyros abyssinica* (Hiern) F.White		Shrub	Least Concern (LC)
69	Ebanaceae	*Diospyros consolatae* Chiov.		Tree	Least Concern (LC)
70	Ebanaceae	*Diospyros* sp.		Tree	
71	Ebanaceae	*Euclea divinorum* Hiern		Shrub	Least Concern (LC)
72	Euphorbiaceae	*Acalypha fruticosa* Forssk.		Shrub	Least Concern (LC)
73	Euphorbiaceae	*Acalypha lanceolata* Willd.		Herb	Not Evaluated
74	Euphorbiaceae	*Acalypha ornata* Hochst. ex A. Rich.		Herb	Least Concern (LC)
75	Euphorbiaceae	*Acalypha fruticosa* Forssk.		Shrub	Least Concern (LC)
76	Euphorbiaceae	*Bridelia micrantha* (Hochst.) Baill.		Tree	Least Concern (LC)
77	Euphorbiaceae	*Croton dichogamus* Pax	Muthinia	Shrub	Least Concern (LC)
78	Euphorbiaceae	*Croton megalocarpus* Hutch.	Kithulu	Tree	Least Concern (LC)
79	Euphorbiaceae	*Euphorbia bicompacta* Bruyns	Kyantha	Shrub	Least Concern (LC)
80	Euphorbiaceae	*Euphorbia candelabrum* Welw. ex Hiern	Kyaa	Tree	Least Concern (LC)
81	Euphorbiaceae	*Euphorbia crotonoides* Boiss.		Herb	Not Evaluated
82	Euphorbiaceae	*Euphorbia tirucalli*	Ndau	Shrub	Least Concern (LC)

83	Euphorbiaceae	*Flueggea virosa* (Roxb. Ex Willd.) Royle	Mukuluu	Shrub	Least Concern (LC)
84	Euphorbiaceae	*Ricinus communis* L.		Tree	Not Evaluated
85	Euphorbiaceae	*Tragia brevipes* Pax.	Kinyeelya	Climber	Not Evaluated
86	Fabaceae	*Acacia brevispica* Harms	Mukuusyi	Tree	Least Concern (LC)
87	Fabaceae	*Acacia gerrardii* Benth.	Muthi	Tree	Not Evaluated
88	Fabaceae	*Acacia hockii* De Wild.		Shrub	Least Concern (LC)
89	Fabaceae	*Acacia mellifera* (Vahl) Benth.		Tree	Least Concern (LC)
90	Fabaceae	*Acacia nilotica* (L.) Willd. ex Delile	Musemei	Tree	Least Concern (LC)
91	Fabaceae	*Acacia seyal* Delile	Kinyua	Tree	Least Concern (LC)
92	Fabaceae	*Acacia tortilis* (Forssk.) Hayne		Tree	Least Concern (LC)
93	Fabaceae	*Albizia gummifera* (J.F. Gmel.) C.A. Sm.		Tree	Least Concern (LC)
94	Fabaceae	*Albizia* sp.		Tree	
95	Fabaceae	*Bauhinia taitensis* Taub.	Mulima	Shrub	Least Concern (LC)
96	Fabaceae	*Bauhinia tomentosa* L.		Shrub	Least Concern (LC)
97	Fabaceae	*Craibia brownii* Dunn		Tree	Not Evaluated
98	Fabaceae	*Crotalaria axillaris* Aiton	Kivinga	Shrub	Not Evaluated
99	Fabaceae	Crotalaria sp.		Shrub	
100	Fabaceae	*Dalbergia melanoxylon* Guill. & Perr.		Tree	Near Threatened (NT)
101	Fabaceae	*Dichrostachys cinerea* (L.) Wight & Arn.		Tree	Least Concern (LC)
102	Fabaceae	*Dolichos sericeus* E.Mey.		Climber	Not Evaluated
103	Fabaceae	*Entada leptostachya* Harms		Liana	Least Concern (LC)
104	Fabaceae	*Eriosema shirense* Baker f.	Ngathu	Herb	Not Evaluated
105	Fabaceae	*Erythrina abyssinica* Lam.		Tree	Least Concern (LC)
106	Fabaceae	*Indigofera lupatana* Baker F.	Muthika	Shrub	Not Evaluated
107	Fabaceae	*Lonchocarpus eriocalyx* Harms	Kinguuthe	Shrub	Not Evaluated
108	Fabaceae	*Millettia vatkei* L.K.Phan	Utwaa	Climbing shrub	Endangered (EN)
109	Fabaceae	*Newtonia hildebrandtii* (vatke) Torre	Mukame	Tree	
110	Fabaceae	*Ormocarpum kirkii* S. Moore	Kithingii	Shrub	Least Concern (LC)
111	Fabaceae	*Rhynchosia hirta* (Andrews) Meikle & Verdc.		Climber	Not Evaluated

112	Fabaceae	*Rhynchosia minima* (L.) DC.	Uthiu	Climber	Least Concern (LC)
113	Fabaceae	*Senna singueana* (Delile) Lock	Mukengeta	Shrub	Least Concern (LC)
114	Fabaceae	*Senna spectabilis* (DC.) H.S. Irwin & Barneby.	Mukengeta	Shrub	Least Concern (LC)
115	Fabaceae	*Tamarindus indica* L.		Tree	Least Concern (LC)
116	Fabaceae	*Zornia setosa* Baker f.		Herb	Not Evaluated
117	Icacinaceae	*Apodytes dimidiata* Arn.		Shrub	Least Concern (LC)
118	Lamiaceae	*Clerodendrum hildebrandtii* Vatke	Mukakaa	Shrub	Least Concern (LC)
119	Lamiaceae	*Clerodendrum* sp.	Muti mukuu	Shrub	
120	Lamiaceae	*Coleus cylindraceus* (Hochst. ex Benth.) A.J.Paton	Kio kinini	Herb	Not Evaluated
121	Lamiaceae	*Erythrochlamys spectabilis* Gürke	Muumba	Herb	Not Evaluated
122	Lamiaceae	*Fuerstia africana* T. C. E. Fries	Kalaku	Herb	Not Evaluated
123	Lamiaceae	*Hoslundia opposita* Vahl		Shrub	Not Evaluated
124	Lamiaceae	*Lantana camara* L.	Musomolo	Shrub	Not Evaluated
125	Lamiaceae	*Leucas grandis* Vatke	Museve	Herb	
126	Lamiaceae	*Leucas martinicensis* (Jacq.) R.Br.		Herb	
127	Lamiaceae	*Lippia javanica* (Burm.f.) Spreng.	Muthieti	Shrub	Not Evaluated
128	Lamiaceae	*Ocimum americanum* L.		Herb	Not Evaluated
129	Lamiaceae	*Ocimum basilicum* L		Shrub	Not Evaluated
130	Lamiaceae	*Ocimum gratissimum* L.	Mukandu	Herb	Not Evaluated
131	Lamiaceae	*Ocimum kilimandscharicum* Baker ex Gürke	Mutaa	Shrub	Not Evaluated
132	Lamiaceae	*Plectranthus barbatus* Andrews	Muvou	Herb	Not Evaluated
133	Lamiaceae	*Plectranthus caninus* B. Heyne ex Roth		Herb	Not Evaluated
134	Lamiaceae	*Rotheca microphylla* (Blume) Callm. & Phillipson		Shrub	Least Concern (LC)
135	Lamiaceae	*Tinnea aethiopica* Kotschy ex Hook.f.		Shrub	Not Evaluated
136	Lamiaceae	*Vitex payos* (Lour.) Merr.	Muu	Tree	Least Concern (LC)
137	Lamiaceae	*Vitex* sp.		Tree	
138	Lamiaceae	*Vitex strickeri* Vatke & Hildebrandt	Muvatha	Tree	Least Concern (LC)
139	Loganiaceae	*Strychnos henningsii* Gilg	Muteta	Shrub	Least Concern (LC)
140	Loganiaceae	*Strychnos spinosa* Lam.		Shrub	

