

# Lake Victoria Watershed Agroforestry Carbon Project

## BIODIVERSITY REPORT

November 2023





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**Trees for the Future (TREES) is an international nonprofit organization, which has been in existence for over 30 years. The organization is headquartered in the US but with overseas operations in several countries in Africa.**

## **Acknowledgement**

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# Abbreviations and Acronyms

AES	Audio Encounter Survey	FTEA	Flora of Tropical East Africa
AM	Africa Migrant	GIS	Geographical information System
AMF	Arbuscular Mycorrhiza Fungi	GPS	Geographical Position System
ANOVA	Analysis of Variance	HCVA	High Conservation Value Areas
APPII	Appendix Two species	IAS	Invasive Alien System
ASAL	Arid and Semi-Arid Lan	INT	Interview
BF	Biofertilizer	IUCN	International Union for Conservation of Nature
BSFL	Black Soldier Flies	IVI	important value index
CBD	Convention of Biological Diversity	KHM	Kisumu, Homabay and Migori
CCA	Canonical Correspondence Analysis	LC	Least Concern
CCB	Community and Biodiversity	LEAP	List of East African Plants
CIDP	County Integrated Development Plan	LULC	Land Use and Land Cover
CITES	Convention on International Trade in Endangered Species	MDS	Multidimensional Scaling
CO <sub>2</sub>	Carbon Dioxide	NC	Nutrient cycling
CR	Critically Endangered	NIR	Near Infrared Radiation
CS	Carbon Sequestration	NMK	National Museums of Kenya
CWR	Crop Wild Relatives	PM	Palaearctic Migrant
DBH	Diameter at Breast Height	PVLG	INVAM
EA	East Africa	SAC	Species Accumulation Curves
EAPRA	East African Plant Redlist Authority	TFTF	TFTF
ECM	Ectomycorrhiz	TLS	Time Limited Search
EMS	Eco Move Service	TZ	Tanzania
EN	Endangered	UK	United Kingdom
ENVI	Environment for Visualizing Images	UNEP	United Nations Environment Programme
ESA	Ecologically Sensitive Areas	USA	United States of America
FAO	Food and Agricultural Organisation	USGS	United States Geological Survey
FD	Food Development	VES	Visual Encounter Surveys
FF	Forest Specialists	VU	Vulnerable
FG	Forest Garden		

# Definition of Terms

**Biodiversity:** Refers to the biological variety and variability of plant and animal life in the world, a particular habitat or a given area. It's often described as a measure of variation at genetic, species and ecosystem level.

**Biodiversity hotspot:** A small area or part of a larger area, which is known to have a relatively higher number of both plant and animal species, and therefore considered as important in comparison to surrounding areas.

**Ecosystem Services:** Are the many and varied benefits that humans freely gain from the natural environment and from functioning ecosystems. Services from nature that make life possible on earth

**Endemic species:** An animal or plant species that is known to occur or is native and restricted to a certain geographical area such as part of a habitat, country, region or continent.

**Global Positioning System:** (GPS) is a network of orbiting satellites that send precise details of their position in space back to earth and are used to provide position on the earth surface.

**Modelling:** A two-dimensional interpretation of biodiversity (species) observations in relation to how they are affected or influenced by features such as slope, vegetation cover, drainage, accessibility and occurrence of springs.

**Threatened Species:** These are plants and animals that are facing various threats that lender them to be described by the IUCN as either Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Near Threatened (NT). These may also be described as Species of Conservation Concern. Species whose populations are perceived as secure (i.e., out of danger of extinction) are described as of Least Concern (LC).



## Executive Summary

### By The Chief Executive Officer

Forest Gardens (agroforestry parcels), a sustainable food-producing system that incorporates tree farming and crop production were introduced in Lake Victoria Watershed Agroforestry Carbon Project (Kisumu, Migori and Homabay County) to mitigate adverse effect of climate, increase food production at the farm level and enhance biodiversity resources. To monitor contribution of forest gardens overtime towards climate change mitigation, improved crop production and enhanced biodiversity resources, acquisition of baseline ecological and biodiversity data was necessary and to align the project to the VERRA-CCB standards. As such, biodiversity assessment was conducted in 2023 to collect species data from three geographical regions-Migori, Homabay and Kisumu where Trees is implementing this project.

From the assessment, data from six (6) taxa; (Plants, macro fungi, herpetofauna (reptiles and amphibians), mammals, and bird species was collected and analysed and this report details the findings.

The assessment was undertaken in November 2023. The plant survey data revealed a rich plant diversity with over 727 species. A total of 582 species of vascular plants were documented in this study, 412 species were recorded from the 28 sample plots while 145 species were collected outside the plots. Assessed 170 species were recorded from desk review. The species were then screened for species of medicinal value, IAS, CWR and species of conservation concern using IUCN red list data, CITES and LEAP for endemic species. A large number of IAS were recorded perhaps due to the intensive farming activities, and disturbances to the natural habitats. The study recorded a rich diversity of medicinal plants, low number of endemics and few species of conservation concern. To date only a few natural habitats remain in the area, these are however undergoing illegal encroachments and other forms of disturbances thereby threatening the biodiversity they contain. Conservation of these natural habits is therefore a priority. There is need

to develop simplified floral checklist for use by non-experts and nature enthusiasts that can help to easily identify useful and common plants in the region.

The assessment of macrofungi and microfungi (Arbuscular Mycorrhiza Fungi, AMF) a total of 50 farms with an established forest gardens (1 year old) and adjacent forested and wetland ecosystems were surveyed for comparison purposes. A total number of 172 macrofungi species distributed across 34 families and 69 genera were documented. Macro-fungi species of the family Agaricaceae (25%), Polyporaceae (15%), Omphalotaceae (6%), Marasmiaceae (6%), Strophariaceae (5%), Mycenaceae (4%), Psathyrellaceae (4%) and Tricholomataceae (3%) were the most commonly represented taxa in the ecosystems. Saprophytic fungi (woodrotting, litter dwellers and soil colonizers) dominated the ecosystem, and were mainly collected in woodlots and live fences. Across the region, the number of macrofungi species recorded were higher in Kisumu County (94), followed by Homabay County (73) while Migori County (43) recorded the least numbers. In addition, a total of 58 AMF species distributed across five families and eleven genera were recorded. AMF species of the family Acaulosporaceae (21), Glomaraceae (18) and Gigasporaceae (13) were the most commonly represented taxa in the ecosystems. *Acaulospora* species had the highest representation with 36% of total AMF species, followed by *Glomus* with 22% total species representation and *Scutellospora* with 9% total species representation. AMF communities, species richness and diversity was relatively similar in surveyed farmlands. Forested and wetland ecosystems in this region did not support high macrofungi species richness, abundance and diversity compared to agricultural land. This study has revealed wide range of macro-fungi community in Lake Victoria Watershed Ecosystem, whose role in carbon sequestration within the contest of forest garden is discussed.

Herpetofauna diversity varied with 69 species known from the area, 33 were confirmed (15 amphibians and 18 reptiles) during the field study. It took less effort in Kisumu and Migori to find species than in Homabay while the sampling effort in Kisumu yielded more than double the specimens found in Homa bay. The species accumulation curves did not plateau in all the three counties. There is only one species that is near threatened with the rest being of least concern. Rainfall was the greatest influencer on herpetofauna diversity and abundance in the three counties.

Mammals survey results indicated that the counties are not endowed with a rich diversity of mammal species. Through indirect sampling method, different mammals were mentioned and some were visibly identified. They included mongoose, bats, porcupine, hyena and monkeys. A total of 22 individuals of rodents belonging to eight species; *Mus sp*, *Mastomys sp*, *Lemniscomys sp*, *Crocidura sp*, *Arvicanthis sp*, *Luphuromys sp*, *Cricetmys sp* and *Grammomys sp*. were identified. The rodent species diversity was low but widely distributed within the three counties. The spread was positively correlated with farming practices. The farmland vegetation had richer diversity compared to forest ecosystem. The invasive *Mus musculus* transcended to the farmlands and to the forest areas.

A total of 144 bird species in 52 families from the three counties were identified with the most diverse family being Ploceidae (weavers & allies; 12 species). Homa Bay County had the highest number of species (96) while Kisumu and Migori had 84 and 77 species respectively. Fourteen species had more than 50% spatial distribution across the study areas. Three species, all recorded in Homa Bay, are listed on the IUCN Red List of Threatened Species. These were: Lesser Flamingo *Phoeniconaias minor* (Near Threatened), Tawny Eagle *Aquila rapax* (Vulnerable), and the Grey Crowned Crane *Balearica regulorum* (Endangered). A majority (128) of the species recorded during the survey were residents. The insectivores had a total of 50 species followed by carnivores (35) and granivores (22). An evaluation of the species on their forest-dependence status showed that

there were no forest-specialists (FF species) – a category dependent on native forested habitats. Two forest generalists (F species) were however recorded: Red-chested Cuckoo *Cuculus solitarius* and Northern Puffback *Dryoscopus gambensis*. Although the number of species recorded in this survey was low, future surveys are needed to build a checklist of individual farms and surrounding areas. Future surveys should therefore be conducted at different times such as during the migration seasons and should diversify survey methods, especially mist-netting at specific sites. To attract ecologically important species such as forest generalists, planting of rows and pockets of indigenous tree species should be encouraged across the landscape, especially in farms neighboring conservation and other natural areas where these rows could act as wildlife corridors.

On spatial analysis Migori County seems to have few areas that are classified as suitable habitat areas; with only 7 of the areas mapped as very high in habitat potential. Subcounties with the highest areas with habitat hotspots in Kisumu County are Nyando (20), Seme and Nyakach, 15 each. Kabonyo/Kanyagwal Ward has the highest suitable habitat areas of about 63 in Nyando Subcounty. Plant species shows considerable number of species occurring in areas with high slope angles, relatively high precipitation, low surface reflectance, near drainage features. There is a relatively high and varied number of bird species in areas with high slope angles than in moderate slope angle areas. Generally, the distribution of mushroom species is more varied in areas with relatively moderate slope angle than in high slope angles. The species are more varied in areas with high species counts than areas with low counts. Relative change of invertebrate species occurs with increase in: precipitation, surface reflectance, and distance away from urban/town centers and road. These distributions apparently increase with increase in slope angle, precipitation and drainage features. The dominant land cover in the project area is bushland (bush cover) that occupy an estimated 39 of the area. This is followed by grassland that covers 21, open shrubland (18), farmlands (16), woodland (5) and wetlands.



## Message From The Vice President of Programs

The **Climate, Community & Biodiversity (CCB) Standards** and the rules and requirements that operationalize them (collectively referred to as the CCB Program) aim at fostering the development and marketing of projects that deliver credible and significant **climate, community and biodiversity benefits** in an integrated, sustainable manner. With these projects gaining momentum in the world and transforming management practices from segregated approaches to holistic approaches where all payers are involved in ecosystem restoration, communities can now participate in building their ability to adapt to the negative effects of climate change and biodiversity loss. These projects now contribute to biodiversity conservation by restoring and protecting the world's natural ecosystems, saving threatened animal and plant species from extinction and maintaining resilient and productive natural ecosystems for humankind and particularly small holder farmers.

Nature-based solutions' (NbS) actions that involve working with nature to address societal challenges, with benefits for both people and biodiversity are widely recognised as having the potential to provide a win-win for jointly addressing the climate and biodiversity crises (IUCN, 2020; Austin et al., 2021; Mori et al., 2021; Seddon et al., 2021; Seddon, 2022). Through restoring, connecting and protecting a wide range of ecosystems and sustainably managing working lands, NbS can help reduce emissions and enhance sinks of greenhouse gases (Girardin et al., 2021) while also reducing the vulnerability of social-ecological systems to the impacts of climate change (Seddon et al., 2020a; Roe et al., 2021; Turner et al., 2022).

Trees For The Future believes in a world where farmers leave a legacy of opportunity through sustainable land management practices and farmers are able to reclaim their agency, break the cycles of climate change and generational poverty and rebuild vibrant food systems. Trees focuses on the triple bottom line of household food security, economic resilience and environmental impact and with the signature forest garden model, Trees

enables farmers adopt this regenerative agroforestry model to revitalize degraded lands and ecosystems through diversification and optimization of the farming crops and multipurpose trees.

Trees is working in Kenya to implement the Lake Victoria Watershed Agroforestry Carbon which uses **VERRA methodology and CCB standards** to develop and generate high quality Verified Carbon Units within 18,000 small holder farmers covering 15,000 Ha in Migori, Homabay and Kisumu. The project will in addition to land restoration strive to 'bend the curve' of biodiversity decline and promote more sustainable and resilient economies. With recent scientific studies pointing out to accelerated loss and decline of biodiversity resources and ecosystem services and with a more than ever plausible risk of mass extinction of species in the next few decades, there is an urgent need to institute urgent measures to reverse this trend. In this regard, Trees partnered with Wangari Mathai Institute for Peace and Environmental Studies and the National Museums of Kenya under the Ecomove Services to undertake a biodiversity study for the Lake Victoria Watershed Agroforestry Carbon Project. The study was carried out in 2023 to establish baseline scenario of biodiversity resources within the region upon which future monitoring will be undertaken to establish the impact of the agroforestry carbon project activities on biodiversity resources. It will also provide a basis for evaluating the project's social and environmental impacts as well as verify the social and environmental benefits generated by the project, enabling investment in generating quality carbon credits with additional benefits. In a snapshot, the assessment identified a total of 727 plant species, 172 macrofungi species, 69 herpatofauna species, 22 mammal species, and 144 bird species. This project hence is geared towards enhancing biodiversity species and enable the smallholder farmers working with Trees build their capacity to adapt to the effects of climate change, improve their food and nutrition security as well as contribute to generation of Verified Carbon Units.



## Acknowledgment By The Country Director

This biodiversity report is the first comprehensive assessment of biodiversity resources for the Lake Victoria Watershed Agroforestry Carbon Project and this reflects the concerted efforts, dedication, constructive comments and invaluable insights of numerous individuals and experts to this process.

We recognize and acknowledge the technical expertise from Prof. Thuita Thenya, Associate Professor – Wangari Maathai Institute For Peace and Environmental Studies and technical support and guidance from the multi-disciplinary team of researchers from the National Museums of Kenya; Dr. Paul Kirika-Plants, Dr. Laban Njoroge – Insects, Dr. Vincent Muchai – Herps and Reptiles, Dr. Henry Ndithia – Birds, Dr. Dickens Odeny – GIS, Immaculate Muthoni – Mammals and Ann Nyandiala.

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Finally, our sincere appreciation goes to our partners and collaborators whose shared commitment to sustainable land management and biodiversity conservation made this ambitious undertaking a reality. Their contributions not only underscore the importance of safeguarding biodiversity resources within Lake Victoria Watershed but also reinforce the collective impact of collaborative, science-based environmental stewardship. Thank you to everyone who played a role in this endeavour, enabling us to document, understand, and promote a more effective implementation of conservation strategies using the Forest Garden approach.

# 1 | Background

## 1.1 Trees for the Future (TREES)

Trees for the Future (TREES) works with farmers to implement Sustainable Land management practices and agroforestry in their small holder farms aimed at revitalizing degraded lands, increasing food production, reducing the impacts of climate change, enhancing technical skills and enhancing adaptive capacities of farmers.

TREES is dedicated to ending extreme hunger and poverty across Sub-Saharan Africa by revitalizing degraded lands using its signature **Forest Garden Approach**. While conventional agriculture programs focus on one or few crops, the Forest Garden Approach is rooted in diversifying each farm with many food crops, multilayered trees and cropping systems so farming families will be self-sufficient in their food production, timber and non-timber forest products and market opportunities. Hence, Forest Garden is an agricultural system designed to maximize use of both horizontal and vertical space, and can be tailored to nearly all agroecological zones. When fully established, a Forest Garden is also temporally optimized to provide a harvest nearly every day of the year. The model is also important for *in-situ* conservation of a wide range of unique genetic resources, agricultural diversity and increases biodiversity resources.

TREES is using this Forest Garden design to implement a Climate, Community and Biodiversity (CCB) project in Lake Victoria watershed

within Homabay, Kisumu and Migori counties. Additionally, the project will generate an estimated 20,291,624 metric tons of CO<sub>2</sub>eq anticipated to be validated and retired under the project.

This ambitious carbon project targets to onboard approximately 85,000 farmers and put 75,000 Ha under the Forest Garden Approach within the next few years. Currently, 18,000 farmers have been mobilized and onboarded in Migori, Homabay and Kisumu Counties.

The project will in addition promote the generation of significant social, environmental and biodiversity benefits while adhering to good practices for the development and use of international social and environmental standards.

The Carbon project is expected to enhance biodiversity resources within the project site and beyond during life span. As part of the international standards requirement for Carbon projects, Trees is required to assess and report on biodiversity resources to demonstrate the impact of implementation of the Forest Garden activities in regard to enhancing biodiversity resources. The assessment will also lead to development of a biodiversity strategy/action plan to provide a roadmap for management of biodiversity resources and to ensure that the project will deliver tangible biodiversity benefits. Thus, this assessment is aimed at establishing the baseline information upon which other assessments and reporting on biodiversity parameters will be based on.

# 2

## Project Site

### 2.1 Geographical Location

**Homa Bay County** in Kenya's Lake Victoria Basin is characterized by a rapidly growing population, high population density, falling food production, and low resilience to climate change. The combined effects of climate change and rapid population growth are increasing food insecurity, environmental degradation, and poverty levels in the county. The county's strategic plan identifies population dynamics, environmental degradation, and climate change as key development challenges. These issues need to be linked in county policies and programs to ensure that projects that address them are implemented jointly. Addressing population growth, environmental degradation, and climate change together should be a top priority if Homa Bay County is to achieve sustainable development. The county government, donors, and program implementers should develop policies and implement programs that integrate population dynamics, environment/climate change, and development.

**Kisumu County** in Kenya's Lake Victoria Basin is characterized by a rapidly growing population, high population density, water scarcity, falling food production, and low resilience to climate change. The combined effects of climate change and rapid population growth are increasing food insecurity, environmental degradation, and poverty levels in the county.

The Kisumu County Integrated Development Plan (CIDP) identifies environmental degradation and climate change as key development challenges, but fails to link them to population dynamics. These issues need to be linked in county policies and programs to ensure that projects that address them are implemented jointly. Addressing population growth, environmental degradation, and climate change together should be a top priority if Kisumu County is to achieve sustainable development. The county government, donors, and program implementers should develop

policies and implement programs that integrate population dynamics, environment/climate change, and development.

**Migori County's** forest cover vegetation comprises of Indigenous forests, Plantations established through planting of seedlings, Woodlands characterized by trees and shrubs, Bush lands, ASAL and Farm land development 1.16.1 Status of Forests in Migori County The county has a potential forest conservation area of approximately 3641.52ha out of which, 1049.13 ha is gazetted and 2592.39 ha non-gazetted. 177ha is under natural forest and 462 ha under forestry plantation. The major forests in the county include Nyasoko, Sagegi, Magina, Giribe, Otacho, Nyamarere, Rabuor, Ranen, Kwa, Aroso, Ombo, Orange, Got Kogalo, Nyaitara, Gatambega, Tarakwiti, Nyandiri and Makangwa.

Agro-forestry systems in the county majorly consist of cultivation practices which combine arboreal species with either annual or perennial crops in a manner which seeks optimal use of land together with maximum return. Farm woodlots farming is commonly preferred as farmers use them for timber, poles, fuel and bee keeping. The destruction of water catchment areas and prolonged drought for example has resulted to reduced water flow consequently leading to a decline in hydro-power production at Gogo hydropower plant.

Environmental issues in the county include deforestation, soil erosion, desertification, flooding, littering and solid waste collection. Deforestation: Widespread poverty in many parts of the county has greatly led to overexploitation of the limited forest resources. Trees are cut purposely for charcoal business, timber and creation of more land for cultivation. Notable effects of the loss of forests have been soil erosion, the silting of dams and flooding and the loss of biodiversity.

## 2.2 Geographical Location

### 2.2.1 Project Area –Kisumu-Migori-Homa Bay

The project is located in the Lake Victoria basin the Counties of Kisumu, Homa bay and Migori Counties (Figure 1). The project sites are in individual household farms that are participants in the carbon project under Forest Garden Approach.

## 2.3 Main objective of the Biodiversity Assessment

The main objective is to identify and document status of biodiversity resources within the Trees Lake Victoria watershed Trees project areas namely; Homabay, Migori and Kisumu, map biodiversity hotspots and develop a 10-year biodiversity management strategy.