141	Loganiaceae	*Strychnos decussata* (Pappe) Gilg		Shrub	Least Concern (LC)
142	Malvaceae	*Azanza garckeana* (F.Hoffm.) Exell & Hillc.	Kitoo	Tree	Not Evaluated
143	Malvaceae	*Cola greenwayi* var. *keniensis* Brenan		Shrub	
144	Malvaceae	*Dombeya torrida* (J.F. Gmel.) Bamps	Muvau	Tree	Not Evaluated
145	Malvaceae	*Grewia bicolor* Juss.	Kikalawa	Shrub	Not Evaluated
146	Malvaceae	*Grewia plagiophylla* K.Schum.		Shrub	Least Concern (LC)
147	Malvaceae	*Grewia similis* K. Schum.	Kituva	Shrub	Not Evaluated
148	Malvaceae	*Grewia* sp.		Shrub	
149	Malvaceae	*Grewia tembensis* Fresen.		Shrub	Not Evaluated
150	Malvaceae	*Hibiscus meyeri* Harv.		Herb	Not Evaluated
151	Malvaceae	*Hibiscus micranthus* L.f.		Shrub	Not Evaluated
152	Malvaceae	*Hibiscus fuscus* Garcke	Mulyambila	Herb	Not Evaluated
153	Malvaceae	*Melhania velutina* Forssk	Kamutootoo	Herb	Not Evaluated
154	Malvaceae	*Sida ovata* Forssk.	Ulunguthu	Herb	Not Evaluated
155	Malvaceae	*Sida rhombifolia* L.	Muswaki	Shrub	Not Evaluated
156	Malvaceae	*Sida* sp.	Muswaki	Herb	
157	Malvaceae	*Thespesia garckeana* F.Hoffm.		Shrub	Least Concern (LC)
158	Meliaceae	*Ekebergia capensis* Sparrm.	Kyuasi	Tree	Least Concern (LC)
159	Meliaceae	*Trichilia emetica* Vahl	Kituluku	Tree	Least Concern (LC)
160	Meliaceae	*Turraea mombassana* Hiern ex C. DC		Shrub	Least Concern (LC)
161	Meliaceae	*Turraea robusta* Gürke	Mutunene	Tree	Least Concern (LC)
162	Meliaceae	*Turraea* sp.		Shrub	
163	Menispermaceae	*Cissampelos pareira* L.		Climber	Not Evaluated
164	Menispermaceae	*Tiliacora funifera* (Miers) Oliv.		Liana	Not Evaluated
165	Moraceae	*Ficus bussei* Warb. ex Mildbr. & Burret		Tree	Not Evaluated
166	Moraceae	*Ficus glumosa* Delile	Kikelenzu	Tree	Least Concern (LC)
167	Moraceae	*Ficus ingens* (Miq.) Miq.		Tree	Least Concern (LC)
168	Moraceae	*Ficus lutea* Vahl		Tree	Least Concern (LC)
169	Moraceae	*Ficus natalensis* Hochst.		Tree	Least Concern (LC)

170	Moraceae	*Ficus stuhlmannii* Warb		Tree	Least Concern (LC)
171	Moraceae	*Ficus sycomorus* L.	Mukuyu	Tree	Least Concern (LC)
172	Moraceae	*Ficus thonningii* Blume	Kiumo	Tree	Least Concern (LC)
173	Moraceae	*Dorstenia arachniformis* Matheka, Malombe, T.Mwadime & Mwachala	Ngondu ya kitumbi	Herb	Critically Endangered (CR)
174	Myrsinaceae	*Rapanea melanophloeos* (L.) Mez		Tree	Not Evaluated
175	Myrtaceae	*Eucalyptus saligna* Sm.	Musanduku	Tree	Least Concern (LC)
176	Nyctaginaceae	*Commicarpus plumbagineus* (Cav.) Standl.		Climber	Not Evaluated
177	Ochnaceae	*Ochna holstii* Engl.		Tree	Least Concern (LC)
178	Ochnaceae	*Ochna ovata F*. Hoffm.	Mutandi	Shrub	Not Evaluated
179	Olacaceae	*Ximenia americana* L.	Kitula	Shrub	Least Concern (LC)
180	Oleaceae	*Jasminum* sp.		Shrub	
181	Orchidaceae	*Aerangis confusa* J.Stewart,		Herb	Not Evaluated
182	Orchidaceae	*Angraecum affine* Schltr.		Herb	Not Evaluated
183	Orchidaceae	*Ansellia africana* Lindl.	Kiwa kya Ilai	Herb	Vulnerable (VU)
184	Orchidaceae	*Bonatea steudneri*		Herb	Not Evaluated
185	Orchidaceae	*Eulophia petersii* (Rchb. f.) Rchb. f.		Herb	Not Evaluated
186	Orchidaceae	*Eulophia streptopetala* Lindl.		Herb	Not Evaluated
187	Orchidaceae	*Rangaeris amaniensis* (Kraenzl.) Summerh.		Herb	Not Evaluated
188	Passifloraceae	*Adenia gummifera* (Harv.) Harms var. *gummifera*	Musoka	Liana	Not Evaluated
189	Phyllanthaceae	*Antidesma venosum* Tul.		Shrub	Least Concern (LC)
190	Phyllanthaceae	*Phyllanthus sepialis* Müll.Arg.	Mwelanganga	Shrub	Not Evaluated
191	Pittosporaceae	*Pittosporum viridiflorum* Sims		Tree	Least Concern (LC)
192	Plumbaginaceae	*Plumbago zeylanica* L.	Mukela Ivai/ Mung'atha	Herb	Not Evaluated
193	Poaceae	*Brachiaria brizantha* (A.Rich.) Stapf		Herb	Not Evaluated
194	Poaceae	*Cynodon dactylon* (L.) Pers.	Ikoka	Herb	Not Evaluated
195	Poaceae	*Eragrostis superba* Peyr.		Herb	Not Evaluated
196	Poaceae	*Hyparrhenia filipendula* (Hochst.) Stapf		Herb	Not Evaluated
197	Poaceae	*Melinis repens* (Willd.) Zizka		Herb	Not Evaluated

198	Poaceae	*Setaria plicatilis* (Hochst.) Hack.		Herb	Not Evaluated
199	Poaceae	*Setaria sphacelata* (Schumach.) Moss		Herb	Not Evaluated
200	Poaceae	*Sporobolus pyramidalis* P.Beauv.		Herb	Not Evaluated
201	Primulaceae	*Rapanea melanophloeos* (L.) Mez		Tree	Not Evaluated
202	Pteridaceae	*Actiniopteris radiata* (Sw.) Link		Herb	Not Evaluated
203	Pteridaceae	*Actinopteris semiflabellata* Pic. Serm	Mwei wa via	Herb	Not Evaluated
204	Rhamnaceae	*Scutia myrtina* (Burm.f.) Kurz		Shrub	Least Concern (LC)
205	Rhamnaceae	*Ziziphus mauritiana* Lam		Tree	Least Concern (LC)
206	Rhamnaceae	*Ziziphus mucronata* Willd.	Kitae	Tree	Least Concern (LC)
207	Rubiaceae	*Afrocanthium keniense* (Bullock) Lantz		Shrub	Vulnerable (VU)
208	Rubiaceae	*Canthium* sp.	Mutei	Shrub	
209	Rubiaceae	*Catunaregam nilotica* (Stapf) Tirveng.		Shrub	Not Evaluated
210	Rubiaceae	*Catunaregam spinosa* (Thunb.) Tirveng. subsp. *spinosa*		Shrub	Least Concern (LC)
211	Rubiaceae	Gardenia volkensii K. Schum.		Shrub	Least Concern (LC)
212	Rubiaceae	*Hymenodictyon parvifolium* Oliv.	Mulinditi	Shrub	Least Concern (LC)
213	Rubiaceae	*Oxyanthus goetzei* subsp. *keniensis* Bridson		Shrub	Vulnerable (VU)
214	Rubiaceae	*Pavetta sepium* var. *glabra Bremek*.		Shrub	Not Evaluated
215	Rubiaceae	*Pavetta* sp.		Shrub	
216	Rubiaceae	*Pavetta teitana* K. Schum.	Muthogoi	Shrub	Vulnerable (VU)
217	Rubiaceae	*Psychotria capensis* (Eckl.) Vatke		Shrub	Least Concern (LC)
218	Rubiaceae	*Psychotria kirkii* Hiern.	Muthumba	Shrub	Not Evaluated
219	Rubiaceae	*Psychotria sp.*		Shrub	
220	Rubiaceae	*Psydrax schimperianus* (A.Rich.) Bridson		Shrub	Least Concern (LC)
221	Rubiaceae	*Rhodopentas bussei* (K.Krause) Kårehed & B.Bremer		Herb	Not Evaluated
222	Rubiaceae	*Rothmannia urcelliformis* (Hiern) Bullock ex Robyns		Tree	Least Concern (LC)
223	Rubiaceae	*Vangueria apiculata* K. Schum.		Tree	Least Concern (LC)
224	Rubiaceae	*Vangueria infausta* Burch.		Tree	Least Concern (LC)
225	Rubiaceae	*Vangueria madagascariensis* J.F. Gmel.	Kikomoa	Shrub	Least Concern (LC)

226	Rubiaceae	*Vangueria schumanniana* (Robyns) Lantz	Kitootoo	Shrub	Least Concern (LC)
227	Rutaceae	*Clausena anisata* (Willd.) Hook. f. ex Benth.		Shrub	Least Concern (LC)
228	Rutaceae	*Fagaropsis hildebrandtii* (Engl.) MilneRedh.	Muvindavindi	Tree	Near Threatened (NT)
229	Rutaceae	*Harrisonia abyssinica* Oliv.	Mukiliuulu	Shrub	Least Concern (LC)
230	Rutaceae	*Toddalia asiatica* (L.) Lam.		Shrub	Not Evaluated
231	Salicaceae	*Flacourtia indica* (Burm.f.) Merrill		Shrub	Least Concern (LC)
232	Salicaceae	*Ludia mauritiana* J.F. Gmel.		Shrub	Least Concern (LC)
233	Santalaceae	*Osyridicarpos schimperianus* A.DC.		Liana	Least Concern (LC)
234	Santalaceae	*Osyris lanceolata* Hochst. & Steud.		Shrub	Least Concern (LC)
235	Sapindaceae	*Allophylus* sp.		Tree	Least Concern (LC)
236	Sapindaceae	*Dodonaea viscosa* Jacq.		Shrub	Least Concern (LC)
237	Sapindaceae	*Pappea capensis* Eckl. & Zeyh.		Tree	Least Concern (LC)
238	Sapotaceae	*Manilkara discolor* (Sond.) J.H. Hemsl.		Tree	Least Concern (LC)
239	Smilacaceae	*Smilax anceps* Willd.		Liana	Not Evaluated
240	Solanaceae	*Solanum incanum* L.	Kikondu	Shrub	Least Concern (LC)
241	Solanaceae	*Solanum renschii* Vatke	Kitongu tongu	Shrub	Not Evaluated
242	Solanaceae	*Solanum* sp.		Shrub	
243	Stilbaceae	*Nuxia congesta* R. Br. ex Fresen		Tree	Least Concern (LC)
244	Talinacaceae	*Talinum portulacifolium* (Forssk.) Asch. Ex Schweinf.	Ndata Kivumbu	Herb	Least Concern (LC)
245	Thymalaceae	*Gnidia latifolia* (Oliv.) Gilg	Muvila	Shrub	Not Evaluated
246	Velloziaceae	*Xerophyta spekei* Baker	Kiandui	Herb	Not Evaluated
247	Verbenaceae	*Lantana rhodesiensis Moldenke*	Kivisavisi	Shrub	Not Evaluated
248	Vitaceae	*Cissus quadrangularis* L.	uswe	Climber	Not Evaluated
249	Vitaceae	*Cissus rotundifolia* (Forssk.) Vahl		Climber	Least Concern (LC)
250	Vitaceae	*Cyphostemma adenocaule* (A.Rich.) Wild & R.B.Drumm.		Climber	Not Evaluated
251	Vitaceae	*Cyphostemma cyphopetalum* (Fresen.) Desc. Ex Wild & R. B.Drumm.	Kiungu Kinini	Herb	Not Evaluated
252	Vitaceae	*Cyphostemma* sp.		Climber	
253	Vitaceae	*Rhoicissus tridentata* (L.f.) Wild & R.B.Drumm.		Climber	Least Concern (LC)