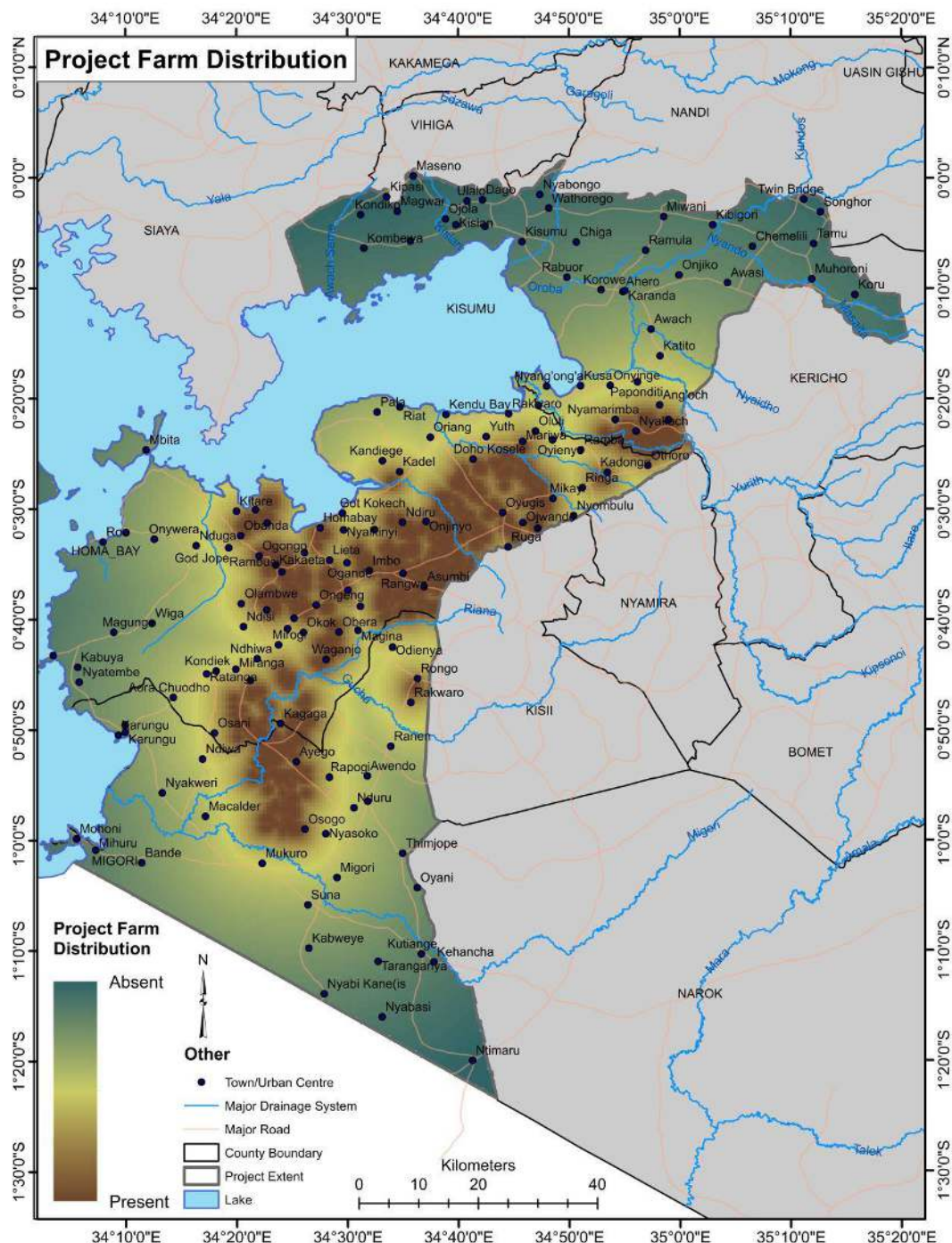


Figure 1: Location of Kisumu-Migori-Homa Bay Project Sites

## 2.4 Specific objectives of the Biodiversity Assessment

Undertake a biodiversity assessment in Lake Victoria watershed project which covers three counties (Migori, Homabay and Kisumu). Also identify other biodiversity rich areas, ecologically sensitive areas, High Conservation Value Areas, areas with invasive species and map biodiversity hotspots. Specifically

- i. Undertake literature review and develop baseline information and preliminary biodiversity maps to guide on a comprehensive biodiversity assessment
- ii. Undertake reconnaissance/stakeholder consultations to generate baseline information, validate literature generated and refine the proposed methodologies, identify sampling areas, draw a sampling frame (Permanent Sampling Plots to be considered) and draw/revise timelines for undertaking the comprehensive biodiversity assessment.
- iii. Undertake a comprehensive biodiversity survey of floral and faunal species for six (6) taxa (Plants, Birds, Mammals, Micro-Fungi, herpetofauna, invertebrates) within the project area (and extending to Protected Areas within the project sites) to establish species composition, distribution, diversity, richness and species of conservation concern (rare, endangered, vulnerable, threatened, and endemic species) using the IUCN scale. The assessment should also identify invasive species and location within the project site.
- iv. Identify High Conservation Value Areas (HC-VAs) and Ecologically Sensitive Areas (ESA's) within the project area.
- v. Identify existing conservation efforts and environmental, ecological, social and physical threats of each taxa and where possible and recommend ways of mitigating them.
- vi. Identifying biodiversity hotspot areas and develop biodiversity hotspot maps to guide TREES in management interventions to enhance floral and faunal biodiversity resources.

- vii. Model future scenarios of the biodiversity status taking into consideration the biodiversity status, existing conservation efforts, proposed management interventions/scenarios and taking into considerations existing and potential threats.
- viii. Prepare and present a draft biodiversity status report to TREES for validation.
- ix. Prepare and present a final biodiversity status report to a wider selected audience in a workshop for adoption.
- x. Install and train TREES staff on use of Artificial Intelligence/vocal acoustics to monitor diversity and abundance of birds and insects within the project sites.
- xi. Prepare a 10-year biodiversity management strategy and a monitoring plan for the Lake Victoria Watershed Project. This strategy and monitoring plan should recommend specific biodiversity conservation programs/management interventions for biodiversity enhancement for future planning, monitoring and reducing threats.

**Note:** The biodiversity assessment findings are documented as per the three regions (Kisumu, Homabay and Migori) and a comparative biodiversity analysis done to guide Trees on management interventions. For this report, it covers objectives 1-9, objective 10 was done separately which objective 11 will be done after completion of the biodiversity assessment report.

## 2.5 Outputs

- i. A detailed scientific methodology for each taxon, a workplan and a description of the experts for undertaking the biodiversity assessment and mapping of hotspots in Lake Victoria Watershed.
- ii. Detailed biodiversity status report for each of the taxon (plants, birds, mammals, micro-fungi, reptiles and amphibians, invertebrates) for Lake Victoria watershed project.

- iii. An abridged version of the detailed biodiversity report.
- iv. A report on biodiversity hotspots (hotspot index graphs, charts, maps, photographs) and any other relevant information of the relevant to biodiversity hotspots within the project area.
- v. A 10-year biodiversity management strategy and a monitoring plan for the Lake Victoria Watershed Agroforestry Carbon Project with recommendations on specific biodiversity conservation programs/management interventions for biodiversity enhancement for future program planning, monitoring and reducing threats.
- vi. Digital copies of all the data in USB drive to include the consolidated metadata. These include all reports, maps, raster data, shapefiles, excel databases and workshop proceedings etc.)
- vii. Identify High Conservation Value Areas (HC-VAs) and Ecologically Sensitive Areas (ESA's) within the project area.
- viii. The assessment indicating invasive species within the project site.
- ix. Training report on TREES staff on use of Artificial Intelligence/vocal acoustics to monitor diversity and abundance of birds and insects within the project sites

# 3

## Approach and methodology

### 3.1 Specific Taxon Methodology

#### 3.2. Plants

Preliminary species diversity and distribution data for Lake Victoria basin, was undertaken prior to the field survey. The review collated data from different sources, including publications, grey literature, and the East Africa herbarium plant databases, to assess the known species diversity and occurrence in the study area. The databases consulted included the List of East African Plants (Mwachala et al., 2011) and the East African Herbarium (EA) specimen database.

In the field, data were collected from two sample plots, measuring 20 m by 20 m in each farm where possible. The plots were subjectively selected to coincide with the farmer's woodlot in each farm, which in most cases were located at both ends of the farms. Opportunistic collections were also made outside the sample plots but within the farms. Geolocation of each sample plot was determined using a cell phone (Global Positioning System) (GPS). Plants encountered in each sample plot were all documented and trees with a DBH of 5 and above were measured and their height estimated and recorded. Identification of the plants encountered was done in the field, but for species that were difficult to identify in the field, voucher specimens were collected for further taxonomic analyses. Specimens were collected and processed following methods outlined in Bridson and Foreman (1992), and later deposited at the East African Herbarium (EA). Plant identification at the EA was carried out using botanical keys found in various monographs that include numerous volumes of the FTEA, Kenya Trees, Shrubs, and Lianas (Beentje, 1994) and the Upland Kenya Wild Flowers (Agnew, 2013).

#### Data analysis

##### Species accumulation curves or Species Area Curve

Species accumulation curves (SAC) were generated for all data points. The sampling sufficiency was assessed by determining whether the point at which a line representing one new species was tangent to the curve had been achieved (e.g., Brewer & McCann 1982).

##### Descriptive statistical analysis

A comprehensive plant checklist was generated and the species diversity screened against the IUCN Red List, the East African Plant Redlist Authority (EAPRA), and the sanctioned CITES list. Other tools, such as the LEAP database and the FTEA catalogues, were used to check for endemism and the extent of distribution of plants in the list. Structural analyses that included height and diameter classification were conducted. The checklist was also screened for medicinal plants and invasive alien species

##### Species richness, diversity and evenness

The biodiversity attributes were analyzed using various indices, including Shannon-Wiener's for diversity, Margalef's for richness, and Pielou's for evenness. Species richness is the total number of individuals of a species acquired from a sampling effort. The species diversity, richness and evenness indices were generated using PRIMER 5 (Clarke & Gorley, 2006).

### 3.3. Fungi

#### Experimental design

A stratified sampling method was used to collect macrofungi diversity and soil samples for Arbuscular Mycorrhiza Fungi (AMF) in Lake Victoria Watershed ecosystem. The ecosystem was stratified into three counties (Kisumu, Migori and Homabay) to

obtain homogenous farm units currently enrolled for cultivation of forest garden by the Tree for Future Organization. To get good representation of farms, in each county three sub-regions were selected randomly, and five to seven farms under forest garden carbon project were selected as sampling units (Table 1), giving a total of fifteen (15) to seventeen (17) sampling units (farms) per county. In each farm, a plot of 60 x 60 m (approximately 1-acre) that comprised of woodlot, home compound, grazed grassy area, cultivated area and live green fence were sampled. Area of each sampling unit (farm) ranged from 2.5 to 5 ha. To compare fungi diversity in the farms and surrounding natural ecosystem, a forested and a wetland ecosystem in the vicinity of the farms were selected in each county. In each natural ecosystem, five (5) plots were demarcated 200m apart along 1km transects using Permanent markers (with their GPS readings). The macrofungi were sampled in 50 m x 50 m plots while soils for AMF assessment was sampled in 6 m x 6 m plots. Most of the wetland ecosystem near the farms were as a result of flooding from heavy rains, hence dropped from sampling.

## Collection of Macrofungi

In each sampling plot, encountered macrofungi were photographed in-situ and fruiting bodies that occurred solitary as well as gregariously counted and recorded. At least 1-10 fruit bodies were removed from substrates and placed in greaseproof paper. Features of macrofungi such as phenology, colour, habitat and type of substrate colonized were recorded. This was meant to help avoid the phenotypic change that is likely to occur after drying. Same species were packaged in separate storage greaseproof papers to avoid spore contamination among the specimens. The specimens were carefully labelled before transportation. Spore prints made from the fresh fruit bodies were used for the identification of most macrofungi that deposited spores. The fleshy specimens were then dried at 40°C. Specimens were preserved for later identification at East African Herbarium.

Table 1: Sampled farms and natural ecosystems in Lake Victoria Watershed Ecosystem

Region	Sub-region	Village	Land Use	Farmers	
Kisumu	North West Kisumu	Nyambela Village	Farmland	Lucy Millicent Otieno	
		Nyambela Village	Farmland	Judith Perez	
		Kathure B Village	Farmland	Fred Wamboya	
		Aboge Village	Farmland	Joseph Juma	
		Aboge Village	Farmland	Phelida Okul Owino	
	West Kisumu	Ulalo Village	Kamenya B	Farmland	David Olale
			Kamenya B	Farmland	Hellen Aloo
			Kamenya B	Farmland	Everyn Cheronu
			Alouch Village	Farmland	Beneditta Amollo
			Ongendi Village	Farmland	Judith Ngeso
			Aluhobe Village	Farmland	Caleb Omondi
	East Seme	Beka Village	Kokech Village	Farmland	Agnes Adhiabo Ongech
			Kasanjo Village	Farmland	Vicent Oloo Ochieng
			Kasanjo C Village	Farmland	Mary Ayoo Otunga
			Kasanjo C Village	Farmland	Joyce Atieno Onyango
	West Kisumu	Nyambela Village	Forest	Karateng Forest	
	East Seme	Magwara	Wetland	Magwara/Abuogo Swamp	

Region	Sub-region	Village	Land Use	Farmers
Migori	God-jobe	Ngiya	Farmland	Agrey Asiema
		Nyanduong	Farmland	Samuel Opiyo Omondi
		God-riye village	Farmland	Lucia Nyamogi
		Osingo Village	Farmland	Dabid Onyalgore
		Bware Kanyange	Farmland	Peter Imbai Kihungu
		Riati Village	Farmland	Patrick Kisinya Omondi
	Uriri	Kamanga Village	Farmland	Benitta Owidhi
		Nyaroya Village	Farmland	Paul Omondi
		Kamanga Village	Farmland	Leonardus Owiti Raburu
		Ogenga Village	Farmland	Evelyne Akinyi
		Ogenga Village	Farmland	Emily Adhiambo
	Kakraoi	Nyamirubi	Farmland	Dickens Odhiambo
		Amino Village	Farmland	Michael Wasonga
		Mabubi Village	Farmland	Dickson Onani
		Mwachi Village	Farmland	Alphayo Aimba Koi
		Mwachi Village	Farmland	Caroline Adisi Gao
		Migingo Village	Farmland	John Odoyo Otieno
	Suna West	Mukuro Village	Forest	Mukuro Forest
	Nyatike	Timlich Ohinga	Forest	Timlich Ohinga
Homabay	Gwassi	Tonga Village	Farmland	Patrick Ochuola
		Tonga Village	Farmland	Morris Okenga
		Tonga Village	Farmland	Peterlis Omollo*
		Wiga Village	Farmland	Francis Owiti Obel
		Kigoto Village	Farmland	Naftali Ogutu
		Kigoto Village	Farmland	Peter Kimwamu Omolo
		Koga Village	Farmland	Collins Aira
		Rianchogu Village	Farmland	Julius Okello
	Ruma Kaksingiri	Kinyenyu Village	Farmland	Samuel Ouma
		Hollo Abwao Village	Farmland	Joseph Ngoya
		Hollo Abwao Village	Farmland	Barack Bachu
		Nyandenda Village	Farmland	Josephine Awino Omondi
		Nyakya Village	Farmland	Stephen Steve Achieng
	Mbita/Ndhiwa	Bungu Kwach Village	Farmland	Christopher Owino Ochinywa
		Yao B Village	Farmland	Beatrice Achieng Ouma
Kandile Village		Farmland	Raphael Ochungo Midida	
Oridi Village		Farmland	Veryl Achieng	
Oridi Village		Farmland	George Okinyi Oluto	
Gwassi	Nyakya Village	Forest	Kirika Hill	

## Soil sampling for AMF species

In each sampling unit (farm), three individual soil cores were taken from the upper 30 cm layer in areas previously sampled for soil carbon. The cores were pooled together, mixed to obtain a representative soil sample per farm. A composite sample was put in a brown sugar bag and taken for AMF isolation at Botany Department, National Museums of Kenya.

## Identification of Macrofungi specimens

The study used both macro and micro-morphological characterization to identify macrofungi species found in EHWT (Mueller et al. 2005, Prakasam 2012, Senthilarasu 2014). The information of the various characteristics was used to identify each specimen by making comparison with illustrations in colour field guides and descriptions. We used varieties of field monograph of coloured mushrooms keys and books (Ryvarden et al. 1994, Härkönen et al. 2003, Phillips 2006, McAdam 2009) as well as Internet-based scientific literature search engine. The macroscopic features ranged from the cap appearance and size, colour, shape, surface texture and surface moisture, gill attachment, gill colour, gill spacing, lamellules, the stem size and attachment, shape, surface texture and surface moisture, presence or absence of partial and universal veils, flesh colour and texture, stem base morphology, habitat/substrate. Microscopic features were carried out using standard microscopic methods (Senthilarasu 2014). The Edinburgh Botanic Gardens colour chart was used for the description of specimens and spore print colours. The dried specimen were revived in 10% KOH in order to study further details, Meltzer reagent and cresyl blue were used to study the spores amyloidity and metachromic reactions respectively.

## AMF Extraction and Assessment

Arbuscular Mycorrhiza Fungi spores were isolated from 50 g (field soil) via wet sieving and centrifugation. A very fine sieve (45 µm) was used to collect spores, and coarse material remaining on the top sieve (750 µm) was checked for sporocarps and very large spores. Spores were separated into groups according to general morphological similarities under a dissecting microscope. Permanent slides of all spores were prepared by placing them in polyvinyl alcohol-lactic acid-glycerin (PVLG) mixed with Melzer's reagent. Spores were cracked open under the cover slip to allow observation of spore wall characteristics and were identified to species according to classical morphological analysis under a compound microscope (Morton, 1988). INVAM isolates and voucher specimens were used as taxonomic references. Spores were identified to species, but where this proved impossible, species were named as morphospecies. Voucher specimens are kept at the NMK collection, Nairobi.

## Data analysis

Macrofungi species densities abundance were calculated as total numbers of individuals observed per plot while AMF was calculated as total number of spores per 50 g soil. Species richness was calculated as total number of species per plot or per 50 g soil in caes of AMF. Species Shannon–Wiener diversity index ( $H'$ ) was calculated for each field plot or region using PAST programme (Hammer et al. 2001). Canonical Correspondence Analysis (CCA) was used to establish relationship between fungi species and land use using PAST software. One-way ANOVA was performed to assess the effects of county, sub-region and land use on fungi communities. Differences between treatment means were separated by Turkey's post hoc test at  $P < 0.05$ . All data were tested for normality, and where necessary count data were logarithm, ( $\log+1$ ) transformed to ensure conformity of the data with ANOVA assumptions.

## 3.4. Reptiles and Amphibians

### a) Desktop review

Desktop literature reviews was undertaken for all proposed study areas to prepare a checklist of amphibians and reptiles found in the various targeted study sites. The data was also mined from the herpetological database developing a species list for use in the field and final report. This also involved adding the species' IUCN Red list conservation status.

### b) Field data collection

Amphibian and reptile sampling was accomplished by use of standardized time limited searches, unstandardized visual encounter surveys and interviews.

#### i) Timed limited searches (TLS)

A 30-minute sampling period making up one-time limited search (TLS) (Karns, 1986; Heyer *et al.*, 1994; Sutherland, 1996, Malonza & Bwong 2023) will be used. Two observers carried out the searches in different habitats. Searches were done in all possible reptile and amphibian micro-habitats such as, tree barks, under stones, decomposing logs, tree stumps, holes, shrubs, bushes including digging within loose soils, wetlands, etc. All the different species and number of reptiles and amphibians found were recorded, photographed or collected. The time limited searches were carried out both during the day and night.

#### ii) Visual encounter surveys (VES)

This un-standardized method was used only for qualitative and semi-quantitative data mainly for presence or absence of species (Rödel & Ernst, 2004). Due to its flexibility and being opportunistic it contributes a lot in generation of species inventories. This method was used during both day and night. From this method other taxonomic group researchers contributed to collection or observation of herpetofauna.

#### iii) Night sampling

At night visual and audio encounter survey (AES) were employed. It involved using a strong spotlight to search and spot species as majority

of herpetofauna such as chameleons and frogs among others are normally reflective and thus easily recognized. It involved listening to frog calls and identifying them from their unique calls and where species cannot be immediately identified, were recorded with a digital voice recorder for later comparison with amphibian calls database. A few nocturnal reptile species were found at this period, but this method was more suitable for amphibians.

#### iv) Interviews

This was carried out by asking different people questions about the different reptiles and amphibians the locals find in the area. A description of the species was asked for and then the interviewee was shown a photo of the animal that distribution guides (i.e., Malonza & Bwong 2023, Spawls *et al.* 2002 and Channing and Howell, 2006) show can be found in the area. To avoid leading the person the photos were always shown after completing the description.

#### v) Identification of Species and Collection of Voucher Specimens

Distribution and identification of the specimens were made using published taxonomic keys (Malonza & Bwong 2023, Spawls *et al.*, 2002; Channing and Howell, 2006) and taxonomy for amphibians will follow Frost *et al.* (2007). Voucher specimens were fixed in 10% formalin after euthanasia. All the materials collected were deposited at National Museums of Kenya (NMK), Nairobi herpetological reference collection. GPS data for each major survey site was determined using a Garmin receiver.

#### vi) Statistical tests and analysis

Species richness and diversity was estimated from the TLS data using Estimate S 8.2 (Colwell, 2009) using TLS data. The data were randomized a thousand times without replacement and graphs drawn using Excel. Species accumulation curves of observed species (Sobs) were generated using Estimates. In the curves, the species richness was plotted as a function of the accumulated number of samples or number TLS. A species and specimen sampling effort index were calculated as a ratio of number of species/specimen and number of TLS in each county.

### 3.5 Mammals

The work included desktop research, laboratory/ collection references which included checking on prior research done in those areas, (KHM). All the data was documented in a spreadsheet.

#### Desktop Review

Before the field work was carried out, desktop review was done so as to form base on what to anticipate when in the field. More data was dug from published journals and the laboratory collection.

The below table shows information from unpublished data, in the mammalogy collection, from different years. Only data that was found is from Kisumu only. There was no data in the public domain for both Migori and Homa Homabay. In Ruma park, most published data was on tsetse fly.

Table 2: List of species from Kisumu after doing desktop review

No.	Genus Name	Locality
1.	<i>Lophuromys</i>	Kisumu
2.	<i>Crocidura</i>	Kisumu
3.	<i>Mastomys</i>	Kisumu
4.	<i>Lemniscomys</i>	Kisumu
5.	<i>Aethomys</i>	Kisumu
6.	<i>Pelomys</i>	Kisumu
7.	<i>Mus</i>	Kisumu
8.	<i>Otomys</i>	Kisumu
9.	<i>Arvicanthis</i>	Kisumu
10.	<i>Rattus</i>	Kisumu
11.	<i>Dasyms</i>	Kisumu
12.	<i>Oenomys</i>	Kisumu
13.	<i>Grammomys</i>	Kisumu

A reconnaissance was carried out to help out in mapping the area for preferable sampling areas and generating of maps for the spatial and temporal assessment. The field work encompassed both combination of standard direct and indirect field methods during the survey (Davies, 2002).

The direct method included laying of traps (Sherman traps) in transects within the selected areas. This involved capture, identification and release. The specimens that could not be identified in the field were collected and identified further at the National museums of Kenya , Mammalogy section.

Indirect methods, where search for scats, prints and bones for mammals were collected, photographed or identified straight from the field. This enhanced the direct sampling method.

#### Direct method

##### Use of Sherman traps

A stratified random design to sample small mammals in the three locations in the western region, Kisumu, Homabay and Migori (KHM) were conducted.

In each location (KHM), 4 sites totalling to 12 sampling points were identified and sampled. The sampling was done in a farm and a forest close to the farm. This was for the purpose of doing a comparative study of mammals diversity between the farm and forest near the farmed area in order to establish the area which had higher biodiversity of mammals. We used a line transect approach as opposed to a grid system. This is because, line transect provides a better resolution of community structure for a given effort (Avenant, 2011) as compared to that of grid. Each transect was 200M long and was laid with 20 traps baited with peanut butter and oat meal grains.

Trap stations targeting shrews and rodents were placed at an interval of 10m in the various habitats of the sampling areas (Gurnell & Flowerdew, 2006). Small mammals were sampled using Sherman live traps measuring 2 x 2.5 x 9" or 5.08 x 6.35x22.86 cm (H.B. Sherman Trap Company, Tallahassee, Florida, USA). These traps were set at microhabitats along transects where small mammals were likely be encountered. These microhabitats preferably areas with defined small mammal trails; included grasslands, farm plantations, active burrows, under tree or shrub logs, rocky outcrops and areas with under shaded vegetation. The sites were preferable since those are areas where mostly rodents forage and live.



(a)



(b)

Plate 1: (a) and (b): Sherman trap used to capture small mammals, baited with oat meal mixed with peanut butter at each trap station. Traps were set in areas with mammal signs, like droppings or path

These traps were deployed for two consecutive nights so as to give them an equal time distribution in each site. We used the Capture-Release method, whereby upon trap inspection each morning, the trapped rodents were removed from the trap, identified by the taxonomy name, all features noted and released on the same capture site. Identification features noted were mass, sex, reproductive status and species-specific traits. Some were collected for more identification purpose and taken to the mammalogy laboratory at National Museums of Kenya. Species were identified to genus level using guide book by Kingdon (2015).

### Indirect Method

For the purpose of indirect sampling, walking slowly along the identified transect was done. The purpose was to look for mammals along and adjacent to the transect. The recording time for each transect was 1km per hour with a pause after 100m to listen for calls or any movement on trees or the bushes. This was done in the selected farm as well as adjacent ones since mammals are known to be mobile and could crisscross around farms. Indirect field techniques encompassed the use of animal signs such as footprints, scrapes, scratches, shelters, burrowings, scats and bones while



(c)



(d)

Plate 2: (c) and (d): Sighting and observation of mammal present: Foot print of a mammal and mole rat burrowing showing activity presence of mammals

direct field techniques involved visual sighting of occurrence or observation of the mammals within the areas of sampling (Wemmer *et al.* 1996; Rudran *et al.*, 1996).

### 3.6 Invertebrates

#### Methods:

Four different invertebrates sampling methods were applied. Each method is discussed in details below.

#### 1. Active searches

These included the use of sweep nets to collect flying and vegetation resting species as well as hand picking from underneath stones and logs.

#### 2. Pan trapping

The pan trapping method is used for sampling flower visitors. These are mainly of pollinators that exclude butterflies. Fifteen (15) blue, yellow and white coloured pans were set in a linear pattern preferably in areas with many flowering plants. They were half-filled with water in which a few drops of odourless liquid detergent were added



Plate 3: Sweep netting in a natural forest (left) and hand picking of termites (right)



Plate 4: Coloured pan traps set to collect flower visiting invertebrates in the three Counties

to break the surface tension. The traps were emptied each evening and samples preserved in 95% ethanol.

### 3. Pitfall trapping

Pit fall traps were used to collect the ground crawling and dwelling invertebrates such as ground beetles, crickets, spiders, millipedes etc. In each of the habitats, 10 pitfall traps were set along the edges of vegetation. The traps were set into pits dug into the ground to align their openings with the ground. These were then half filled with water to which few drops of liquid detergent were added. The traps were collected after one night of trapping. The trapped invertebrates were preserved in plastic vials containing 95%.

**4. Pond netting:** Using an aquatic net, macro-invertebrates were collected from available aquatic habitats that were within farmlands. Only one farm in Nyabere village in Kisumu County had a suitable aquatic habitat. A standardized sample was taken from the three biotopes (micro habitats) available namely flowing, sand and marginal vegetation. In the first two invertebrates were collected for one minute each a while in marginal vegetation, this was done along a two metre stretch untimed. The specimens were then emptied onto a sorting tray. Using pair of forceps, specimens were separated from the debris and then put into vials with 95% alcohol for preservation. Adult dragonflies were collected using a sweep net and put in entomological envelopes for transportation to the laboratory.



Plate 5: A pitfall trap (left) and harvesting of pitfall catches (right)



## 3.7 Birds

### Sampling birds using line transects

Birds were searched in an area following an irregular line transect for a period of three hours in the mornings (08:00-12:00 hrs) and two hours in the afternoons (14:00-16:00). The later were affected by weather and could therefore not last for three hours in most days. A pair of 10x42 binoculars were used to make observations. Each species observed was recorded as well as the number of individuals as an assessment of relative abundance. Species were recorded as either seen or heard.

### Determination of feeding guilds

Each species was assigned a feeding guild based on their principal food taken. Guilds are groups of species in an ecological community that exploit the same set of resources in a similar manner, but are not necessarily closely related taxonomically (Ehrlich et al., 1988). Feeding guilds used in this review follows classification adopted by Pineda-Diez de Bonilla et al. (2012) where six guilds are recognized based on principal food material utilized by a species. These guilds are: insectivores (insects, variety of invertebrates), granivores (seeds), omnivores (animal and plant materials), nectarivores (flower nectar), frugivores (fruits), algivores, piscivores, carnivores (meat-eaters) and scavengers. The diet, and consequently the feeding guild, of each species was determined from information provided at <https://birdsoftheworld.org/bow/home>

Alcohol preserved specimens were sorted, mounted on stainless steel entomological pins and dried in ovens for several days. Dried specimens were identified using taxonomic keys and the reference collections at the National Museums of Kenya.



Plate 6: Laboratory processing of specimens at the National Museums of Kenya

## Species identification, data collection and synthesis

The Kenya Bird Map Atlas App (BirdLasser) was used for recording observations (including GPS coordinates). Zimmermann et al. (1996) was used as the main reference for field identification of birds together with the African Bird Club's Birds of Africa App (<https://www.africanbirdclub.org/apps/>). Further, Bradley & Ikawa (2023) was consulted on distribution and confirmation of species occurrence. eBird App was used to plot the transects and determine the distance walked. Two observers working together made observations. For each observation, the following data was recorded: date, time, site name/number, species name, number of individuals, elevation, GPS coordinates of position of the observer (synonymous to species' position), and detection type (seen or heard).

Although there is an updated version of the *Checklist of the Birds of Kenya* (Bird Committee, 2019), this report follows taxonomy presented by the Bird Committee (2009). This is due to the many revisions effected in the 2019 list such as splitting and order of species, genera and families, that are yet to become well understood or common in general use (including availability of updated field guides) among the bird enthusiasts.

The IUCN Red List of Threatened Species (BirdLife International, 2023) was used to determine the global conservation status of each species. Bennun et al. (1996) provided an assessment of the avifauna assemblages that are dependence on forested habitats. In this criteria, three categories are used: forest-specialists (FF species), forest generalists (F species) and forest visitors (f species). This assessment was important to detect if there are sites among those surveyed that are still supporting species dependent on forested habitats.

## 3.8 Spatial analysis

The spatial analysis was helpful in identifying and mapping of biodiversity hotspots in selected projects areas in Kisumu, Migori and Homa Bay in Kenya working with the various experts as outline above. This involved identification and mapping of areas that are biologically rich areas that face threats of destruction especially through human actions. In doing this change in land cover and land use over time was analyzed. This helped to provide picture of the positive or negative land cover and land use change that has occurred in the target study sites overtime. The spatial analysis enabled in the identification of biodiversity hotspots based on the extent of negative change in land use that is degradation.

Spatial analysis used satellite images as secondary data. These was processed and analyzed using GIS software to identify the hotspots. Primary data was also collected using field-based GIS mapping especially during ground truthing where by training data was also collected to guide the spatial analysis process. Ground truthing involved discussions with local communities to help identify and ascertain results of spatial analysis at a finer scale.

### Biodiversity data and Spatial integration

The data collected for various taxon was geo-referenced in order to enable integration with spatial data. Various taxon used GPS enabled mobile app. Spatial analyst and team leader took leadership in assisting the various taxa expert in preparation of geo-referenced data collection tools, where necessary.

### Satellite data

The land cover analysis was carried out using available satellite images i.e., secondary data. Landsat images sourced from the United States Geological Survey was used in the exercise. Landsat images was considered not only because of their wide availability but also due to their long period of coverage beginning in 1972 to date. They also have a high spatial resolution of 30M and a temporal resolution of 16 days. This makes them the best for long term land cover analysis.

The specific Landsat satellites whose data was used depending on the designated study period interest and included Landsat 5, Landsat 7 and Landsat 8. Images were sourced based on the rows and paths that covers the study sites. The images preference was given to those months that exhibit similar weather conditions or seasons.

### **Image processing**

Image processing and analysis was done using ENVI 5.3. The USGS images are usually geometrically rectified and thus no further orthorectification is needed. The images were layer stacked to allow use of several spectral bands in the analysis hence allowing for greater detail. The layer stacked images were then mosaicked in case the images derived are from different scenes in order to form continuous images by merging images from the different scenes.

### **Image classification**

Image classification involved automatic categorization of pixels of the multispectral satellite images into specific classes. This allowed identification of homogenous groups of pixels which represent various features or land cover classes of interest. Classification assigned each image pixel to a particular class such as dense forest, sparse forest, water, agricultural use, and settlement areas etc thus producing thematic maps of the original image.

### **Unsupervised classification**

Unsupervised classification uses an automated technique that searches for natural groups, or clusters of pixels based on their brightness in several bands. Unsupervised classification, unlike supervised classification, does not begin with a predefined set of classes but the user labels or defines what the grouped classes represent. This could be further ascertained through ground truthing. Unsupervised classification was done using Isodata classification. This algorithm assigns pixels to the most probable cluster based on spectral similarity to the presumed mean. Belongingness is established iteratively based on the most common cluster to which the pixel may associate. The results of the unsupervised

classification was used to guide a field-based ground truthing exercise.

### **Ground-truthing**

Ground truthing was done to establish the true situation on the ground. This also served to evaluate results of the unsupervised classification and enhance accuracy of the results. Ground truthing was done along transects running across the study sites. This involved recording data on land use, land cover at selected points along transects. The recorded data included: the geographical coordinates, textual description and photos of the study points using GPS.

### **Supervised classification**

Supervised classification used the maximum likelihood supervised classification. This assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. This involves classification of clusters pixels in a dataset into classes corresponding to the user defined classes. In doing this, the spatial analyst selects representative samples of different surface cover types from the image i.e., training areas. These training areas are defined by the training points and information obtained during the ground truthing exercise. The ENVI classification algorithms used the training data to learn what each class looks like in multispectral or hyperspectral data space. Land cover and land use types are therefore classified into classes that are homogenous representational areas you want mapped in the output data. Image classification helped to quantify extents of change detection between classes and identified degraded areas.

### **Change detection**

The classified images were converted into vector layers in form of shapefiles and used to conduct change detection and quantification of land cover types. Change detection employed the thematic change method. This involved subtractive change detection between two or more classified images. The process yields a thematic change classification image showing results of change between different classes over time. Change

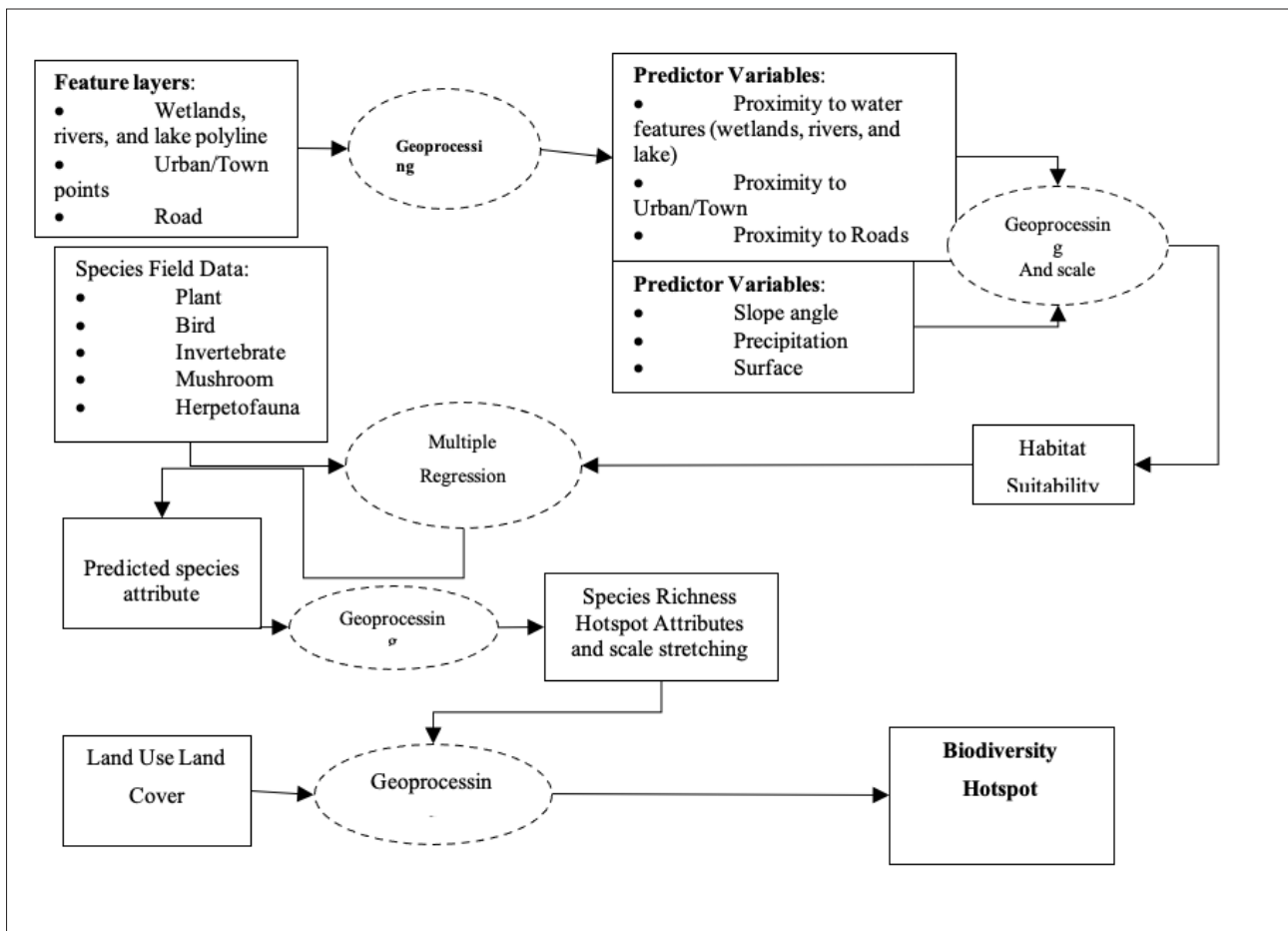
detection therefore measures the changes that have occurred in the study sites between different classes over the selected time intervals in the study period. The thematic change method also lead to establishment of a change matrix showing differences in land cover and land use between the different intervals over the study period. This differentiation enabled detection of the change in specific land cover and land use types within classes and between time periods.

### Map production

The outputs were exported to arc GIS software for map production. This involved overlaying various features to produce needed maps. The overlaid features acted as reference points during interaction with the derived maps. The maps produced included features related to factors of degradation to inform identification of biodiversity hot spots.

### Biodiversity Hotspot analysis

Based on the assumption that hotspots hold disproportionately more species per unit area, and in combination with a more comprehensive approaches owing to the availability of spatial variables that potentially correlate with species richness, a new GIS-based approach was adopted for the model development. This approach customizes hotspot parameters at a local scale, which provide a tool for prioritization of areas for conservation. In this regard, it is considered in this analysis that biodiversity hotspot analysis is an overall product of a mean spatial weighting index of spatial predictor variables that consist of species richness, vegetation cover, slope angle, drainage density, spring distribution density, and proximity (accessibility) of sites to human activities that potentially affect ecological integrity. The process was achieved through geoprocessing technique in ArcGIS software.



Spatial layers were resolved to 2 km working pixel for spatial integration of the variables. Hotspot analysis was initially conducted and visualized for each predictor variable. Later, the variables were integrated in matrix of attributes under geoprocessing to allow for stretching variable indices from 0 to 1 scale. An average index from the six variables was derived to depict the overall biodiversity hotspot. Hotspot for predictor variables and the overall biodiversity was assigned into three major classes of Very Hot, Moderately

Hot and Less Hot using Equal Interval (with limited manual adjustment) classification in GIS software (Table 3). The classification for the variables uses indexes, are categorized in the table 3 below and process summarised in the diagram below. Areas which are Very Hot are related to potentially high biodiversity hotspot while Less Hot areas have very low biodiversity. This information was useful in guiding field sampling and was validated during field data collection.

Table 3: Spatial predictor variable with the description of Categorical scale of Hotness for biodiversity conservation

Predictor Variable	Less Hot	Moderately Hot	Very Hot
Species	Less rich in species, Less Biodiversity Hotspot	Has moderate richness	Very rich in species, High Biodiversity Hotspot
Slope	Low slope angle, Vulnerable to Encroachment, Less Biodiversity Hotspot	Moderately steep	High slope angle, Vulnerable to Degradation, High Biodiversity Hotspot
Vegetation cover	Low vegetation Index, Less Biodiversity Hotspot	Moderate vegetation index	High Index, High Biodiversity Hotspot
Spring Density	No or Low counts of springs, Less Biodiversity Hotspot	Moderate counts of springs	More counts of spring, High Biodiversity Hotspot
Drainage System	No or low Drainage Density, Less Biodiversity Hotspot	Moderate density of drainage	High Drainage Density, High Biodiversity Hotspot
Road	More road network density, Presence of Invasive Species, Less Biodiversity Hotspot	Moderate density of road network	No or less road density, High Biodiversity Hotspot

# 4

## Results and Discussion Biodiversity Thematic Areas

### 4.1 Introduction

This chapter presents the findings of the desktop review and field work in terms of species diversity in each taxa as well as the results of the spatial analysis.