ANNEX II: Checklist of bird species documented within the sacred groves

S/NO	FAMILY	COMMON NAME	SCIENTIFIC NAME	FOREST DEPENDENCE
1.	Numididae	Helmeted Guineafowl	*Numida meleagris*	f
2.	Phasianidae	Crested Francolin	*Francolinus sephaena*	f
3.	Phasianidae	Yellow-necked Spurfowl	*Francolinus leucoscepus*	f
4.	Threskiornithidae	Hadada Ibis	*Bostrychia hagedash*	f
5.	Scopidae	Hamerkop	*Scopus umbretta*	f
6.	Falconidae	Lanner Falcon	*Falco biarmicus*	f
7.	Accipitridae	Brown Snake Eagle	*Circaetus cinereus*	f
8.	Accipitridae	Gabar Goshawk	*Micronisus gabar*	f
9.	Accipitridae	Great Sparrowhawk	*Accipiter melanoleucus*	F
10.	Accipitridae	Augur Buzzard	*Buteo augur*	f
11.	Accipitridae	African Hawk Eagle	*Aquila spilogaster*	f
12.	Accipitridae	Crowned Eagle	*Stephanoaetus coronatus*	FF
13.	Columbidae	Lemon Dove	*Aplopelia larvata*	FF
14.	Columbidae	Dusky Turtle Dove	*Streptopelia lugens*	f
15.	Columbidae	African Mourning Dove	*Streptopelia decipiens*	f
16.	Columbidae	Red-eyed Dove	*Streptopelia semitorquata*	f
17.	Columbidae	Laughing Dove	*Streptopelia senegalensis*	f
18.	Columbidae	Emerald-spotted Wood Dove	*Turtur chalcospilos*	F
19.	Columbidae	Tambourine Dove	*Turtur tympanistria*	f
20.	Musophagidae	White-bellied Go-away-bird	*Corythaixoides leucogaster*	f
21.	Cuculidae	Klaas's Cuckoo	*Chrysococcyx klaas*	f
22.	Cuculidae	White-browed Coucal	*Centropus superciliosus*	f
23.	Apodidae	Mottled Swift	*Tachymarptis aequatorialis*	f
24.	Apodidae	Little Swift	*Apus affinis*	f
25.	Coliidae	Speckled Mousebird	*Colius striatus*	f
26.	Coliidae	Blue-naped Mousebird	*Urocolius macrourus*	f
27.	Alcedinidae	Grey-headed Kingfisher	*Halcyon leucocephala*	f
28.	Alcedinidae	Malachite Kingfisher	*Alcedo cristata*	f
29.	Meropidae	Little Bee-eater	*Merops pusillus*	f
30.	Upupidae	African Hoopoe	*Upupa epops*	f
31.	Bucerotidae	African Grey Hornbill	*Tockus nasutus*	f
32.	Capitonidae	Red-fronted Barbet	*Tricholaema diademata*	f
33.	Capitonidae	Spot-flanked Barbet	*Tricholaema lacrymosa*	f
34.	Capitonidae	Red-and-yellow Barbet	*Trachyphonus erythrocephalus*	f
35.	Capitonidae	D'Arnaud's Barbet	*Trachyphonus darnaudii*	f
36.	Indicatoridae	Scaly-throated Honeyguide	*Indicator variegatus*	f
37.	Indicatoridae	Greater Honeyguide	*Indicator indicator*	f
38.	Picidae	Nubian Woodpecker	*Campethera nubica*	f

39.	Platysteiridae	Chin-spot Batis	*Batis molitor*	f
40.	Malaconotidae	Grey-headed Bushshrike	*Malaconotus blanchoti*	f
41.	Malaconotidae	Sulphur-breasted Bushshrike	*Chlorophoneus sulfureopectus*	f
42.	Malaconotidae	Brown-crowned Tchagra	*Tchagra australis*	f
43.	Malaconotidae	Black-crowned Tchagra	*Tchagra senegalus*	f
44.	Malaconotidae	Black-backed Puffback	*Dryoscopus cubla*	f
45.	Malaconotidae	Slate-coloured Boubou	*Laniarius funebris*	f
46.	Malaconotidae	Tropical Boubou	*Laniarius aethopicus*	f
47.	Laniidae	Common Fiscal	*Lanius collaris*	f
48.	Oriolidae	Black-headed Oriole	*Oriolus larvatus*	f
49.	Dicruridae	Common Drongo	*Dicrurus adsimilis*	f
50.	Monarchidae	African Paradise Flycatcher	*Terpsiphone viridis*	f
51.	Corvidae	Pied Crow	*Corvus albus*	f
52.	Hirundinidae	Plain Martin	*Riparia paludicola*	f
53.	Hirundinidae	Wire-tailed Swallow	*Hirundo smithii*	f
54.	Hirundinidae	Red-rumped Swallow	*Cecropis daurica*	f
55.	Cisticolidae	Singing Cisticola	*Cisticola cantans*	f
56.	Cisticolidae	Rattling Cisticola	*Cisticola chiniana*	f
57.	Cisticolidae	Tawny-flanked Prinia	*Prinia subflava*	f
58.	Cisticolidae	Yellow-breasted Apalis	*Apalis flavida*	F
59.	Cisticolidae	Grey-backed Camaroptera	*Camaroptera brachyura*	f
60.	Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*	f
61.	Pycnonotidae	Sombre Greenbul	*Andropadus importunus*	F
62.	Pycnonotidae	Yellow-bellied Greenbul	*Chlorocichla flaviventris*	f
63.	Pycnonotidae	Northern Brownbul	*Phyllastrephus strepitans*	F
64.	Pycnonotidae	Grey-olive Greenbul	*Phyllastrephus cerviniventris*	FF
65.	Pycnonotidae	Cabanis's Greenbul	*Phyllastrephus cabanisi*	FF
66.	Pycnonotidae	Eastern Nicator	*Nicator gularis*	f
67.	Sylviidae	Red-faced Crombec	*Sylvietta whytii*	f
68.	Sylviidae	Grey-capped Warbler	*Eminia lepida*	f
69.	Timaliidae	Hinde's Babbler	*Turdoides hindei*	f
70.	Zosteropidae	Abyssinian White-eye	*Zosterops abyssinicus*	F
71.	Zosteropidae	Montane White-eye	*Zosterops poliogastrus*	f
72.	Sturnidae	Greater Blue-eared Starling	*Lamprotornis chalybaeus*	f
73.	Sturnidae	Superb Starling	*Lamprotornis superbus*	f
74.	Sturnidae	Hildebrandt's Starling	*Lamprotornis hildebrandti*	f
75.	Turdidae	African Bare-eyed Thrush	*Turdus tephronotus*	f
76.	Muscicapidae	Cape Robin Chat	*Cossypha caffra*	F
77.	Muscicapidae	Rüppell's Robin Chat	*Cossypha semirufa*	F
78.	Muscicapidae	White-browed Robin Chat	*Cossypha heuglini*	f
79.	Muscicapidae	Spotted Palm Thrush	*Cichladusa guttata*	f
80.	Muscicapidae	White-browed Scrub Robin	*Cercotrichas leucophrys*	f
81.	Muscicapidae	African Grey Flycatcher	*Bradornis microrhynchus*	f