The results are presented in the order: plants, fungi, reptiles and amphibians, mammals, invertebrates, birds and spatial analysis. The plants section starts with a description of vegetation types of each study site. In each taxon, the total number of species (diversity/richness) is provided at family, genus and/or species, and in a few instances, sub-species level. An appendix with the full species list is also presented for each taxon. The species are further evaluated in terms their conservation importance using criteria such as IUCN Red List of Threatened Species, CITES Appendices, Endemism, national protection, and for birds, their forest habitats dependency, migration status and feeding guilds.

Further, species that are invasive (especially plants), are also highlighted. Groups that are of some economic importance such as use in ethno medicine, food, ecotourism potential and other socio-cultural uses as well as species that are good biological indicators are presented.

Photographs, taken in the field or borrowed from other sources, are presented to show some of the highlighted species and/or their habitats as well as observations made in the field such as human interferences with natural systems, soil erosion and unauthorised or unacceptable logging activities.

In addition to the images and explanatory text, the results are presented with illustrations in form of tables, graphs and pie-charts. Where applicable, statistical tests are performed to understand and help with interpretation of the findings.

In each taxon, a discussion accompanied by some recommendations that are specific to the taxon is provided. The chapter winds up with a spatial analysis that utilises the GIS techniques to help explain species' observations and occurrence in the field resulting to identification of critical sites that are important in protection and conservation of biodiversity in the water tower. This process involves combination of species richness data with environmental and physical variables namely: slope, accessibility, vegetation index, springs density and drainage.

## 4.2 Taxa: Plants

Paul M. Kirika & Judith Wanza, EA Herbarium, National Museums of Kenya

### 4.2.1. Introduction

Biological diversity which encompasses all living organisms and their habitats is critical to the continued survival of humanity. The livelihoods of many communities in developing countries depend on biological resources for their daily necessities such as food, fuel, medicines, housing materials and economic security. Moreover, rich biodiversity supports ecosystem resilience necessary to cope with periodic environment stresses such as drought and floods. The five main threats to biodiversity are habitat loss, pollution, over-exploitation, invasive species, and climate change. While alien invasive species are mainly introduced and spread through movements and trade, the other threats are a direct result of human population growth and associated use of resources.

Plants are the primary producers, through which all other living organisms on this planet depend on. Globally, there are an estimated 390,000 plant species documented to date, of these, about



20000 species comprise non flowering plants. The tropical ecosystems of the world are most species rich, harbouring 2/3 of the total number of species globally.

Kenya, with more than 7000 vascular plant species, has the second richest flora within the eastern Africa region compared to Tanzania (11000), Uganda (4500) and Ethiopia (6000), this is because of the wide geographic distribution, diverse climatic conditions and variety of soil types (Zhou et al. 2017). This plant diversity comprises 1720 genera and 240 families, which are dominated by flowering plants, majority of the species are legumes (708), grasses (576) and daisy family (403). The entire Lake Victoria basin in Kenya has about 2000 documented plant species of which only about 20 are endemic to the area (Zhou et al. 2017).

Documentation and dissemination of biodiversity data of a given area is key to drawing sustainable species conservation strategies as underpinned by the tenets of the Convention on Biological Diversity (CBD). Inventories provide the much-needed biodiversity data on the presence, diversity and distribution of species within a given geographical area. These data are an important tool in helping to develop appropriate management plans. They aid in the identification and adoption of appropriate conservation interventions of any ecosystem.

### 4.2.2. Vegetation and Plant diversity

Twenty-eight study sites consisted of woodlots and orchards in farmlands (23), mainly with *Eucalyptus* and *Grevillea robusta* trees but occasionally with remnants of indigenous species such as *Ficus sycomorus* and *Albizia coriaria*. Five sites were established in the natural habitats, however these are also modified through illegal encroachment, fires, poaching of indigenous trees and planting of exotic species.

A total of 412 plant species were recorded from the 28 sample plots studied, majority of the plots (23) were located in farmlands while only five were

established in the natural habitats. About 170 species were recorded outside the sample plots, giving a total of 582 species recorded in this study. Statistical analyses were undertaken using data collected from the sample points only.

The 412 species recorded were classified into 336 genera and 88 families, with the most speciose family being Fabaceae (87 species, 15%), Asteraceae (59, 10%), Poaceae (57, 10%), Malvaceae (35, 6%) and Lamiaceae (30, 5%) (Fig. 2).

### 4.2.3. Species area curve (SAC) or Species accumulation Curve

To help determine the sampling sufficiency of the study a species area curve for the 28 sample plots was generated (Figure 3). A high diversity of 412 species were encountered in the 28 sample points. Despite the impressive diversity the curve did not flatten by the last sampling, indicative of an existing potential to encounter more species with additional sampling.

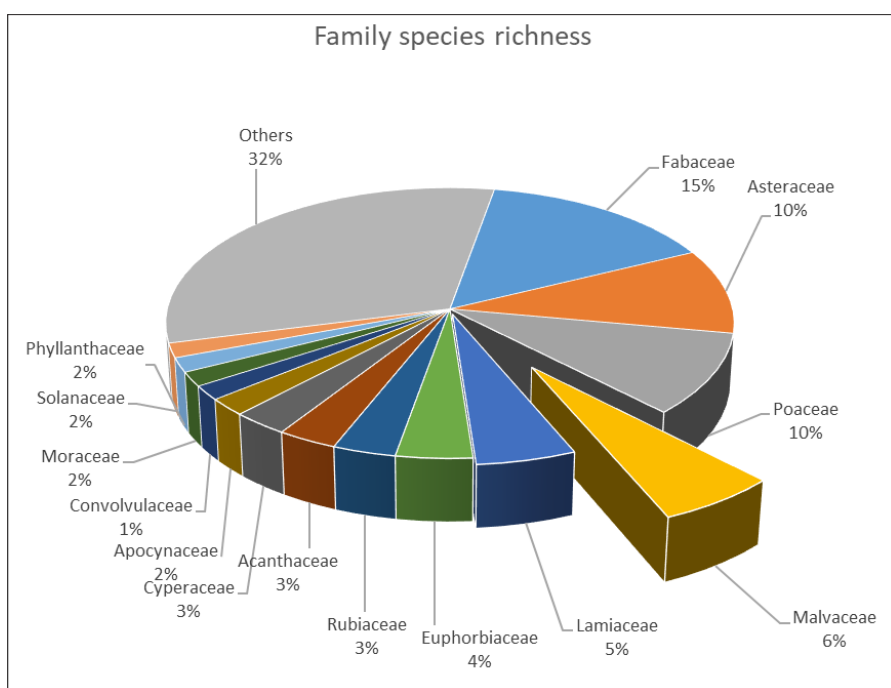


Figure 2: Family Species Richness

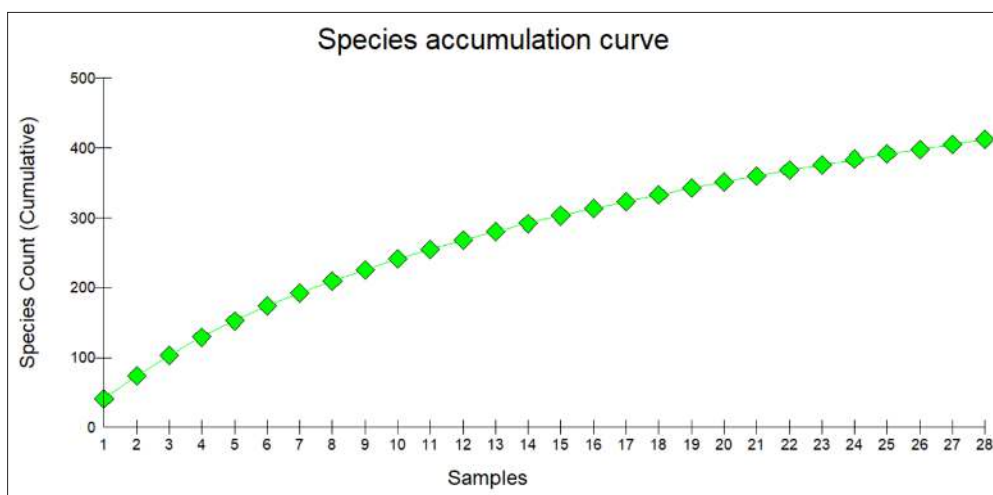


Figure 3: Species area curve

#### 4.2.4. Species diversity and composition

Diversity indices were generated from the 412 species recorded from the 28 sample plots. Kisumu recorded the highest species diversity while Migori had the lowest plant diversity and also in terms of Margalef & Shannon diversity indices. However,

Kisumu had a lower species evenness (Table 4) compared to the other counties.

Among the sites studied, sample plots from Kisumu recorded a higher number of species followed by Homabay, while Migori recorded the least (Table: 5).

Table 4: Summary of species richness and diversity per region

	Total species (S)	Margalef richness (d)	Pielou's evenness (J')	Shannon diversity (H')
<b>Homabay</b>	196	34.21	0.97	5.12
<b>Kisumu</b>	254	40.41	0.96	5.32
<b>Migori</b>	187	32.26	0.97	5.07
<b>Total</b>	412	58.38	0.94	5.67

Table 5: Comparison of species diversity per cluster

Cluster	Total species (S)	Margalef richness (d)	Pielou's evenness (J')	Shannon diversity (H')
<b>HBC1</b>	120	23.39	0.98	4.70
<b>HBC2</b>	100	21.10	0.99	4.58
HBC3	28	8.10	1.00	3.33
KC4	57	13.85	1.00	4.04
<b>KC1</b>	132	24.97	0.98	4.79
<b>KC2</b>	119	22.87	0.98	4.67
<b>KC3</b>	85	18.12	0.99	4.39
<b>MC1</b>	97	19.37	0.98	4.47
<b>MC2</b>	75	16.40	0.98	4.24
<b>MC3</b>	79	17.51	0.99	4.34

HB-Homabay, - Kisumu, M-Migori

Multi-dimensional scaling (MDS)

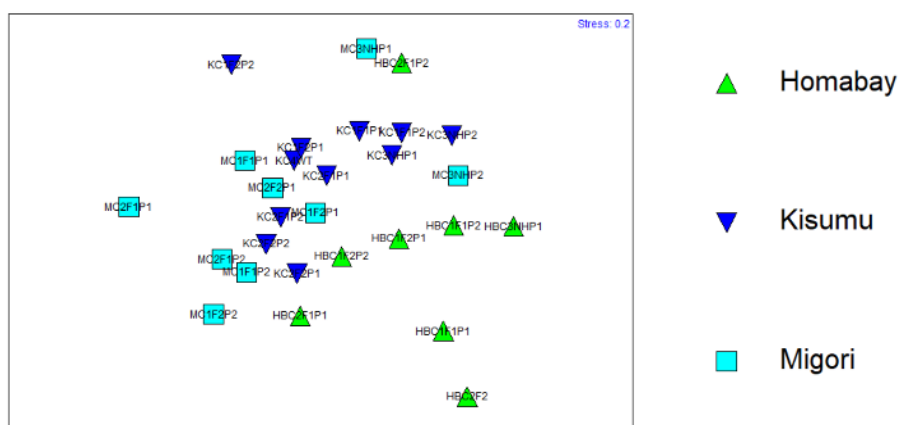


Figure 4: Multidimensional scaling plot showing plot (dis)similarity

MDS plot helps to visualize the similarity or dissimilarity between sample points (Figure 4). Each region partly appears to harbour a different species composition with plots from the same region largely clustering together. However, some sample plots displayed unique species composition such as HBC2F1P2 which clustered with (MC3NHP1) from Migori Hamabay which clustered with another plot from the natural habitat in Migori.

#### 4.2.5. Species diversity and tree structure in the Natural habitats

Among the natural habitats studied, Mukuro forest registered the highest species richness and diversity followed by Karateng' and Kiringa while Thimlich Ohinga the lowest diversity according to all the three diversity indices examined (Table 6). This may be due to the fact that the natural habitat of Thimlich Ohinga are still undisturbed and intact, therefore does not have the influx of invasive weeds as observed in Karateng, Mukuro and Kiringa Hills.

All trees with a DBH of 5 and above were documented, their height estimated and recorded, these measurements were used to determine their structure. A total of 39 tree species were recorded from the three regions and are hereby used to understand the general vegetation structure of the woodlots in the study area. The aspects analysed include diameter classification, height structure, basal area, species frequency, abundance and the important value index (IVI).

Table 6: Multidimensional scaling plot showing plot (dis) similarity

Natural Habitat	Total species (S)	Margalef richness (d)	Shannon diversity (H')
Thimlich Ohinga (Migori)	41	10.77	3.71
Karateng Hills (Kisumu)	83	18.56	4.42
Kiringa (Homabay)	56	13.66	4.03
Mukuro (Migori)	93	20.30	4.53
<b>Total</b>	<b>203</b>	<b>36.01</b>	<b>5.23</b>

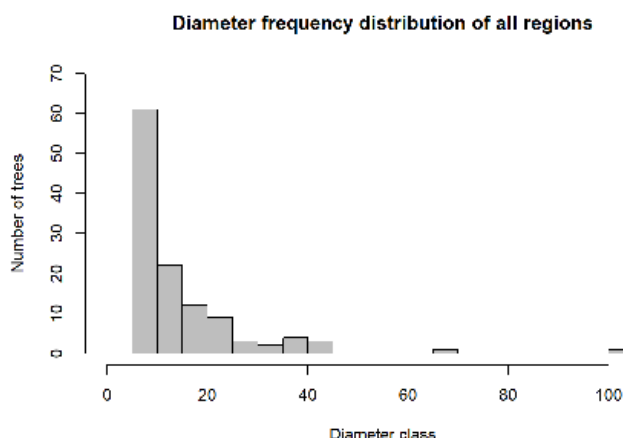


Figure 5: Diameter frequency in all regions

There is a considerable representation of young trees in the lower classes up to the class of 45 cm where inconsistency was observed. The middle class is missing an indication of strong presence of selective harvesting of trees in that class. Trees with DBH between 20 and 40 are also few proportionally to fill the higher diameter groups in the near future. These results indicate that farmers harvest the trees on their farms before they attain greater DBH and therefore potential unsustainability.

Tree diameters in Migori were smaller than in the other regions with the majority of the records being 7 cm and below. Diameters were more even in Homabay with mean above 10 meters. Kisumu had the greatest average DBH of 22 cm with the majority of the plants scoring below the mean (Figure 6).

In overall, tree heights were averagely 9.3 meters tall. Most of the individuals fall within classes of 5 – 10 meters and only a few exceeded 15 m (Figure 7).

Trees in Migori had high similarity in height distribution, however lower stature than Kisumu, which had tallest trees but with a very high disparity in ranges. Homabay had the shortest trees (Figure 8).

#### 4.2.6. Important Value Index (IVI)

In totality across all regions, Eucalyptus sp., Delonix regia, Senna sp., Combretum molle, Psidium guajava, Acacia seyal var. fistula, Makhamia lutea, Searsia crenulata, Ficus sycomorus and Combretum collinum were the most significant plants. In Homabay, the most important trees

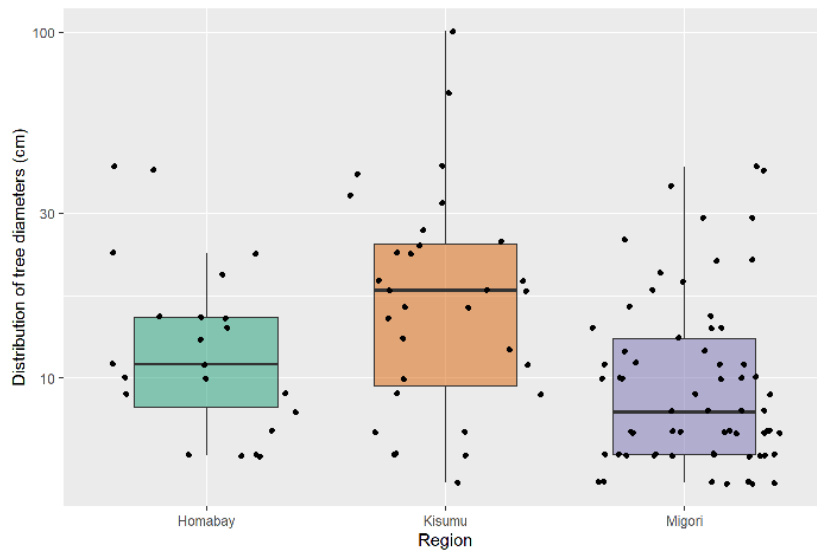


Figure 6: Box plot showing the tree diameters

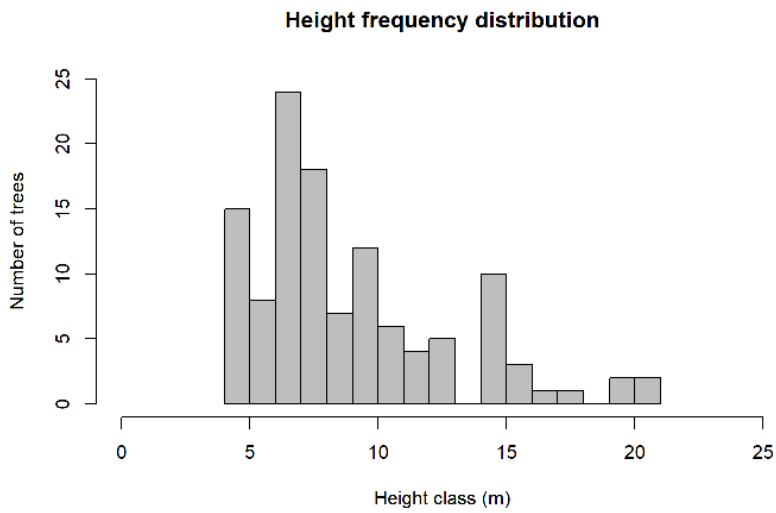


Figure 7: Graph showing the height frequency distribution

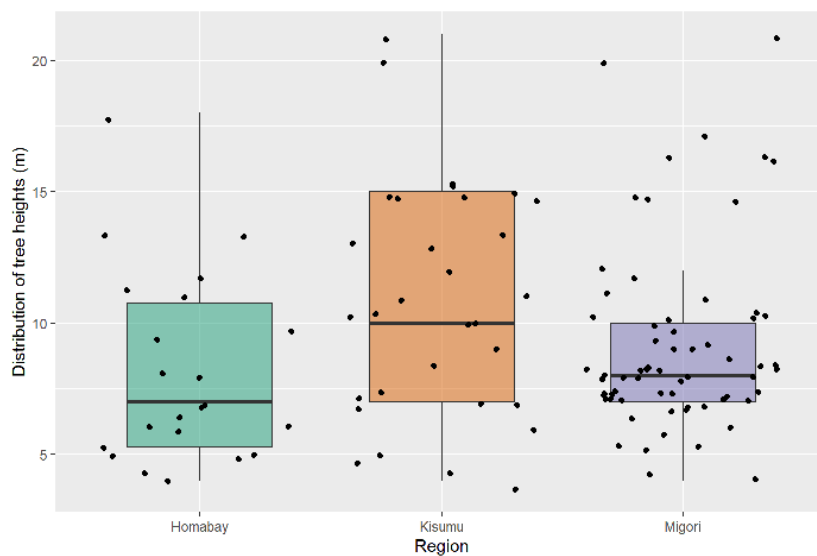


Figure 8: Box plot showing the distribution of tree heights

included as advised by IVI values in brackets included; *Acacia seyal* var. *fistula* (40.2), *Lannaea schimperi* (24) *Catha edulis* (15.8), *Ozoroa insignis* (11.4) and *Balanites aegyptiaca* (11.2). In Kisumu, they included *Delonix regia* (43), *Psidium guajava* (35), *Eucalyptus* sp. (31.6), *Combretum molle* (19.5) (IVI)

and *Acacia* sp. (18.6). In Migori, most significant species were *Eucalyptus* sp. (162), *Senna* sp. (31), *Rhus natalensis* (15), *Combretum collinum* (10.7) and *Combretum molle* (10) (Table 7).