82.	Muscicapidae	African Dusky Flycatcher	*Muscicapa adusta*	f
83.	Nectariniidae	Collared Sunbird	*Hedydipna collaris*	F
84.	Nectariniidae	Amethyst Sunbird	*Chalcomitra amethystina*	f
85.	Nectariniidae	Scarlet-chested Sunbird	*Chalcomitra senegalensis*	f
86.	Nectariniidae	Bronze Sunbird	*Nectarinia kilimensis*	f
87.	Nectariniidae	Variable Sunbird	*Cinnyris venustus*	f
88.	Passeridae	White-browed Sparrow Weaver	*Plocepasser mahali*	f
89.	Passeridae	Chestnut-crowned Sparrow Weaver	*Plocepasser superciliosus*	f
90.	Ploceidae	Grosbeak Weaver	*Amblyospiza albifrons*	f
91.	Ploceidae	Baglafecht Weaver	*Ploceus baglafecht*	f
92.	Ploceidae	Eastern Golden Weaver	*Ploceus subaureus*	f
93.	Ploceidae	Vitelline Masked Weaver	*Ploceus vitellinus*	f
94.	Ploceidae	Village Weaver	*Ploceus cucullatus*	f
95.	Ploceidae	Yellow Bishop	*Euplectes capensis*	f
96.	Estrildidae	Yellow-bellied Waxbill	*Coccopygia quartinia*	f
97.	Estrildidae	Common Waxbill	*Estrilda astrild*	f
98.	Estrildidae	Red-cheeked Cordon-bleu	*Uraeginthus bengalus*	f
99.	Estrildidae	Purple Grenadier	*Granatina ianthinogaster*	f
100.	Estrildidae	Peters's Twinspot	*Hypargos niveoguttatus*	f
101.	Estrildidae	Red-billed Firefinch	*Lagonosticta senegala*	f
102.	Estrildidae	Bronze Mannikin	*Spermestes cucculatus*	f
103.	Motacillidae	African Pied Wagtail	*Motacilla aguimp*	f
104.	Fringillidae	African Citril	*Crithagra citrinelloides*	f
105.	Fringillidae	Reichenow's Seedeater	*Crithagra reichenowi*	f
106.	Fringillidae	Brimstone Canary	*Crithagra sulphurata*	f
107.	Fringillidae	Streaky-headed Seedeater	*Crithagra gularis*	f
108.	Fringillidae	Streaky Seedeater	*Crithagra striolata*	f
109.	Emberizidae	Golden-breasted Bunting	*Emberiza flaviventris*	f

ANNEX III: Checklist of butterfly species documented within the sacred groves

	Order	Family	Scientific Name	Common Name	IUCN Status	Mat	Mund	Sam	Syov	Lil	Kal	Kav	Mut
1.	Lepidoptera	Hesperiidae	*Acleros ploetzi*	Macken's Dusky Skipper	NE	0	0	1	0	0	0	0	0
2.	Lepidoptera	Hesperiidae	*Acleros mackenii*	Shade Dart	LC	0	0	0	0	0	0	1	0
3.	Lepidoptera	Hesperiidae	*Coeliades forestan*	Striped Policeman	LC	0	1	0	0	0	0	0	0
4.	Lepidoptera	Hesperiidae	*Coeliades anchises*	One-Pip Policeman	LC	0	0	0	0	0	0	0	1
5.	Lepidoptera	Hesperiidae	*Eagris sabadius*	Orange Flat	NE	0	0	0	0	0	2	1	0
6.	Lepidoptera	Hesperiidae	*Eretis lugens*	Savanna Elf	NE	0	0	0	0	1	0	0	0
7.	Lepidoptera	Hesperiidae	*Gegenes hottentota*	Marsh Hottentot Skiper	LC	1	0	0	0	0	0	0	0
8.	Lepidoptera	Hesperiidae	*Sarangesa lucidella*	Lucidella Elfin	NE	0	0	0	0	1	0	0	0
9.	Lepidoptera	Lycaenidae	*Anthene butleri*	Pale Hairtail	LC	0	0	0	0	0	0	1	0
10.	Lepidoptera	Lycaenidae	*Axiocerses tjoane*	Eastern Scarlet	LC	1	0	0	0	0	0	0	0
11.	Lepidoptera	Lycaenidae	*Cacyreus lingeus*	Bush Bronze	LC	20	3	0	1	0	0	0	0
12.	Lepidoptera	Lycaenidae	*Euchrysops subpallida*	Ashen Smoky Blue	LC	1	3	0	4	0	0	3	3
13.	Lepidoptera	Lycaenidae	*Freyeria trochylus*	Grass Jewel	LC	0	1	0	0	0	0	0	0
14.	Lepidoptera	Lycaenidae	*Hypolycaena philippus*	Purple-brown Fairy Hairstreak	LC	1	0	1	2	0	0	0	0
15.	Lepidoptera	Lycaenidae	*Leptotes pirithous*	Lang's Short-tailed Blue	LC	0	5	0	1	0	0	0	0
16.	Lepidoptera	Lycaenidae	*Zizeeria knysna*	African Grass blue	LC	2	1	0	2	0	2	0	0
17.	Lepidoptera	Lycaenidae	*Zizula hylax*	Pygmy Grass Blue	LC	17	0	0	1	0	0	0	0
18.	Lepidoptera	Nymphalidae	*Acraea eponina*	Orange Acraea	NE	2	2	3	3	4	0	0	6
19.	Lepidoptera	Nymphalidae	*Acraea natalica*	Natal Acraea	LC	0	0	0	1	0	0	3	0
20.	Lepidoptera	Nymphalidae	*Amarius niavius*	The Friar	NE	0	0	0	2	0	0	0	0
21.	Lepidoptera	Nymphalidae	*Amauris sp*		NE	0	0	0	1	0	0	0	0
22.	Lepidoptera	Nymphalidae	*Antanartia dimorphica*	Northern Short-tailed Admiral	LC	1	0	1	0	0	0	0	0
23.	Lepidoptera	Nymphalidae	*Bybilia ilithyia*	Spotted Joker	NE	0	0	2	2	1	0	0	3
24.	Lepidoptera	Nymphalidae	*Bybilia anvatara*	Common Joker	NE	0	0	0	0	1	0	0	0
25.	Lepidoptera	Nymphalidae	*Charaxes candiope*	Green-veined Charaxes	LC	0	0	0	0	1	0	1	0
26.	Lepidoptera	Nymphalidae	*Danaus chrysippus*	African Monarch	LC	4	0	0	2	4	1	0	5
27.	Lepidoptera	Nymphalidae	*Hamanumida daedalus*	Guinae-fowl Butterfly	LC	0	0	0	0	0	0	1	0
28.	Lepidoptera	Nymphalidae	*Hypolimnus missipus*	Danaid Eggfly	NE	0	2	0	3	0	0	2	4
29.	Lepidoptera	Nymphalidae	*Junonia natalica*	Natal Pansy	LC	7	0	4	7	3	0	2	3
30.	Lepidoptera	Nymphalidae	*Junonia oenone*	Dark Blue Pansy	LC	1	0	0	2	0	0	2	3
31.	Lepidoptera	Nymphalidae	*Junonia hierta*	Yellow Pansy	LC	0	0	0	0	1	0	0	0
32.	Lepidoptera	Nymphalidae	*Melanitis leda*	Twilight Brown	LC	0	0	0	0	2	0	0	0
33.	Lepidoptera	Nymphalidae	*Neocoenyra gregorii*		NE	0	0	0	0	0	0	1	0
34.	Lepidoptera	Nymphalidae	*Neptis sp*		NE	0	1	0	1	0	0	0	0
35.	Lepidoptera	Nymphalidae	*Neptis serena*	Serene Sailor	LC	0	0	1	0	0	0	0	0
36.	Lepidoptera	Nymphalidae	*Neptis saclava*	Spotted Sailor	LC	0	0	0	1	0	0	0	0
37.	Lepidoptera	Nymphalidae	*Phalantha phalantha*	Common Leopard Butterfly	NE	8	0	3	2	0	0	0	0
38.	Lepidoptera	Nymphalidae	*Precis tugela*	Dry Leaf Commodore	LC	1	0	0	0	0	0	0	0
39.	Lepidoptera	Papilionidae	*Graphium leonidas*	Veined Swallowtail	LC	0	0	0	1	0	0	0	0
40.	Lepidoptera	Papilionidae	*Papilio demodocus*	Citrus Swallowtail	LC	6	5	3	2	4	1	8	2

41.	Lepidoptera	Papilionidae	*Papilio nireus*	Narrow Green-banded Swallowtail	LC	0	6	4	3	0	0	7	2
42.	Lepidoptera	Papilionidae	*Papilio dardanus*	Flying Handkerchief	LC	0	0	1	0	0	0	0	0
43.	Lepidoptera	Pieridae	*Belenois zochalia*	Forest Caper White	LC	2	0	3	0	0	0	0	0
44.	Lepidoptera	Pieridae	*Belenois crawshayi*	Crawshay's White	NE	0	0	1	0	0	0	0	0
45.	Lepidoptera	Pieridae	*Belenois creona*	African Caper White	LC	0	0	0	0	3	0	12	2
46.	Lepidoptera	Pieridae	*Catopsilia florella*	African Migrant	LC	15	7	9	5	6	2	15	6
47.	Lepidoptera	Pieridae	*Colotis euippe*	Round-winged Orange Tip	LC	1	0	2	0	0	0	0	0
48.	Lepidoptera	Pieridae	*Colotis evenina*	African Oranger Tip	LC	2	0	0	0	0	0	1	0
49.	Lepidoptera	Pieridae	*Colotis regina*	Queen Purple Tip	LC	0	4	0	0	0	0	0	0
50.	Lepidoptera	Pieridae	*Colotis protomedea*	Yellow Splendour Tip	NE	0	0	0	0	2	0	0	0
51.	Lepidoptera	Pieridae	*Colotis hetaera*	Eastern Purple Tip	NE	0	1	0	0	0	0	0	0
52.	Lepidoptera	Pieridae	*Colotis aurigineus*	Double-banded Orange	NE	1	0	0	0	0	0	0	0
53.	Lepidoptera	Pieridae	*Eronia leda*	Autumn-leaf Vagrant	LC	2	3	1	0	0	0	0	0
54.	Lepidoptera	Pieridae	*Eurema regularis*	Even-bordered Grass Yellow	NE	2	0	0	1	0	0	0	0
55.	Lepidoptera	Pieridae	*Eurema floricola*	Malagasy Grass Yellow	NE	0	6	2	0	0	0	0	0
56.	Lepidoptera	Pieridae	*Eurema brigitta*	Broad-bordered Grass Yellow	LC	1	1	0	0	0	0	0	0
57.	Lepidoptera	Pieridae	*Nepheronia thalassina*	Cambridge Vagrant	LC	1	0	0	0	0	0	0	0

***NE**- Not Evaluated; **LC**-Least Concern; **Mat**- Matooi; **Mund**- Mundu; **Sam**- Sammy; **Syov**-Syuvinda; **Lil**- Lilya; **Kal**- Kalinde; **Kav**- Kavyiu and **Mut**- Mutweiti

ANNEX IV: Key Informant Guide Questions

PART 1: RESPONDENT INFORMATION

1. Name of the respondent (Optional)
2. Gender of the respondent (Male/Female)
3. Age of respondent in years
4. Education level of respondent
5. Occupation
6. How long have you been involved in activities dealing with sacred groves?