Table 7: Tree ranking based on the important value index

Important value index (IVI) of trees regionally				
Species	Homabay	Kisumu	Migori	Grand Total
<i>Eucalyptus</i> sp.		31.6	162.0	84.6
<i>Delonix regia</i>		43.0		35.5
<i>Senna</i> sp.			31.1	13.1
<i>Combretum molle</i>		19.5	10.0	13.1
<i>Psidium guajava</i>		34.9		12.4
<i>Acacia seyal</i> var. <i>fistula</i>	40.2			10.5
<i>Makhamia lutea</i>	8.1	11.9	9.0	10.5
<i>Searsia crenulata</i>	8.8		15.0	10.2
<i>Ficus sycomorus</i>		16.2		8.7
<i>Combretum collinum</i>	7.7		10.7	7.4
<i>Acacia</i> sp.		18.6		7.3
<i>Lannaea schimperi</i>	23.9			6.1
<i>Vernonia amygdalina</i>		5.6	9.3	5.9
<i>Ozoroa insignis</i>	11.4			5.5
<i>Albizia coriaria</i>			8.0	5.4
<i>Bischofia javanica</i>		12.8		5.3
<i>Mangifera indica</i>			7.8	5.2
<i>Balanites aegyptiaca</i>	11.2			5.2
<i>Bridelia micrantha</i>		8.7		5.0
<i>Senna siamea</i>	8.8		4.4	4.7
<i>Croton macrostachyus</i>		7.7		4.0
<i>Catha edulis</i>	15.8			3.9
<i>Combretum molle</i>			8.9	3.7
<i>Terminalia mollis</i>			5.1	2.5
<i>Ficus</i> sp.			5.0	2.5
<i>Turraea robusta</i>		6.0		2.3
<i>Leucaena leucocephala</i>	8.2			2.2
<i>Cupressus lusitanica</i>			4.7	2.1
<i>Searsia crenulata</i>	7.9			2.0
<i>Allophylus rubifolius</i>			4.5	2.0
<i>Moringa oleifera</i>			4.5	1.9
<i>Euclea divinorum</i>	7.9			1.9
<i>Acacia seyal</i>	7.8			1.8
<i>Grevillea robusta</i>		5.6		1.8
<i>Combretum collinum</i>			4.4	1.8
<i>Citrus</i>	7.7			1.8
<i>Ficus</i> sp.		5.6		1.8
<i>Ficus</i> sp.	7.7			1.8
<i>Carisa edulis</i>			4.4	1.8

#### 4.2.7. Species of Conservation interest

Eight species of conservation interest were recorded including, *Vitex fischeri* var. *keniensis*, which is categorised as endangered (EN) according to IUCN red List, *Bothriocline bagshawei*, *Dracaena parva*, *Tragia subsessilis*, which are EA endemics according to the LEAP database. Others include *Osyris lanceolate* (sandlewood) which is currently overexploited in the perfume industry, one orchid and two aloe species namely; *Cyrtorchis arcuate*, *Aloe lateritia* and an *Aloe macrosiphon* which are listed in Appendix II of CITES.

#### 4.2.8. Medicinal Plants

Over two hundred medicinal plants used by different communities for herbal medicines in Kenya were recorded (**Appendix 1**). Some of the medicinal plants recorded including *Carissa spinarum*, *Hygrophila spiciformis*, *Kigeria africana*, *Ozoroa insignis*, *Pittosporum manii* and *Rhotheca myricoides* are illustrated in Plate 7.



A. *Carissa spinarum*;  
B. *Hygrophila spiciformis*;  
C. *Kigeria africana*  
D. *Ozoroa insignis* ssp. *reticulata*;  
E. *Pittosporum viridiflorum*;  
F. *Rhotheca myricoides*

Plate 7: Some Medicinal plants recorded

#### 4.2.9. Crop wild relatives

Crop wild relatives (CWR) are plant species occurring in the “wild” and which are closely related to domesticated crop species. CWR may contribute genetic material for the improvement of crops, thereby providing for increased disease resistance, fertility, crop yield or other desirable traits. Among the CWR documented include *Eleusine indica*, *Sorghum arundinaceum*, *Solanum dasyphyllum* and *Dioscorea schimperana*.

#### 4.2.10. Invasive Alien species (IAS)

Invasive alien plant species are plants introduced into places outside their natural range, negatively impacting native biodiversity, ecosystem services or human well-being. Invasive plants are one of the major causes of biodiversity loss and species extinctions, and thus a global threat to

food security and livelihoods. Climate change facilitates the spread and establishment of many alien species and creates new opportunities for them to become invasive thus compounding the problem. Further, IAS can reduce the resilience of natural habitats, agricultural systems and urban areas to climate change. Invasive species pose a threat to natural vegetation since they generally outcompete indigenous species thereby reducing their numbers and eventually changing the ecological integrity of an ecosystem.

Invasive species were prevalent in all the three counties both in the farmlands and in the natural habitats. The abundance of invasive species in the natural habitats, may be as a result of the disturbances through illegal tree cutting for timber and charcoal making, overgrazing and encroachment. A total of 42 IAS were recorded for this study as indicated in Table: 8 below.

Table 8: Invasive Alien Species (according to Witt, A. & Luke, Q. (2017)

Family	Species	Lf
Agavaceae	<i>Agave sisalana</i> Perr. ex Engelm.	S
Apocynaceae	<i>Cascabela thevetia</i> (L.) Lippold	S
Apocynaceae	<i>Catharanthus roseus</i> (L.) G. Don	S
Asteraceae	<i>Ageratum conyzoides</i> L.	H
Asteraceae	<i>Parthenium hysterophorus</i> L.	H
Asteraceae	<i>Tithonia diversifolia</i> (Hemsl.) A. Gray	H
Asteraceae	<i>Xanthium pungens</i> Wallr.	H
Bignoniaceae	<i>Jacaranda mimosifolia</i> D. Don	T
Combretaceae	<i>Terminalia catappa</i> L.	T
Convolvulaceae	<i>Cuscuta reflexa</i> Roxb.	H
Convolvulaceae	<i>Ipomoea cairica</i> (L.) Sweet	C
Convolvulaceae	<i>Ipomoea hildebrandtii</i> Vatke	S
Euphorbiaceae	<i>Jatropha curcas</i> L.	S
Euphorbiaceae	<i>Ricinus communis</i> L.	T
Fabaceae	<i>Caesalpinia decapetala</i> (Roth) Alston	S
Fabaceae	<i>Calliandra houstoniana</i> (Mill.) Standl. var. <i>calothyrsus</i> (Meisn.) Barneby	S
Fabaceae	<i>Delonix regia</i> (Bojer ex Hook.) Raf.	T
Fabaceae	<i>Leucaena leucocephala</i> (Lam.) de Wit	T
Fabaceae	<i>Mimosa pigra</i> L.	S

Family	Species	Lf
Fabaceae	<i>Mimosa pudica</i> L.	H
Fabaceae	<i>Senna bicapsularis</i> (L.) Roxb.	S
Fabaceae	<i>Senna didymobotrya</i> (Fresen.) Irwin & Barneby	S
Fabaceae	<i>Senna hirsuta</i> (L.) H.S.Irwin & Barneby	S
Fabaceae	<i>Senna occidentalis</i> (L.) Link	H
Fabaceae	<i>Senna septemtrionalis</i> (Viviani) Irwin & Barneby	T
Fabaceae	<i>Senna siamea</i> (Lam.) H.S.Irwin & Barneby	T
Fabaceae	<i>Senna spectabilis</i> (DC.) H.S.Irwin & Barneby	T
Lamiaceae	<i>Hyptis suaveolens</i> Poit.	H
Myrtaceae	<i>Psidium guajava</i> L.	T
Myrtaceae	<i>Syzygium cumini</i> (L.) Skeels	T
Nyctaginaceae	<i>Mirabilis jalapa</i> L.	H
Passifloraceae	<i>Passiflora edulis</i> Sims	C
Passifloraceae	<i>Passiflora foetida</i> L.	C
Proteaceae	<i>Grevillea robusta</i> R.Br.	T
Salicaceae	<i>Dovyalis caffra</i> (Hook.f. & Harv.) Warb.	S
Solanaceae	<i>Capsicum annuum</i> L.	H
Solanaceae	<i>Cestrum aurantiacum</i> Lindl.	S
Solanaceae	<i>Datura stramonium</i> L.	H
Solanaceae	<i>Solanum campylacanthum</i> Hochst. ex A.Rich.	H
Verbenaceae	<i>Duranta erecta</i> L.	S
Verbenaceae	<i>Lantana camara</i> L.	S

#### 4.2.11. Discussion

This study documented 582 species of vascular plants which is about 30% of the currently known species for the region. In addition, 145 species were extracted from grey literature, and the East Africa herbarium plant databases following a desktop review prior to the field survey. A plant checklist of the lake basin was subsequently generated, with a total of 727 species (**Appendix 1**), indicating a rich floral diversity. This is the first such checklist for the region. A new record for Kenya *Desmodium canum* (J.F.Gmel.) Schinz & Thell. was documented for the first time during this study, the species is a recent introduced to Kenya for livestock fodder.

The species area curve generated did not reach an asymptote meaning that more species are expected to be recorded, thus further biodiversity studies are vital. Future studies should also target additional taxa such as lichens and bryophytes that were not addressed in this study.

The Kenyan part of Lake Victoria basin harbours over 2000 species of vascular plants. However, the region has a low rate of endemism with only 20 endemic plant species documented so far, this translates to a low density in endemism at 7.35 i.e 20 per species/10000 km<sup>2</sup>. Nevertheless, the region has a high species density of 768.38, compared to the coast region which has about 3000 species with a lower species density of 471.34 but has a high density of endemic species at 27.33 (Zhou et al. 2019).

Plants play an important role in human health both as a source of herbal medicine and in research and discovery of new drugs. Lake Victoria basin is an important reservoir of medicinal plants as demonstrated in this study which has recorded over 200 medicinal plants. It is therefore crucial to protect the habitats where these medicinal plants occur so as to safeguard them for current use as herbal remedies and as raw materials for future discovery of new drugs.

The importance value index calculated, indicated the majority of species with a high importance value were exotic species, planted by farmers for various reasons, most important for timber. However, a few indigenous species were also

found to have a high importance value index. There were no trees with large DBH which means trees are harvested before they acquire large diameter and even height. Trees in natural habitats also had small diameter, an indication of disturbances.

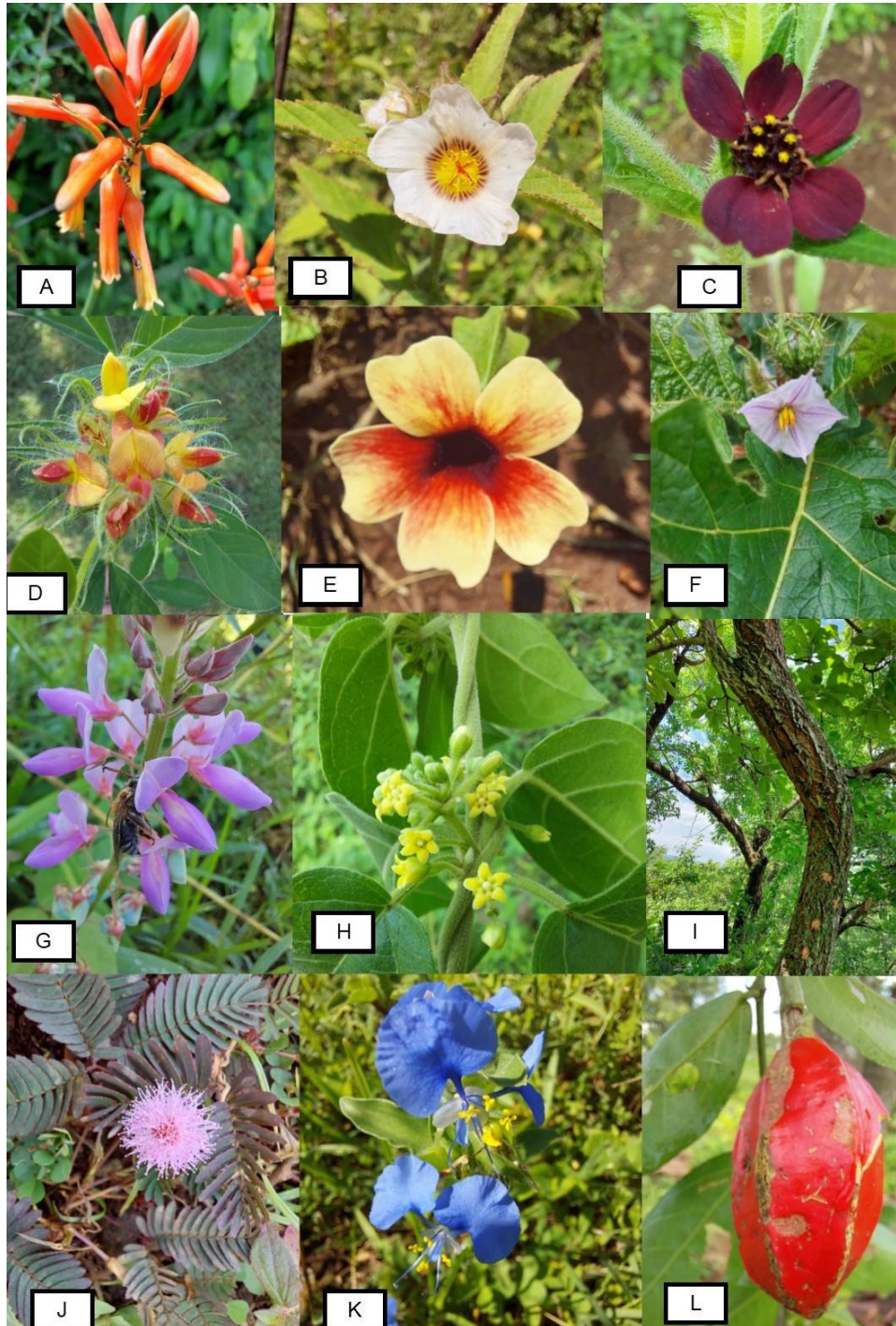


Plate 8: Some plant species found within Lake Victoria Watershed Ecosystem.

**A.** *Aloe macrostemon*; **B.** *Sida cordifolia*; **C.** *Aspilia kostachyi*; **D.** *Crotalaria ononoides*; **E.** *Thunbergia annua*; **F.** *Solanum dasyphyllum*; **G.** *Desmodium intortum*; **H.** *Pentarrhinum abyssinicum*; **I.** *Terminalia mollis*; **J.** *Mimosa pudica*; **K.** *Commelina benghalensis*; **L.** *Capparis erythrocarpos*

#### 4.2.12. Conclusion and Recommendations

Lake Victoria basin area has a rich plant diversity but with a low rate of endemism and low in species of conservation interest. The region has a species diversity that is yet to be documented as indicated by the species area curve, which did not reach an asymptote. Further biodiversity inventories are therefore recommended, which should also include taxa not assessed in this study e.g lichens and bryophytes.

Biodiversity of the natural habitats is currently threatened by ongoing encroachments in Karateng hills, Mukuro forest and Gwasi hills, this may eventually lead to the complete destruction of these few remaining natural habitats. Thus, leading to loss of ecosystem services provided by these ecosystems. These habitats are also important as carbon sinks and as refugia for important plant species and therefore need protection from further encroachment and other forms of disturbances. There is a need to contain the influx of invasive alien species, considering that a large number of IAS were documented.

Currently, biodiversity data for the natural habitats in the Lake basin watershed are scanty and fragmentary. Further biodiversity and ecological

studies in these habitats are recommended. This will help generate scientific data that would help understand these ecosystems better and therefore help in formulating appropriate management and conservation interventions.

Currently, the region lacks a simplified floral guide (see example Plate 8), which can help non-specialists and students to easily identify plant species of the local flora. The development of a pictorial plant guide of useful and common plants of Lake Victoria basin is therefore recommended.

In order to reduce the current loss of biodiversity there is need to enhance conservation, through;

- a) Rehabilitation of the degraded natural habitats through tree planting using indigenous species in collaboration with the local communities.
- b) Limit farming activities on the steep slopes in addition to terracing.
- c) Discourage destructive agricultural practices such slash and burn cultivation.
- d) Diversify means of livelihoods, through environmentally friendly activities such as cultural and ecotourism that promote environmental conservation.

## 4.3 Taxa: Fungi

By Mary Nyawira Muchane & Kelvin Maina Waithaka



### 4.3.1. Introduction

Fungi is one of the taxa whose information can help in predicting soil carbon build up in forest garden, owing to its huge potential to sequester carbon through carbon its hyphae. Fungi is a group of eukaryotic organisms that produce somatically and sexually, using spores, have glucans and chitin cell walls and are key in provision of ecosystem services in natural ecosystem (Lindahl et al., 2013). There are about 1.5 to 5.1 million species of fungi in the world, classified in eleven major phylum (Hibbett et al., 2011). Out of 1.5 million fungi species only 300,000 fungi species have been described, partly due to their existence below ground and their microscopic nature (Hawksworth, 2012). There are two categories of fungi, macro- and micro-fungi. Macrofungi are fungi species visible

to the naked eye ( $\geq 1$  cm in size) and possesses mature spore bearing and a distinct fruiting body. Globally, about 210,000 species of macrofungi are estimated. Micro-fungi on the other hand are fungi species not visible with naked eyes. Among them is arbuscular mycorrhizal fungi (AMF), belonging to phylum Glomeromycota (Schüßler et al., 2001). AMF form mutualistic associations with plant roots and account for a substantial amount of microbial biomass. In this relationship, fungi benefit from a supply of sugars from host plant species and the plants benefit from the increased absorbing capacity of mycorrhizal root systems (Smith et al., 2001). The AMF symbiosis has a wide occurrence, and associate with roots of most angiosperms, gymnosperms, pteridophytes, and even bryophytes (Smith and Read, 2007).

Both macro- and micro-fungi community are an integral part of the agriculture and forest environment that perform significant roles in maintenance of plant community through mycorrhizal associations and nutrient recycling (Boa, 2004). In their natural conditions, fungi are good indicators of environmental change influencing crucial ecosystem processes such as organic matter decomposition, pollutant degradation, nutrient cycling and productivity in terrestrial and aquatic ecosystems (Hawksworth, 2012). In particular, macrofungi are early indicators of environmental changes, and very good bio-indicator in predicting plant and animal changes in an ecosystem (Laganà et al., 2002). In addition, macrofungi are important in supporting local livelihoods through provision of food and income as well as diverse diet for wildlife and humans (da Fonseca et al. 2015). Fungi that forms symbiotic association with plant roots (ectomycorrhiza and AM fungi), further, play a critical role in plant nutrition, water uptake, protection of plants against root-borne diseases, amelioration of polluted environment and formation stable soil structure (Smith and Read, 2007). Fungi in particular mycorrhiza fungi have also been shown to play an important role in the sequestration of C in soil under elevated CO<sub>2</sub> and N deposition. Mycorrhiza fungi is estimated to sequester over 13 billion metric tons of CO<sub>2</sub> in the soil annually, equivalent to about 36% of global fossil fuel emissions (Wiltshire and Beckage, 2022). Losses of mycorrhiza fungi is often linked to poor plant nutrition, poor soil aggregation and plant ability to resist root-borne diseases, resulting to low crop production, increased soil erosion and high cost of managing soil borne diseases (Muchane et al 2012). Understanding the status of fungi diversity is therefore key in determining level of soil health, reducing climate change risks and extent of soil degradation.

Despite the vital role of fungi in natural and agro-ecosystems, fungi remain neglected during implementation of biodiversity conservation and climate change mitigation projects. However, recent studies have confirmed the significant role of mycorrhizal fungi play in global carbon flow, and have proposed the need to include mycorrhizal fungi in climate and carbon models as well as

in conservation policies and practices (Hawkins et al 2023). In addition, fungal information has been shown to predict environmental changes, changes in quality of ecosystem services and guide in development of innovative rehabilitation strategies. Under the context of forest gardens, fungi can play a vital role in predicting soil carbon build-up with time. This survey, therefore, envisaged to understand status of fungal (Macrofungi and Arbuscular Mycorrhiza Fungi) diversity in Lake Victoria Watershed Ecosystem with aim of providing baseline data upon which future biodiversity monitoring programs in forest gardens can be based. Specific objectives of this work were to: (i) document status of fungi (Macrofungi and AMF) diversity in farmlands with established forest garden (1 year) in Kisumu, Migori and Homabay counties and (ii) assess status of fungi in adjacent forested and wetland ecosystem for comparison.