PART 2: CULTURAL AND SPIRITUAL SIGNIFICANCE

1. What role do sacred groves play in the community's cultural and spiritual life?
2. What are the traditional beliefs and practices associated with sacred groves?
3. Are there any rituals or ceremonies still performed in these groves today?

PART 3: COMMUNITY PERCEPTIONS AND ATTITUDES

1. How does the local community perceive sacred groves today compared to the past?
2. What factors have influenced changes in community attitudes toward sacred groves?
3. Are there any generational differences in how people perceive these groves?

PART 4: CONSERVATION AND THREATS

1. What are the main threats facing sacred groves in this community?
2. How have deforestation, urbanization, or land use changes affected these groves?
3. What traditional and modern conservation practices exist to protect sacred groves?
4. Who is responsible for maintaining and protecting these groves?

PART 5: POLICY AND GOVERNANCE

1. Are there any local or government policies that support the protection of sacred groves?
2. How effective have these policies been in conserving these sites?
3. What additional measures do you think should be taken to enhance protection efforts?

PART 6: FUTURE PERSPECTIVES

1. How do you see the future of sacred groves in this community?
2. What recommendations do you have to ensure the sustainability of these sites?

ANNEX V: Focus Group Discussions (FDGs) Guide Questions

Perceptions and attitudes of local communities towards Sacred Natural Sites in Makueni

Date: ……………………………………………………………………………………

Area: ……………………………………………………………………………………

SECTION 1: PARTICIPANTS

S/No	Name	Age	Gender	Education Level	Occupation	Sign
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

SECTION 2: COMMUNITY PERCEPTIONS AND VALUES

1. What do sacred groves mean to you and the community?
2. Do different groups (e.g., elders, youth, men, women) perceive sacred groves differently?
3. How do young people today view these groves compared to previous generations?

SECTION 3: ROLE IN DAILY LIFE AND TRADITIONS

1. How are sacred groves used in daily community activities?
2. What cultural or religious practices are associated with these groves?
3. Are there any restrictions or taboos related to sacred groves?

SECTION 4. ENVIRONMENTAL AND CONSERVATION ASPECTS

1. How do sacred groves contribute to environmental conservation (e.g., biodiversity, water sources)?
2. Have you noticed any environmental changes in or around the sacred groves over time?
3. What efforts are currently in place to protect sacred groves?

4. What are some traditional beliefs related to specific plants and animals found in sacred groves?

SECTION 5. THREATS AND CHALLENGES

1. What are the biggest threats to sacred groves in this community?
2. Have modern developments (e.g., agriculture, infrastructure, population growth) affected these groves?
3. How does the community respond to these threats?
4. Are there any fears or concerns about granting outsiders access to sacred groves?

SECTION 6. SOLUTIONS AND RECOMMENDATIONS

1. What strategies can be implemented to preserve sacred groves?
2. How can traditional knowledge and modern conservation methods be integrated?
3. What role should the community, government, and other stakeholders play in protecting these sites?

ANNEX VI: Self-administered Questionnaire

This questionnaire aims to explore the attitudes, beliefs, and perceptions of local residents regarding sacred Natural Sites. Your responses will help us gain insights into the cultural importance of these sites, community involvement in their conservation, and potential challenges they face. Participation in this survey is entirely voluntary, and your responses will remain confidential. There are no right or wrong answers—please respond honestly based on your personal views and experiences. Thank you for your time and valuable input!

SECTION 1: DEMOGRAPHIC INFORMATION

1. Age:
( ) Under 18
( ) 18–30
( ) 31–50
( ) Above 50

2. Gender:
( ) Male
( ) Female
( ) Non-binary/Prefer not to say

3. Education Level:

☐ No formal education

☐ Primary education

☐ Secondary education

☐ Higher education

☐ Other (specify): ___________

4. Occupation:

( ) Farmer
( ) Businessperson
( ) Teacher
( ) Community leader
( ) Spiritual leader
( ) Other: ___________

5. Role in the Community:

( ) Elder
( ) Religious leader
( ) Educator
( ) Local government official
( ) Other: ___________

6.**Proximity to Sacred Site**:

( ) 0–5km
( ) 6–10km
( ) 11+km

SECTION 2: AWARENESS AND UNDERSTANDING OF SACRED GROVES

7. How familiar are you with sacred groves in your community?

( ) Very familiar
( ) Somewhat familiar
( ) Not familiar

8. Do you have sacred groves in your community?

( ) Yes
( ) No
( ) Not sure

9. How many sacred groves in your community?
( ) One
( ) Two
( ) More than two

10. How long have sacred groves been part of your community's traditions?
( ) For generations (over 50 years)
( ) A few decades (20–50 years)
( ) Recently (less than 20 years)
( ) Don't know

SECTION 3: CULTURAL AND SPIRITUAL SIGNIFICANCE

11. What is the main cultural or spiritual significance of sacred groves in your community? (Select up to 2)
( ) Religious worship
( ) Hosting rituals or ceremonies
( ) Connection with ancestors
( ) Symbol of cultural identity
( ) Other: ___________

12. Are there specific rituals or festivals linked to sacred groves?
( ) Yes
( ) No
( ) Don't know

13. If yes, name them
a……………………………………………………………………………………………
b……………………………………………………………………………………………
c……………………………………………………………………………………………
d……………………………………………………………………………………………

14. Do you think sacred groves are essential to preserving your community's traditions?
( ) Yes, they are very important
( ) Somewhat important
( ) Not important

15. Do you people in your community perform rituals in sacred sites today?
( ) Yes
( ) No

( ) I don’t know

16. If yes, how often?
( ) Very often
( ) Very rarely

SECTION 4: PERCEPTIONS AND ATTITUDES

17. How do people in the community generally perceive sacred groves?
( ) With great respect and reverence
( ) As an ordinary place
( ) With fear or caution due to taboos
( ) Other: __________

18. Are there any taboos or restrictions associated with sacred groves?
( ) Yes, many taboos and restrictions
( ) A few taboos or restrictions
( ) None

19. Please give some of the taboos/restrictions you know about sacred groves
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

20. What do you believe is the primary purpose of sacred groves?
( ) Religious/spiritual purposes
( ) Ecological conservation
( ) Providing resources (e.g., timber, medicinal plants)
( ) Cultural preservation
( ) Other: __________

SECTION 5: ECOLOGICAL AND PRACTICAL IMPORTANCE

21. Do sacred groves help in protecting the environment?
( ) Yes, they play a significant role
( ) Somewhat, but not a primary role
( ) No, they don’t contribute to the environment.
( ) I don’t know.