#### **4.3.2. Macrofungi community within Lake Victoria Watershed Ecosystem**

The study recorded 172 macrofungi species distributed across 34 families and 69 genera in division Ascomycota (1 genera within 1 family) and Basidiomycota (68 genera within 33 families) (Figure 9, Plate 9, Appendix 2-7). In division Ascomycota, the macrofungi species belonged to class Sordariomycetes represented by Xylariaceae family, and Xylaria genus. In division Basidiomycota, macrofungi species majorly belonged to class Agaricomycetes represented by 33 families. In class Agaricomycetes, order Agaricales (72%) represented the highest proportion of families followed by polyporales (16%). The family representation in other orders (Boletales, Hymenochaetales, Auriculariales, Russulales, Phallales and Geastrales) had less than 4%. Overall, the Agaricaceae family had the highest number of specie (45) followed by Polyporaceae (25), Omphalotaceae (11), Marasmiaceae (10), Strophariaceae (8), Mycenaceae (7), Psathyrellaceae (7) and Tricholomataceae (5). Other families (30) were represented less by than 4 species each. At County level, Kisumu County recorded the highest number of macrofungi species (94 species in 29 families and 47 genera),

followed by Migori county (73 species in 23 families and 51 genera) while Homabay County (43 species in 14 families and 29 genera) had the least. Approximately 58% of the specimens were identified to species level, while 40 % were classified as a morphospecies belonging to some genus (Table 2). Approximately 0.02% of species were too old lacking major identification traits, hence were classified up to family level.

### 4.3.3. Distribution of macrofungi in different biotrophic group

The macrofungi were placed in three different biotrophic groups based on their nature of utilizing substrates to determine their distribution across the sites. The first group belonged to the saprotrophic

species potentially colonizing litter, soil organic matter and wood-based substrates. The second group represented the ectomycorrhiza fungi known to form symbiotic association with tree roots. The third group comprised of the parasitic macrofungi known to colonise dead or living trees. The Lake Victoria Ecosystem had high number of saprophytic fungi with 90% (Woodrotters 28%, soil dwellers 38%, litter decomposers 26%) representation in comparison to other groups (Figure 9). Parasitic ectomycorrhiza (ECM) species followed with 5% representation. The termite cultivated and parasitic species had least representation that comprised of 2% and 1% respectively.

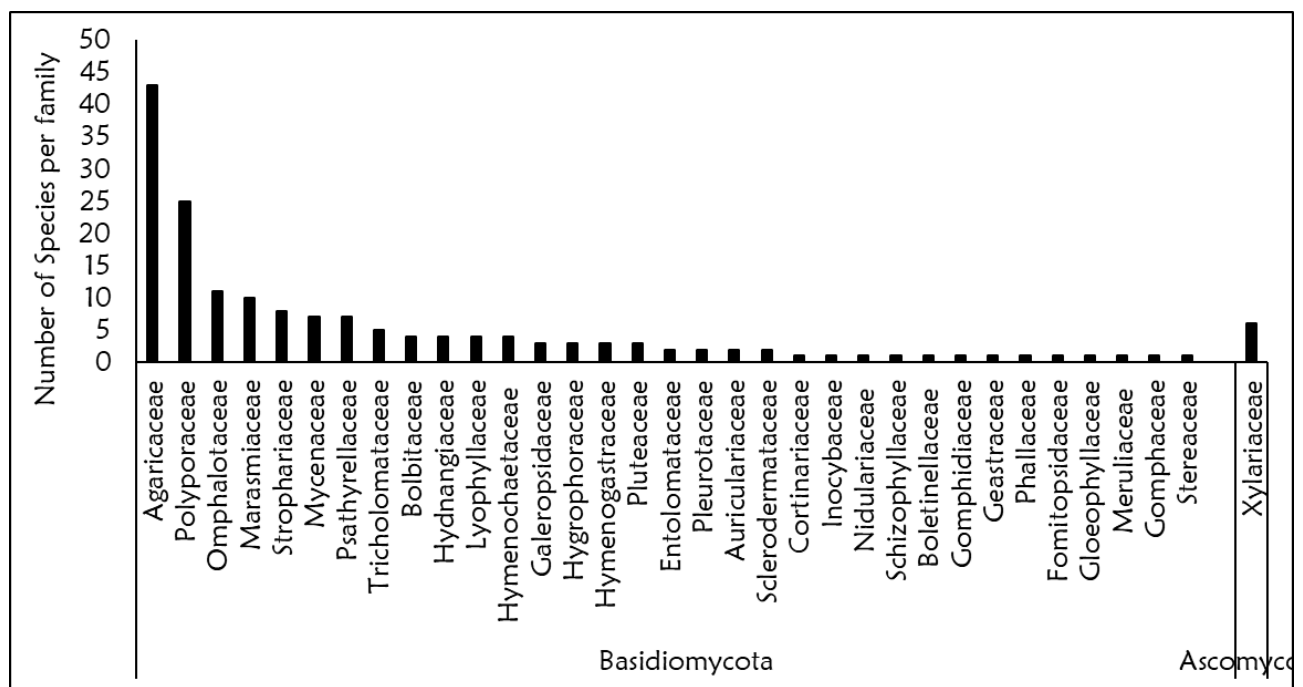


Figure 9: Distribution of Macrofungi families within Lake Victoria Water Shed Ecosystem



Plate 9: Some macrofungi species found within Lake Victoria Watershed Ecosystem

*Auricularia delicata* (a), *Leucoagaricus* sp (b), *Volvariella volvacea* (c), *Phallus rubicundus* (d), *Marasmius haematocephalus* (e), *Termitomyces aurantiacus* (f), *Lentinus triginus* (g), *Scleroderma citrinum* (h), *Laccaria laccata* (i), *Hypholoma fasciculare* (j), *Neonothopanus hygrophanus* (k), *Pisolithus arrhizus* (l), *Lentinus crinitus* (m), *Ramaria stricta* (n), *Ganoderma curtisii* (o) and *Geastrum triplex* (p)

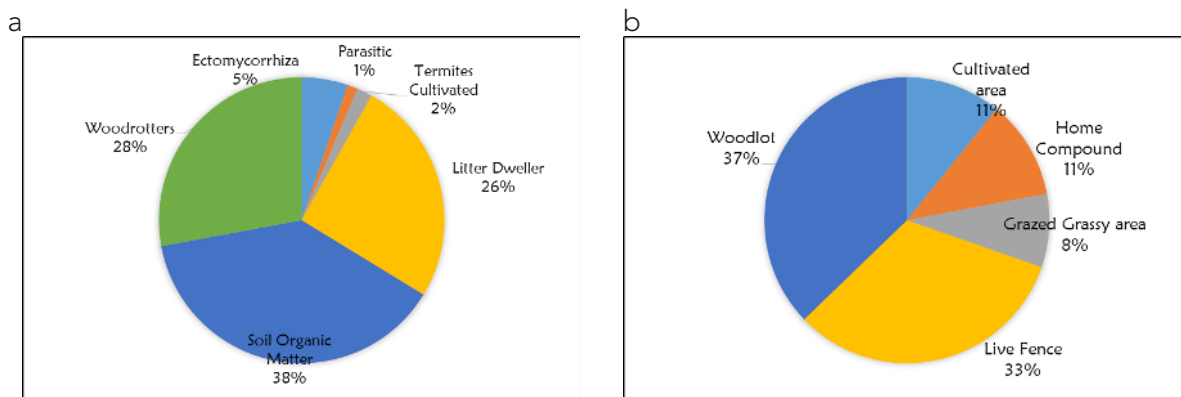


Figure 10: Quantitative distribution of macrofungi in Lake Victoria Watershed Ecosystem based on substrate (a) and land use type (b)

#### 4.3.4. Macrofungi Community across different Counties, sub-regions and landuse

Status of macrofungi species abundance, richness and diversity in Lake Victoria Watershed Ecosystem is presented in Table 9. The macrofungi species abundance ranged between 2.8 and 171.6 in a sampling unit (plot, 3600 m<sup>2</sup>) while species richness ranged between 0.2 to 8.3 species. Analysis of total species abundance and richness across all land uses (farmland, forest and wetland) revealed no significant difference ( $p > 0.05$  in all cases) across counties (Figure 11). However, analysis of species richness across sampled farmland revealed a significant difference ( $F = 4.76$ ,  $p = 0.01$ ) across counties, with farmlands in Kisumu County recording the highest macrofungi species richness compared to farmlands in Migori and Homabay counties (Figure 12). Species richness within farmlands in Homabay and Migori Counties was not statistically different ( $p > 0.05$ , Figure 12). Analysis of species abundance across sampled farmlands followed similar trends, though not statistically different across counties ( $p > 0.05$ ).

Analysis of macrofungi species abundance and richness in farmlands in various sub-regions within the counties, revealed significant differences ( $F = 2.27$ ,  $p = 0.016$ ,  $F = 2.23$ ,  $p = 0.018$ ), with farmlands in North West Kisumu, Seme and Ruma Kaskingiri sub-regions recording the highest values of macrofungi species richness and abundance (Table 9). Surprisingly, sampled forested and wetland ecosystems did not record higher macrofungi species and abundance as expected (Table 9).

Shannon–Weiner diversity index  $H'$  for macrofungi community ranged from 0.56 to 2.87, showing a relatively diverse macrofungi community in farmlands and forested ecosystems with exception to Kirika hill ecosystem which had zero diversity value (Table 9). Farmlands in Kisumu and Migori County recorded diversity values above 1.7 with exception to farmland in Kakraoi region with diversity value of less than 1.7. In Homabay County, only farmlands in Gwasssi area had a diversity value above 1.7. Farmlands in other regions (Ruma Kaskingiri and Mbita/Ndhiwa) had a diversity value of less than 1.7. Surprisingly, forested ecosystems in entire Lake Victoria ecosystem did not record

higher diversity values compared to farmlands as expected. Simpson's diversity index (D-1) showed a similar trend as Shannon  $H'$  diversity index with diversity index (D-1) above 0.5. Only two macrofungi species were recorded in Kirika Hill, hence a record of zero diversity (Table 9).

To understand influences of land use type on macrofungi species within the farmland, we classified land use types within a farmland into four categories namely cultivated area (area with cultivated crops), woodlot (area with trees), grazed grassy area (areas left for grazing livestock) and home compound (area near the house). Quantitative distribution of macrofungi species in various land uses types in a given farmland are shown in Figure 12. The highest number of macrofungi species were recorded in woodlots and live fences, with 37% and 33% representation respectively. Number of macrofungi species recorded in cultivated area and home compound followed with 11% representation while grazed grassy areas recorded the least with 8% macrofungi representation.

#### 4.3.5. Macrofungi species composition in Lake Victoria Watershed Ecosystem

To understand macrofungi species distribution across counties and land uses, a canonical correspondence analysis was conducted. Figure 11 shows how macrofungi species are distributed across the Counties and land uses. The canonical correspondence analysis revealed significant variation in macrofungi species composition across the counties and land uses (CCA,  $R < 0.73$ ,  $p < 0.06$ ), explaining between 23- 27 % of the variability in the dataset (Figure 13). The scatter plot shows Kisumu counties supported different macrofungi communities as compared to Migori and Homabay Counties. For example, Migori County supported many ectomycorrhiza species as compared to other counties.

**Table 9** Status of macrofungi species abundance, richness and diversity indices for three Counties in Lake Victoria Watershed Ecosystem. Shannon–Weiner diversity index ( $H'$ ) values above 1.7 and  $< 7.0$  indicate a diverse community. Simpson's diversity index 1-D with values close to 1 showing a diverse macrofungi community.

Table 9: Status of macrofungi species abundance, richness and diversity indices

Land use	Region	Sub-region	Abundance	Species Richness	Shannon H Index	Simpson 1-D Index
			-----Plot (3600 m <sup>2</sup> )-----			
Farmland	Kisumu	North West Kisumu	171.6	6.4	2.32	0.86
		Kisumu West	58.8	6.2	2.75	0.88
		Seme	134.8	8.3	2.87	0.92
	Migori	God-jobe	68.4	3.3	1.96	0.76
		Urii	93.0	4.2	1.95	0.76
		Kakraoi	23.1	2.3	1.47	0.56
	Homabay	Gwasssi	10.1	2.4	2.42	0.88
		Ruma Kaksingiri	105.6	4.8	1.55	0.67
		Mbita/Ndhiwa	48.6	3.0	1.64	0.73
Forest	Kisumu	Karateng Forest	21.6	3.0	2.11	0.83
	Migori	Mukuro Forest	11.6	3.0	2.32	0.87
		Timlich Ohinga	43.8	5.4	2.44	0.87
	Homabay	Kirika Hill	2.8	0.2	0.00	0.00
Wetland	Kisumu	Seme	32.2	1.4	1.39	0.72
	Migori	N/A	N/A	N/A	N/A	N/A
	Homabay	N/A	N/A	N/A	N/A	N/A

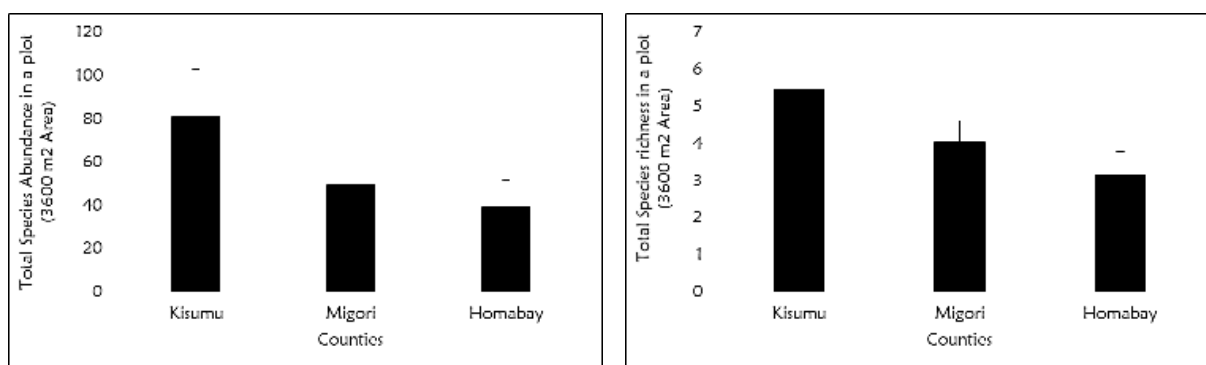


Figure 11: Distribution of macrofungi species abundance (a) and richness (b) across all land uses

Distribution of macrofungi species abundance (a) and richness (b) across all land uses (farmland, forests and wetland) in the three counties in Lake Victoria Watershed Ecosystem (Figure 11). Error bars represent standard error at  $p \leq 0.05$ .

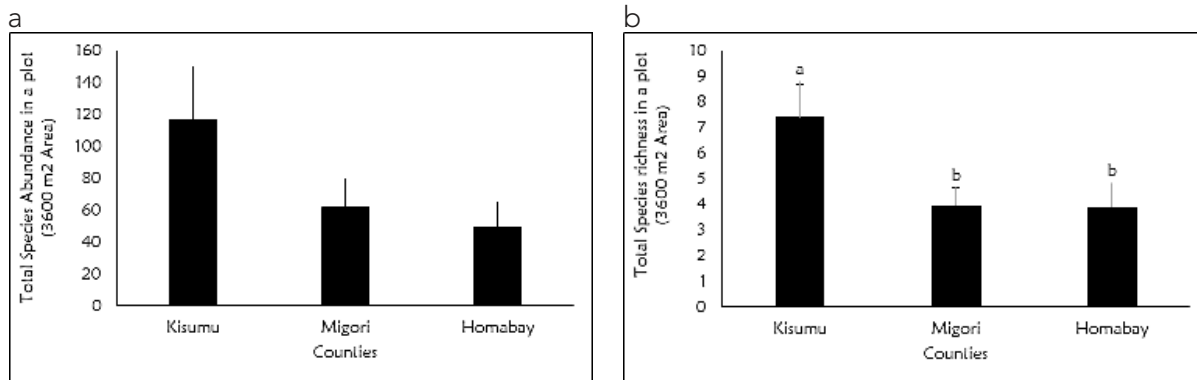


Figure 12: Distribution of macrofungi species abundance (a) and richness (b) across farmlands

Distribution of macrofungi species abundance (a) and richness (b) across farmlands alone in the three counties in Lake Victoria Watershed Ecosystem (Figure 12). Errors bar represent standard error at  $p \leq 0.05$ .

Arbuscular Mycorrhiza Fungi species composition in Lake Victoria Watershed Ecosystem (Figure 13). Canonical correspondence analysis (CCA) are shown using species abundance in 50 g of soil. Vectors representing different counties and land uses are shown in green. Size and orientation of the vectors represent correlation among them and with the axes. The smaller the angle between the vectors (or a vector) and the longer the vectors, the more correlated are the variables represented by the vectors. See key to species in appendices 1-3.

### 4.3.6. AMF Species

Identification based on spore morphology indicated 58 AMF species distributed across five families and eleven genera (Figure 14 Table 10, Plate 10). Acaulosporaceae family had the highest number of species (21), followed by Glomaceae (18) and Gigasporaceae (13). Diversisporaceae and Claroideoglomeraceae families had the lowest number of species (each family had 3 species). Thirty-five AMF fungi species were identified to species level while twenty-three AMF species could not be identified to species level but were morphologically different from the other species in the genera and were thus maintained as separate morphotypes (Table 10). *Acaulospora* species had the highest representation with 36% of total AMF species, followed by *Glomus* with 22% total

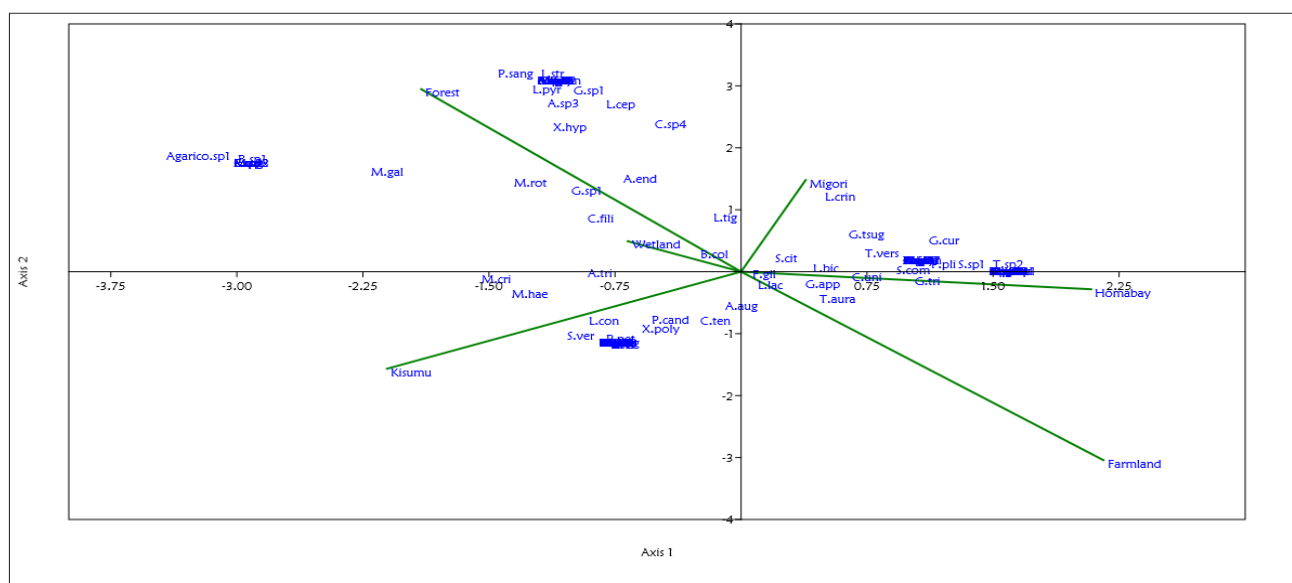


Figure 13: Arbuscular Mycorrhiza Fungi species composition in Lake Victoria Watershed Ecosystem

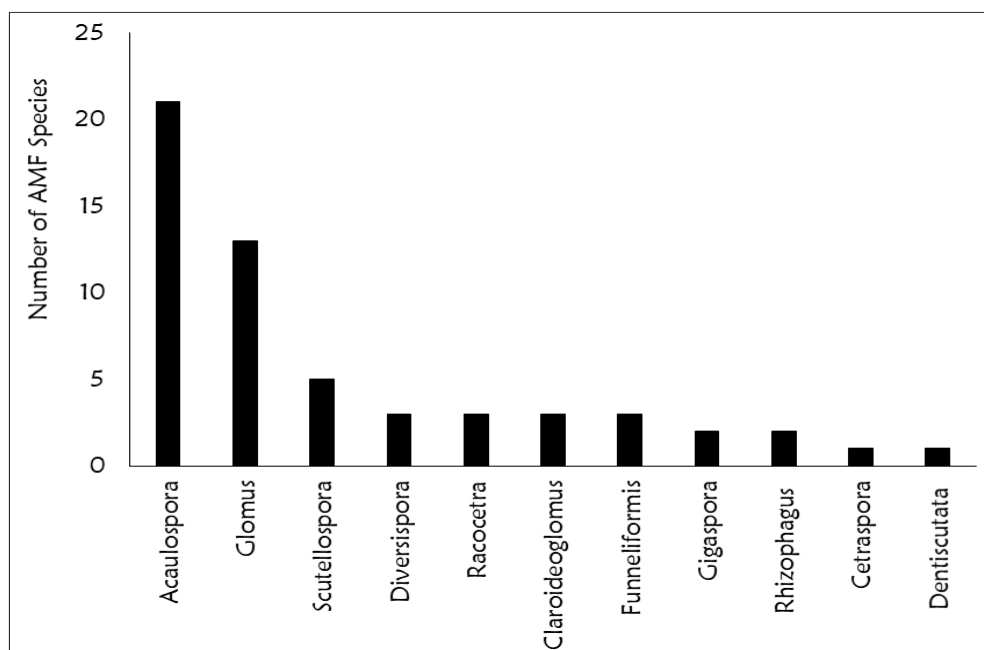


Figure 14: Distribution of Arbuscular Mycorrhiza Fungi genera in Lake Victoria Water Shed Ecosystem

species representation and *Scutellospora* with 9% total species representation. Other species in other genera had 5% representation or less (Figure 14). At County level, Kisumu County recorded the highest number of macrofungi species (51 species

in 5 families and 10 genera), followed by Migori county (38 species in 5 families and 11 genera) while Homabay County (42 species in 5 families and 8 genera) had the least.

Table 10: Spore numbers of Arbuscular Mycorrhizal Fungal species (per 50 g soil) in Lake Victoria Watershed Ecosystem

Family	Genus	Species	Kisumu	Migori	Homabay
Acaulosporaceae	<i>Acaulospora</i>	<i>alpina</i>	1.0	0.1	1.4
		<i>bireticulata</i>	–	–	0.2
		<i>delicata</i>	–	0.4	–
		<i>denticulata</i>	0.2	–	–
		<i>excavata</i>	0.2	0.1	0.2
		<i>gegadensis</i>	0.2	0.3	0.1
		<i>herrerae</i>	4.2	2.5	3.5
		<i>mellea</i>	2.0	2.0	4.0
		<i>morrowiae</i>	1.3	1.4	0.6
		<i>rehmii</i>	0.6	0.2	0.2
		<i>rugosa</i>	0.2	–	0.2
		<i>scrobiculata</i>	3.8	2.9	5.3
		<i>sieverdingii</i>	4.0	1.3	3.5
		<i>sp1-3</i>	1.4	0.8	1.5
		<i>sp4</i>	0.1	–	–
		<i>sp5, 6</i>	0.1	–	0.1
<i>sp7</i>	0.1	–	–		
<i>sp8</i>	0.1	0.1	–		

Family	Genus	Species	Kisumu	Migori	Homabay
Diversisporaceae	<i>Diversispora</i>	<i>spurca</i>	0.2	0.2	0.2
		<i>sp1-2</i>	–	0.1	–
Gigasporaceae	<i>Cetraspora</i>	<i>pellucida</i>	0.9	1.1	0.8
Gigasporaceae	<i>Gigaspora</i>	<i>decipiens</i>	1.9	3.1	1.8
		<i>gigantea</i>	0.9	1.2	1.4
Gigasporaceae	<i>Dentiscutata</i>	<i>nigra</i>	0.1	0.3	0.1
Gigasporaceae	<i>Racocetra</i>	<i>fulgida</i>	1.4	1.4	0.7
		<i>gregaria</i>	0.1	–	0.7
		<i>persica</i>	2.0	1.2	1.0
Gigasporaceae	<i>Scutellospora</i>	<i>calospora</i>	6.3	1.7	1.6
		<i>dipurpurascens</i>	0.7	0.5	0.2
		<i>scutata</i>	0.4	1.3	0.9
		<i>sp1</i>	0.5	0.9	0.4
		<i>sp2</i>	0.2	–	–
Claroideoglomeraceae	<i>Claroideoglomerus</i>	<i>etunicatum</i>	0.5	–	0.1
		<i>lamellosum</i>	0.5	0.4	0.5
		<i>sp1</i>	0.2	–	–
Glomeraceae	<i>Funneliformis</i>	<i>coronatum</i>	0.2	–	–
		<i>geosporus</i>	4.3	1.7	5.0
		<i>mosseae</i>	0.6	–	–
		<i>caledonius</i>	–	–	0.2
	<i>Glomus</i>	<i>aggregatum</i>	0.8	0.3	–
		<i>ambisporum</i>	4.3	3.3	1.7
		<i>hoi</i>	1.0	0.9	0.4
		<i>macrocarpum</i>	–	–	0.4
		<i>multicaule</i>	–	0.1	0.9
		<i>Sp1, 2</i>	0.4	0.4	0.2
		<i>Sp3-4</i>	0.3	–	0.3
		<i>Sp5</i>	0.1	0.2	–
	<i>Rhizophagus</i>	<i>clarus</i>	0.4	–	–
		<i>sp1</i>	0.2	–	0.3

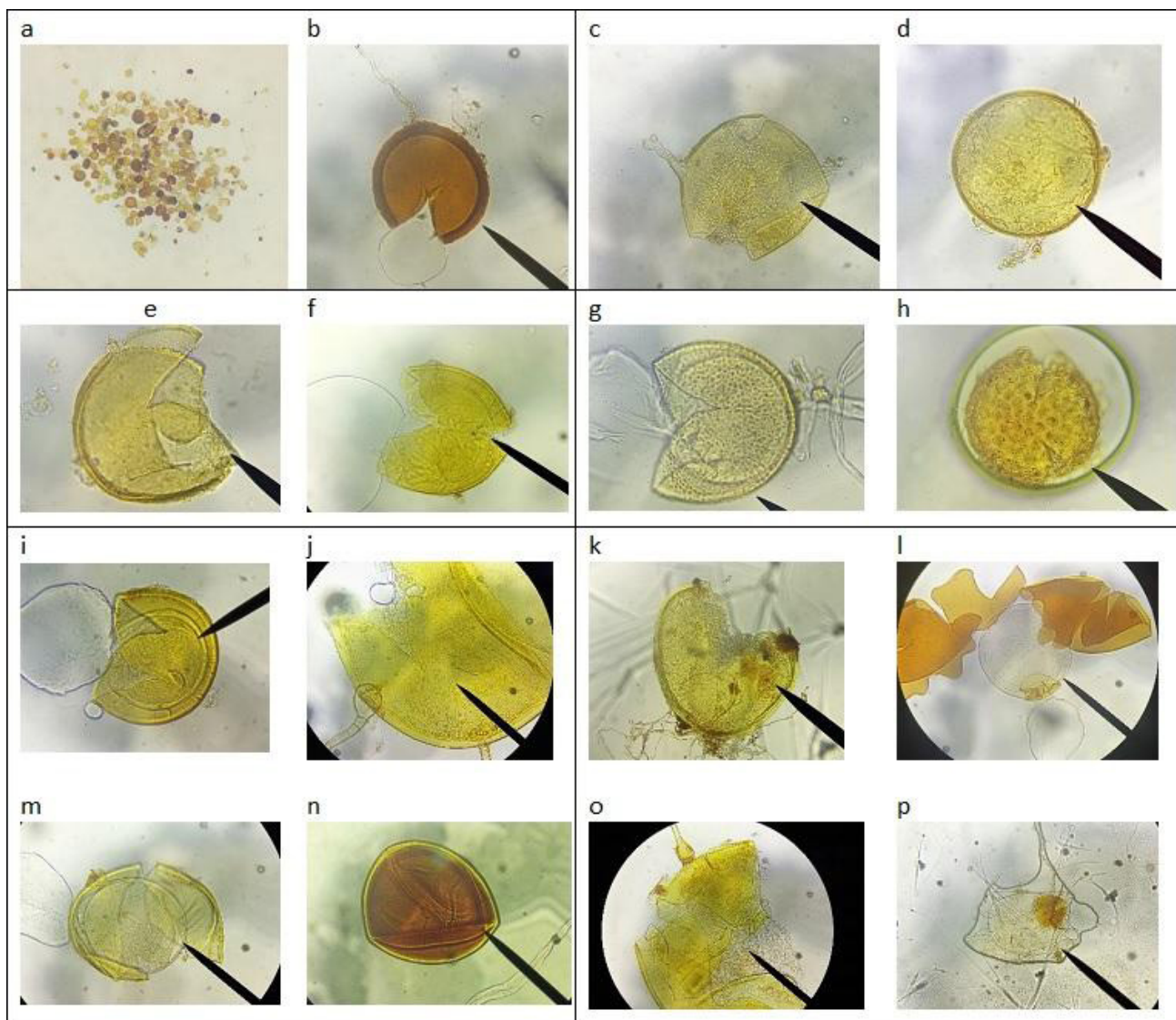


Plate 10: Some Arbuscular Mycorrhiza Fungi species found within Lake Victoria Watershed Ecosystem

AMF spore diversity in a sample under dissecting microscope (a), *Glomus ambisporum* (b), *Funneliformis geoporus* (c), *Claroideoglomus etunicatum* (d), *Rhizophagus clarus* (e), *Acaulospora herrerae* (h), *Acaulospora scrobiculata* (g), *Acaulospora bireticulata* (h), *Acaulospora mellea* (i), *Gigaspora decipiens* (j), *Gigaspora gigantea* (k), *Racocetra persica* (l), *Scutellospora calospora* (m-n), *Scutellospora dipurpurascens* (o), *Scutellospora scutata* (p) (Plate 10)

#### 4.3.7. Status of Arbuscular Mycorrhiza Fungi species diversity

Status of Arbuscular Mycorrhiza Fungi (AMF) in Lake Victoria Watershed Ecosystem is shown in Table 11. The AMF species abundance ranged between 75 and 292 spores per 250 g while species richness ranged between 15 to 30 species per 250 g of soil across different counties, region and land uses. Analysis of total species abundance and richness in all land uses revealed a significant difference ( $F = 3.05$ ,  $p=0.05$ ,  $F = 3.76$ ,  $p=0.03$  respectively) across counties, with Kisumu County recording

the highest AMF species abundance and richness, followed by Homabay County (Figure 15). Migori County recorded the least species abundance and richness (Figure 15). However, analysis of total abundance and richness across farmlands in the three counties showed no significant differences ( $p>0.05$  in all cases, Figure 16). There was however trends of high species richness and abundance in farmlands in Kisumu County.

In counties, species richness and abundance across sub-regions showed variabilities (Table 11). In Kisumu County, farmlands in Seme sub-region

had the highest values of species richness and abundance, followed by north west Kisumu while Kisumu West had the least. In Migori County, farmlands in God-jobe had the highest species richness and abundance, followed by farmland in Kakraoi while farmland in Uriri had the lowest. In Homabay County, farmlands in Mbita/Ndhiwa sub-region had the highest species richness and abundance, followed by farmlands in Gwasssi while farmlands in Ruma Kasingiri region had extremely low levels. Sampled forested and wetland ecosystems did not record high AMF species and abundance as expected (Table 11).

Shannon–Weiner diversity index  $H'$  for AMF community ranged from 2.31 to 2.93 showing a relatively diverse fungi community in both farmland and forested ecosystems. Surprisingly, forested ecosystems in Migori Region recorded lower diversity values compared to farmland. Simpson’s diversity index  $D$  showed a similar trend as  $H'$  with Migori forests having the lowest value ( $D = 0.86$ ) while farmlands in Uriri region recorded the highest species diversity ( $D = 0.93$ ) (Table 11).

#### 4.3.8. Arbuscular Mycorrhiza Fungi species composition

Figure 17 shows how AMF species were distributed across the Counties, sub-regions and land uses. The canonical correspondence analysis did not reveal significant shift in AMF species composition across different counties, regions and land uses (CCA,  $R < 0.5$ ,  $p < 0.05$ ). However, the scatter plot show trends of natural ecosystems (forest and wetland) supporting different AMF communities as compared to the farmlands. Macrofungi species community showed in Homabay County as compared to other counties. Natural ecosystems and farmlands in Homabay counties supported more species from family Glomeraceae as compared to other families. Status of Arbuscular Mycorrhiza Fungi (AMF) species abundance, richness and diversity indices for three Counties in Lake Victoria Watershed Ecosystem (Table 11). For Shannon–Weiner diversity index ( $H'$ ), values above 1.7 and  $< 7.0$  indicate a diverse community; hence, all habitats in this study fit this criterion. Simpson’s diversity index  $1-D$  showed a high diversity for all habitats with values above 0.9 close to 1

Table 11: Status of Arbuscular Mycorrhiza Fungi (AMF) species abundance, richness and diversity indices

Land use	Region	Sub-region	Species	Species	Shannon	Simpson
			Abundance	Richness	H Index	1-D Index
-----250 g soil-----						
Farmland	Kisumu	North West Kisumu	207	26.00	2.65	0.90
		Kisumu West	194	26.00	2.65	0.89
		Seme	255	30.00	2.88	0.92
	Migori	Suna East	254	23.00	2.76	0.92
		Uriri	132	26.00	2.93	0.93
		Suna West	148	18.00	2.56	0.91
	Homabay	Gwasssi	172	25.00	2.85	0.92
		Ruma Kasingiri	75	15.00	2.46	0.90
		Mbita/Ndhiwa	297	30.00	2.72	0.90
Forest	Kisumu	Karateng Forest	197	25.00	2.75	0.91
	Migori	Mukuro Forest	81	13.00	2.07	0.84
		Timlich Ohinga	130	18.00	2.17	0.82
	Homabay	Ruma Kasingiri	292	19.00	2.39	0.88
Wetland	Kisumu	Seme	277	25.00	2.51	0.88
	Migori	N/A	N/A	N/A	N/A	N/A
	Homabay	N/A	N/A	N/A	N/A	N/A

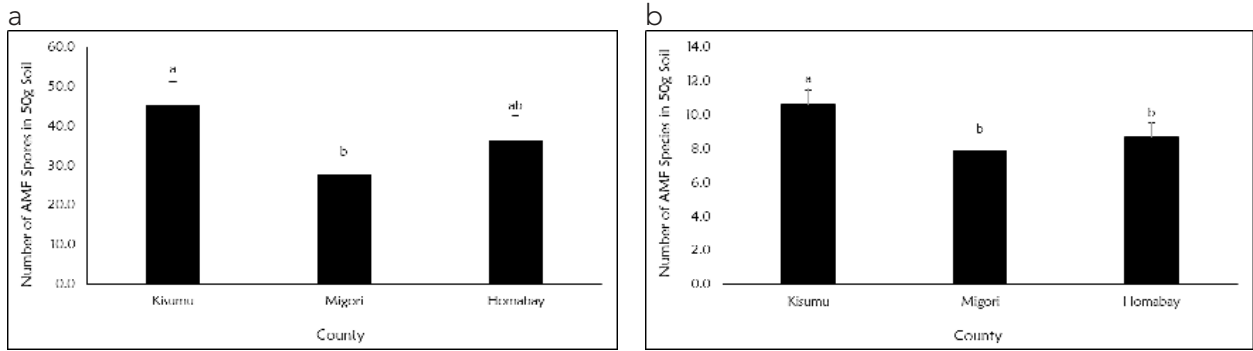


Figure 15: Distribution of AMF species abundance (a) and richness (b) across all regions land uses

Distribution of AMF species abundance (a) and richness (b) across all regions land uses in the three counties in Lake Victoria Watershed Ecosystem (Figure 15). Kisumu county had high AMF species variability and abundance as Errors bar represent standard error at  $p \leq 0.05$ .

Arbuscular Mycorrhiza Fungi species composition in Lake Victoria Watershed Ecosystem. Canonical correspondence analysis (CCA) are shown using species abundance in 50 g of soil. Vectors representing different counties and land uses are shown in green (Figure 17). Size and orientation of the vectors represent correlation among them and with the axes. The smaller the angle between the vectors (or a vector) and the longer the vectors, the more correlated are the variables represented by the vectors. See key to species in appendices 1-5.

### 4.3.9. Unique fungi Species in Lake Victoria Watershed Ecosystem

This work yielded saprophytic (90%), ectomycorrhizal (5%), termite cultivated (2%) and parasitic (1%) species (Figure 17). Saprophytic community is majorly responsible for nutrient cycling, carbon sequestration and maintenance of soil health. Among the saprophytic community a wide range of edible and medicinal mushrooms species were document such as *Auricularia auricularia*, *Ganoderma applantum*, *G. sessile*, *G. curtisii*, *G. australe*, *Macrolepiota dolichaula* among others (Table 12). Termite cultivated species included three species among them *Termitomyces aurantiacus* and *Termitomyces microcarpus* (Table 12). *Termitomyces* species are a good source of food, and in this region are

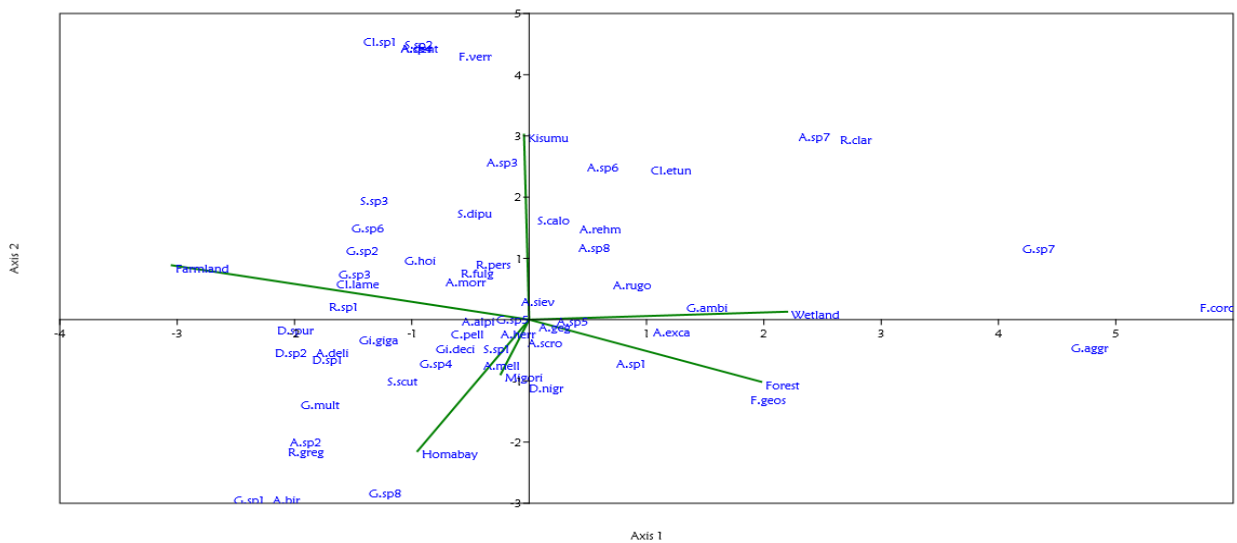


Figure 17: Arbuscular Mycorrhiza Fungi species composition in Lake Victoria Watershed Ecosystem

harvested from the wild for consumption with Ugali. Ectomycorrhiza community comprised of *Laccaria bicholor*, *Laccaria laccata*, *Pisolithus arhizus* and *Scleroderma citrinum* documented growing in association with *Eucalyptus* trees. The species enhances water and nutrient uptake of host species, improves soil structure and protects host species against soil-borne root diseases. We

also recorded a unique *Boletinus* species from Karateng forest. Most species in this genus are described as vulnerable, due to their association with leafcurl ash aphid. No critically endangered, endangered and threatened macrofungi species are reported in Lake Victoria Watershed Ecosystem.

Table 12: Selected macrofungi species and their role (nutrient cycling, food, medicine and indicators) in Lake Victoria Watershed Ecosystem

Family	Genus	Substrate	Uses
Xylariaceae	<i>Xylaria species</i>	W	NC, CS, M
Agaricaceae	<i>Agaricus species</i>	S	NC, CS, FD
	<i>Macrolepiota dolichaula</i>	S	NC, CS, FD
Hydnangiaceae	<i>Laccaria bicholor</i>	ECM	NC, CS, PN
	<i>Laccaria laccata</i>	ECM	NC, CS, PN
Mycenaceae	<i>Mycena species</i>	L	NC, CS
Marasmiaceae	<i>Marasmius</i>	L	NC, CS
Pleurotaceae	<i>Pleurotus citrinopileatus</i>	W	NC, CS, FD
Schizophyllaceae	<i>Schizophyllum commune</i>	W	NC, CS, FD
Sclerodermataceae	<i>Scleroderma citrinum</i>	ECM	NC, CS, PN
Hymenochaetaceae	<i>Fuscoporia gilva</i>	W	NC, CS, P, M
	<i>Fuscoporia torulosa</i>	W	NC, CS, P, M
	<i>Hymenochaete rubiginosa</i>	W	NC, CS, P, M
Ganodermataceae	<i>Ganoderma applanatum</i>	W	NC, CS, P, M
	<i>Ganoderma australe</i>	W	NC, CS, P, M
	<i>Ganoderma curtisii</i>	W	NC, CS, P, M
	<i>Ganoderma sessile</i>	W	NC, CS, P, M
Lyophyllaceae	<i>Termitomyces aurantiacus</i>	T	NC, CS, FD
	<i>Termitomyces microcarpus</i>	T	NC, CS, FD
Polyporaceae	<i>Lentinus species</i>	W	NC, CS, FD
	<i>Lenzite elegans</i>	W	NC, CS, FD
Auriculariaceae	<i>Auricularia auricula-judae</i>	W	NC, CS, FD

Key - nutrient cycling (NC), Carbon sequestration (CS), Parasitic (P), Plant Nutrition (PN), Biofertilizer (BF), Food (F) and Medicinal (M), soil colonizers (S), Ectomycorrhiza (ECM), Woodrotters (W), Termite cultivated (T) Food development (FD)

#### 4.3.10. Discussion

Forest garden projects have the potential of mitigating adverse effects of climate change through improved carbon storage capacity of the soil and restoration of biodiversity, that consequently lead to increased agricultural productivity and income to the farmers. This report provides status of fungi community in various land use systems in Lake Victoria region, represented by macrofungi and Arbuscular Mycorrhiza Fungi. The purpose of this report is to provide baseline information upon which fungi diversity in forest gardens can be assessed and monitored.