22. What environmental benefits do sacred groves provide? (Select all that apply)

( ) Biodiversity preservation
( ) Water conservation
( ) Soil fertility improvement
( ) Protection against erosion
( ) Other: __________

23. Do sacred groves provide any practical benefits to the community?
( ) Yes, such as medicinal plants, food, or timber
( ) No, they are preserved only for cultural or religious purposes
( ) Not sure

SECTION 6: THREATS AND CHALLENGES

24. Are sacred groves under threat in your community?
( ) Yes, very threatened
( ) Somewhat threatened
( ) No, they are well-protected

25. What are the main threats to sacred groves in your community? (Select all that apply)
( ) Deforestation
( ) Erosion of cultural values
( ) Urbanization or development projects
( ) Climate change
( ) Declining interest among younger generations
( ) Others, specify…………………………………………………………………………..

26. Do younger generations show the same interest in sacred groves as older generations?
( ) Yes, they are equally invested
( ) No, they are less interested
( ) Not at all
( ) Not sure

27. How did elders pass information to younger generation on sacred groove practices?
( )
( )

SECTION 7: RECOMMENDATIONS AND FUTURE PERSPECTIVES

28. What measures would you recommend to protect sacred groves? (Select up to 3)
( ) Educating younger generations about their importance

( ) Implementing strict conservation policies
( ) Collaborating with NGOs or external organizations
( ) Integrating sacred groves into tourism initiatives
( ) Other: ___________

29. How can the community better engage the younger generation in preserving sacred groves?
( ) Including sacred groves in school curriculums
( ) Organizing community cultural events around sacred groves
( ) Encouraging youth participation in conservation activities
( ) Involving them in ecotourism activities in the sacred groves
( ) Other: ___________

30. What role should external organizations (e.g., NGOs, government bodies) play in conserving sacred groves?
( ) Provide funding and resources
( ) Conduct awareness campaigns
( ) Help establish conservation policies
( ) Other: ___________

31. What management strategies are currently in place to protect sacred groves in your community?
( ) Traditional practices and local taboos
( ) Community-led conservation groups
( ) Government regulations and policies
( ) None, there are no specific management strategies
( ) Other: ___________

32. What additional management strategies do you believe could enhance the protection of sacred groves?
( ) Regular monitoring and patrolling
( ) Establishing legal ownership or protection rights
( ) Allocating funds for sacred grove maintenance
( ) Creating partnerships between local leaders and environmental groups
( ) Other: ___________

Thank You for Your Time!

ANNEX VII: Household Questionnaire

This socio-economic survey aims to assess the profitability of growing maize, beans, green grams, hay production, and beekeeping (Langstroth hives). Your responses will help in understanding costs, yields, and market dynamics to support better decision-making.

Section 1: Farmer and Farm Details

1. Farmer's Name: ________________________
2. Location (County/Sub-County/Village): ________________________
3. Farm Size (Total in Acres): ___________
4. Land Use Distribution (Acres per value chain):
   - Maize: ___________
   - Beans: ___________
   - Green Grams: ___________
   - Hay Production: ___________
   - Beekeeping (No. of Hives): ___________
   - Other (Specify): ___________

Section 2: Cost of Procuring Inputs (Per Acre/Hive)

5. Land Preparation Cost (Plowing, Harrowing, etc.): ___________ Ksh
6. Seed/Pasture Establishment Cost (Including varieties for hay): ___________ Ksh
7. Sowing/Planting Labour Cost: ___________ Ksh
8. Weeding Labour Cost: ___________ Ksh
9. Chemicals/Pesticides Cost (Including weed control for hay fields): ___________ Ksh
10. Fertilizer/Manure Cost (For crops and pasture fields): ___________ Ksh
11. Equipment Costs (Hives, harvesting tools, Hay Baling Machines, etc.): ___________ Ksh

Section 3: Harvesting and Processing Costs

12. Crop Harvesting Cost (Maize, Beans, Green Grams): ___________ Ksh
13. Post-Harvest Processing Cost (Drying, Shelling, Storage, etc.): ___________ Ksh
14. Honey Harvesting & Processing Cost (If Beekeeping): ___________ Ksh
15. Hay Harvesting and Baling Cost: ___________ Ksh
16. Cost of Storage and Packaging (Gunny Bags, Containers, Bales, etc.): ___________ Ksh

Section 4: Output and Yields (Specify Per Acre or Hive)

17. Total Maize Harvested (Kg/Bags per acre): ___________
18. Total Beans Harvested (Kg/Bags per acre): ___________
19. Total Green Gram Harvested (Kg/Bags per acre): ___________
20. Total Hay Harvested (Bales per acre): ___________
21. Total Honey Produced (Kg per hive): ___________
22. Other By-Products Produced (Residues, Royal Jelly, Bee Wax, etc.): ___________

Section 5: Sales and Income

23. Selling Price of Maize per Kg/Bale: ___________ Ksh
24. Selling Price of Beans per Kg/Bale: ___________ Ksh
25. Selling Price of Green Gram per Kg/Bale: ___________ Ksh
26. Selling Price of Hay per Bale: ___________ Ksh
27. Selling Price of Honey per Kg: ___________ Ksh
28. Total Revenue from Maize Sales: ___________ Ksh
29. Total Revenue from Beans Sales: ___________ Ksh
30. Total Revenue from Green Gram Sales: ___________ Ksh
31. Total Revenue from Hay Sales: ___________ Ksh
32. Total Revenue from Honey Sales: ___________ Ksh
33. Total Revenue from Other By-Products (Residue, Bee Products, etc.): ___________ Ksh

Section 6: Challenges and Recommendations

34. **What are the major challenges faced in production?**

- High input costs
- Pests & diseases
- Unstable market prices
- Climate change effects (Drought, floods, etc.)
- Lack of storage facilities
- Limited market for hay
- Others (Specify): _________________

35. **What support would help improve productivity and profitability?**

- Access to better seeds and inputs
- Improved market access
- Training on pasture management (For hay farmers)
- Training on better farming techniques
- Financial support or subsidies
- Others (Specify): _________________

Thank you for your Time!