#### 4.3.11. Macrofungi Status in Lake Victoria Watershed Ecosystem

Results of this study show diverse macrofungi assemblage in Lake Victoria Watershed Ecosystem, with 172 macrofungi species distributed in 34 families and 69 genera. This number follows within the lower limit of what has been reported in mountainous forested (160 – 224 species) ecosystems (Kost 2002, Njuguini et al 2018, Muchane et al 2021). Since Nyanza region has tropical humid climate with wet and dry seasons favourable for proliferation of macrofungi species, this number could be an underestimate of the total mushroom species in this region. Mushroom have a short life of 1-20 days, necessitating sampling in more than one mushroom fruiting season to capture entire macrofungi community. The sampling period in this study coincided with mid-period of rainy season, suggesting we could have missed early and late fruiting macrofungi species. We therefore propose need for future survey taking into consideration seasonality and other ecological and environmental factors that influence macro-fungi diversity to complement this data.

Saprophytic fungi especially woodrotting, litter dwellers and soil colonizers fungi in Agaricaceae and Polyporaceae families dominated the macrofungi community in this region. These macrofungi species were mainly documented in woodlots and live fences as opposed to cultivated area (Figure 17). In fact, less than 15 macrofungi species were documented in cultivated soil as opposed to over 50 species documented in

woodlots and live fences. Several studies have shown high numbers of saprophytic fungi in wooded ecosystem due to presence of favorable conditions such as recalcitrant organic-based substrates, abundant wood substrates, high soil organic matter and favourable micro-climate in terms of favourable moisture conditions (Tibuhwa et al 2011, Muchane et al 2021). On the other hand, poor mushroom diversity in cultivated soil is linked to low or lack of wood substrates and low levels of soil organic matter. Macrofungi diversity in cultivated soil may be increased through use of organic inputs or through intercropping of agro-forestry tree species with the food crops. This suggests the potential forest gardens have in increasing macrofungi communities in agricultural land. The benefits of such increases include improved carbon sequestration through enhanced decomposition of organic substrate, improved soil aggregation, improved productivity (trees and crops) and income. In addition, saprophytic macrofungi species are very sensitive to changes in levels organic inputs in given ecosystems, hence a very good bio-indicator of carbon enrichment in carbon farming project such as forest gardens.

Ectomycorrhiza fungi (ECM) species were recorded in small proportion in this region, and mainly occupied woodlots planted with exotic tree species such as *Eucalyptus* and *Pines*. The numbers of ECM species were particularly high in Migori County, where most farm had *Eucalyptus* trees planted for commercial purposes. *Eucalyptus* trees are among most popular commercial plantations in Kenya, and are obligatory ECM dependent. Their growth and development depend on ECM species, explaining high number of ECM species. Our results revealed presence of *Cortinarius*, *Laccaria*, *Inocybe*, *Scleroderma* and *Pisolithus* species in *Eucalyptus* plantations in this ecosystem. Apart from Miombo woodland that support ECM species, *Eucalyptus* plantation provides alternative host for ECM species. This shows plantation forests as an important ecosystem that may help in conserving macrofungi communities not found in indigenous forests, and contribute significantly to carbon storage capacity.

*Termitomyces* species were also poorly represented in this ecosystem indicating low influence of termites in this region. Members of

*Termitomyces* live symbiotically with termites of the family Termitidae and are exclusively found in certain regions of Africa and Asia (Singer 1986, Tibuhwa et al 2011). Reports from farmers suggest presence of higher numbers of *Termitomyces* species in this region than documented, since most of these species sprout four to six weeks after on-set of rainy season. This suggests need for regular surveys to document *Termitomyces* species not found during the sampling period. Parasitic species were very few in the ecosystems, indicating presence of healthy plant community.

Our results show variation in macrofungi species abundance, richness, diversity and composition across different farmlands and ecosystems, with farmlands in Kisumu County recording higher diversity. This variation could be linked to sampling time, levels of land degradation and diversity of land uses. In Kisumu County for example, woodlots comprised of indigenous trees and few exotic tree species while in Migori County, woodlots comprised of exotic tree species, mainly *Eucalyptus* stands. In Homabay County, most farmlands and woodlots occurred in rocky areas with very young soil, and very few exotic tree species. Presence of diverse woodlots across farmland in different counties suggest differences in type and diversity of organic substrate as well as nature of micro-habitat present for proliferation of macrofungi communities. Diversity of macrofungi is known to vary depending on micro-habitats, plant species composition and diversity of organic substrate present (Muchane et al 2021), thus explaining difference observed across the counties. Taking into consideration that, carbon sequestration potential of given soil depends on fungi community, our results suggest variation in amount of carbon stored in various farmland. Promoting growth of relatively similar tree species in forest gardens across the counties, would help minimize the difference and equalize and improve carbon storage potential in entire ecosystem.

Natural ecosystems (forests, grassland) are known to support wide range of mushroom assemblage, diversity, abundance and species richness due to abundance of wood substrates from different plant species (Tibuhwa et al 2011). Contrary to our expectations forested ecosystem and farmland supported similar macrofungi diversity. These

results contrast many studies showing high macrofungi community in natural ecosystems compared to cultivated ecosystem (Tibuhwa et al 2011, Njuguini et al 2018). However, results collaborate with other studies showing low macrofungi communities in forested areas linked to destruction of favorable macro- and micro-climate (humid conditions, temperature), high levels of anthropogenic interferences, low litter fall and degradable wood substrates and presence of open gaps through degradation. In this study, the remaining natural forest remnants were highly degraded with evidences of tree cutting for charcoal and firewood. Local community in this region solely rely on remaining natural forest for energy. In Homabay and part of Migori County, remaining natural forest ecosystems are located in rocky places where farming is relatively hard, hence the soils in these natural forested ecosystems are still young, and rocks outcrops are currently undergoing weathering. This means the soil lacks potential of retaining adequate soil organic matter to support macrofungi.

#### **4.3.12. Status of Arbuscular Mycorrhiza Fungi in Lake Victoria Watershed Ecosystem**

This study has revealed 58 AMF species across Lake Victoria Watershed ecosystem. This is extremely a high number of species representation compared to what has been reported (<30 AMF species) in many regions in Kenya (Jefwa et al., 2009; Mathimaran et al., 2007, Muchane et al 2012). We attribute this observation to sampling of diverse land use systems (farmland, forest and wetland) and presence of favourable weather condition that favored growth of diverse plant communities in this region. Although farming systems in these regions are characterized by continuous cropping, the farmers have sustained diverse land uses systems in their farmland such as grazed grassland and woodlots. Minimal soil disturbances in such land uses could have contributed to high numbers of species observed. This suggests need for more detailed work that influences various land use system (grazed grassland, woodlots and farmlands) on AMF species community in this region. Despite high number of AMF species reported across the counties, species richness and spore abundance

representation were relatively low (9 species and 36 spores per 50 g soil) across all the sites. We attribute this partly to soil sampling season, which was done after the onset of rainy season and when the crops were in vegetative stage. During this sampling time, most spores germinated and AMF sporulation rate may have been low (Douds and Millner, 1999). Similarly, AMF species reported here were mainly assessed from field soil alone. Trap culture were set to reveal AMF species that may not have sporulated during the sampling period.

Arbuscular Mycorrhiza Fungi community in this region is mainly dominated by members of Acaulosporaceae family followed by members of Glomeraceae and Gigasporaceae families. Dominance of Members of Acaulosporaceae has been shown before in Kenya agroecosystems and is linked to acidic soil with soil pH less than six (Mathimaran et al 2007; Muchane et al 2012). Members of Glomeraceae on the other hand are linked to high levels of soil organic matter and high levels of soil nitrogen (Treseder and Allen, 2002, Muchane et al 2013), while members of Gigasporaceae family are shown to grow better in less disturbed soils (Jansa et al., 2002). We did not conduct soil physicochemical analysis and there are very few studies reporting soil properties in this region. A recent reports on soil properties of sugar farms in Nyando region, Kisumu County reported moderately acidic soil with low organic matter and total soil N (Amolo et al 2017). If such results are replicated in other areas in the region, this suggest high members of Acaulosporaceae compared to Glomeraceae in agroecosystems, supporting our results. Trends of high numbers of members of Glomeraceae in natural ecosystem may suggest elevated organic matter and total nitrogen levels in natural ecosystems compared to cultivated farms. Recent work on AMF communities associated with *Carissa edulis* growing under natural ecosystem reported dominance of Gigasporaceae and Glomeraceae species in the rhizosphere of *Carissa edulis* (Ogoma et al 2021), suggesting their proliferation soils with elevated organic matter. This further suggest a shift in AMF species composition towards dominance of members of Glomeraceae with increases in soil organic matter following successful implementation of forest

gardens. Detailed physicochemical analysis of soil properties are however needed to understand its influences on AMF community in this region.

Surprisingly, our results suggest a homogenous AMF community across different counties and land uses in Lake Victoria Watershed Ecosystem. We attribute this to high levels of land degradation and deforestation of natural ecosystem in this region. In Kisumu, the Karateng hills is among the few remaining natural ecosystem, which is currently highly degraded with only few indigenous plant species left. In Migori County, most of forested ecosystems have been degraded, and planted with fast growing exotic plants. In Mukuro forest, for example, the natural forested area has been replaced with fast growing exotic species (*Cypress*, *Eucalyptus*, *Pine*), and the forest is left with only a small portion of indigenous forest towards the tip of the Mukuro hills. In Homabay County, deforestation rate was estimated at 200 hectares per year especially in Gwasssi hill in early 2000 (KWTA, 2019). However, following gazettelement of Gwasssi hills as Water Tower ecosystem, this trend has been slightly minimized. High degradation levels of natural ecosystem in this region could have declined AMF species diversity and may have caused a shift in AMF species composition. In addition, most natural ecosystem in this region are located in hilly areas with very big rock outcrops and very young soil resources. There is therefore need for detailed studies to monitor influences of human activities on AMF communities in this region.

#### **4.3.13. Role of Fungi and Forest Garden in Carbon Sequestration**

Although we did not study relationship between fungi communities in this region and soil organic carbon, fungi are among soil microbial communities that plays a vital role in global carbon cycle. It has been demonstrated that fungi especially mycorrhiza fungi contribute to carbon sequestration by increasing demand for carbon in plants during photosynthesis, high biomass of extramatrical hyphae ranging between 20–80% and formation and sustainability of stable soil aggregates in the soil. Through these processes, mycorrhizal fungi for example can hold up to 50 to 70 percent of the total carbon stored in leaf litter and soil (Parihar et al.,2020). This means, changes

in mycorrhizal biomass can affect soil carbon storage capacity and the rate at which soil carbon is returned back to the atmosphere, thus making it a good predictor of soil carbon storage in an ecosystem. In addition, Arbuscular Mycorrhiza Fungi (AMF) are among soil microbial communities proposed as good bio-indicators of soil health due to their high sensitivity to environmental changes especially changes in soil properties (soil carbon), their ubiquitous distribution, diverse ecological roles, early indicator of environmental changes and remarkable biological diversity (Schalamuk and Cabello, 2010). Monitoring fungi community changes when implementing soil management strategies is therefore vital in ensuring sustainability of active AMF populations that will positively influence the soil physical, chemical and biological properties including plant health and carbon sequestration. Given their role in carbon sequestration and soil health, fungi should therefore be integral to any climate change mitigation strategy, since enhancing fungal populations and diversity can be a natural, cost-effective way to sequester carbon and improve soil health.

#### 4.3.14. Unique fungi species in Lake Victoria Ecosystem

Lake Victoria watershed ecosystem supports diverse fungi communities. The ecosystem is endowed in a wide range of *Agaricus* species. We have documented an average of 25 *Agaricus* species in this region, occurring in both grazed land, woodlots and cultivated soil. *Agaricus* species colonizes soil organic matter, and their presence in ecosystem suggest soil rich in soil organic matter. Some of *Agaricus* are edible while others are deadly poisonous. Another diverse genera in this region is *Ganoderma* (7). *Ganoderma* species are important wood-decaying fungi causing white rot. *Ganoderma* species are also pathogenic causing root and stem rot on a variety of monocots, dicots, and gymnosperms, which results in the death of affected trees. The species are also edible, consumed mainly for their high protein content (20%–30% crude protein of the dry matter), rich vitamin B, and low fat free of cholesterol. In addition, the species are also medicinal used in treatment of migraine, hypertension, asthma,

hepatitis, cancer, and cardiovascular problems. In Kenya, wild harvesting of the species for medicinal purposes is not yet documented, but elsewhere *Ganoderma* species are facing extinction necessitating urgent collection and conservation. In this site we have also documented three species of genus *Pleurotus*. *Pleurotus* species (Oyster) are white-rot saprophytic fungi on hardwood trees. The species also have nematophagous ability of catching and paralyzing nematodes. *Pleurotus citrinopileatus* species recorded in this area are edible, and are currently under cultivation. *Mycena* and *Marasmius* species were also quite abundant especially in Kisumu County. Species from these two genus were collected mainly in live fences decomposing leafy and small plant twigs. In addition, other edible species like *Auracalaria*, *Macrolepiota* among others were also documented (Appendix 2-7). We did not record macrofungi species currently red-listed in need of conservation. To date, only 280 fungi species (0.02% of fungi community) have been red-listed in IUCN, and mostly are from temperate regions (IUCN, 2019). This is very low number compared to 20-47% plant species globally red-listed as threatened with extinction (Pitman and Jørgensen, 2002). In Kenya, endemic, endangered and threatened fungi species are not yet documented. This suggest need for detailed field studies in this region to discover fungi species in need of urgent conservation measures. This information will be important in advising site-specific action plans that favorable to fungi diversity

#### 4.3.15. Conclusion

Fungi are an integral part of the agriculture and forest environment that perform significant roles in maintenance of plant community through mycorrhizal associations, nutrient recycling and mitigation of adverse effect of climate change. Results of this survey show a diverse macrofungi and AMF diversity in Lake Victoria Watershed ecosystem, hosting a total number of 171 macrofungi species and 58 AMF species. This number however may be an under-estimate of fungi communities in this ecosystem since our result is based on one macrofungi fruiting season. This suggests need for detailed studies taking into consideration seasonality as well

as ecological and environmental factors that influence macro-fungi diversity. Saprophytic fungi dominated the macrofungi community, and were mainly documented in woodlots and live fences as opposed to cultivated area. This suggests the potential forest gardens have in increasing fungi

communities in agricultural land, thus restoring soil health, productivity and carbon sequestration capacity of the soil. This being first comprehensive report on status of fungi in Lake Victoria Watershed Ecosystem, it provides baseline information for future studies.

## 4.4 Taxa: Amphibians and Reptiles

By Vincent Muchai and Atubwa Howard



Cover photo: Common species from the area and a wetland in God Jope left to right top Uganda blue headed tree agama (credit W. Wamiti), striped skink, Chevron-throated dwarf gecko, Banded banana frog, Lesser Cross-marked Toad and Nutti's river frog.

### 4.4.1. Introduction

The Herpetofauna (amphibians and reptiles) diversity differs significantly across different ecological zones in Kenya due to the varying effects of climate, vegetation, elevation, anthropogenic factors, and management policies (Ndiritu et al 2021, Ngwava et. al. 2021, Eustace, et al. 2021, Malonza et. al. 2018). This variation makes the distribution of reptiles and amphibians to be higher in others yet lower in others. In Kenya, the

highlands and montane environments tend to have fewer herpetofauna assemblages as compared to the lowlands and warmer (Malonza, 2015, Ngwava et. al. 2021, Malonza et al 2011). The distribution of these species is dependent on whether they are amphibians or reptiles. Amphibians are mostly found in highland and coastal forests while the reptiles occupy the warmer dryland areas including savannah, dryland forest, equatorial rain forests (such as Kakamega) and Lake Victoria and the coastal areas.

Amphibians and reptiles are easily affected by any environmental change in quality, state and condition (Collins & Storfer, 2003; Mazerolle, 2003). Their limited movement capability and their habitat preference makes them good environmental change indicators. In particular, the biphasic lifestyle of many amphibians of occupying both aquatic and terrestrial environments during different parts of their life cycle make their response to alteration in flow likely to differ from wholly aquatic species like fish and some amphibians (Eskew et al., 2012).

According to the National Museums of Kenya herpetofauna database, Kenya has over 260 species of reptiles comprising about 140 snakes, 110 lizards and the rest being tortoises, terrapins and crocodiles. On the other hand, there are roughly 120 species of amphibians. In Nyanza counties, there has been no coordinated herpetofauna research carried out, most of it has been sporadic collections. From the National Museums of Kenya database, no collection have been made before in Homabay except for this study. The study took place between 29<sup>th</sup> April and 14<sup>th</sup> May 2023 which was the rainy season.

#### 4.4.2. Existing data

Data obtained from National Museums of Kenya herpetofauna databases, literature and the current field work shows there are 69 species. These comprise 27 amphibians and reptiles being 42 species (see Appendix 8). Out of the 69 species, 33 were confirmed (15 amphibians and 18 reptiles) during the field study.

#### 4.4.3. Species Diversity and Abundances

After 21 days of sampling a total of 88 Time Limited Searches (TLS) were carried out, accounting for 88 man-hours. In Kisumu 31 Time Limited Searches were carried out while in Migori and Homabay they were 28 and 29 respectively. In Kisumu and Migori there were more amphibians than reptiles recorded. Migori had more amphibians and Homabay the least and on the other hand, Homabay and Migori had more reptiles than Kisumu (see table 13). It took less effort in Kisumu and Migori to find species than in Homabay while the sampling effort in Kisumu yielded more than double the specimens found in Homa bay.

Table 13: Summary of species diversity, abundances, and efforts in the Kisumu, Migori and Homabay counties

Sampling Method		Kisumu	Migori	Homabay
<b>Number of TLS</b>		31	28	29
<b>Amphibians</b>	<b>TLS</b>	14	14	8
	<b>VES</b>	3	4	0
	<b>Interviews</b>	0	0	0
<b>Combined total</b>		12	13	8
<b>Reptile</b>	<b>TLS</b>	9	5	9
	<b>VES</b>	4	3	1
	<b>Interviews</b>	2	3	4
<b>Combined total</b>		11	11	13
<b>Overall Diversity</b>		21	19	16
<b>TLS Abundance</b>		423	218	182
<b>Species sampling effort index</b>		0.677	0.678	0.551
<b>Specimen sampling effort index</b>		13.645	7.785	6.275

In terms of species diversity 33 species were recorded through all methods (See Table 14). The time limited searches was the most effective method and yielded the most species. More species were recorded in Kisumu than Migori and Homa Bay with the latter yielding the least. Species found occupied diverse habitats as shown in Table 14 with amphibians found mostly in the wetlands and the reptiles in the terrestrial habitats. This is with the exception of Nile monitor lizard, *Varanus nilotica* and the Williams mud terrapin, *Pelusios williamsi*

With more sampling there was increased number of species in all the three counties. However, the species accumulation curves did not plateau in all the three counties as shown in figure 18. This means that more species could be found with more sampling as seen in appendix 8.

#### 4.4.4. Species of Conservation Concern

All the species are of least concern (LC) in the IUCN species red list except for the *Python sebae* which is listed as near threatened (NT). Three species (Kenya Banana Frog *Africalus septentrionalis*, Kakamega agama *Agama kaimosae* and Howell's reed frog *Hyperolis howelli*) are endemic to Kenya and Tanzania. Four species of chameleons (Elliot's Groove-throated Chameleon, *Trioceros elliotii*, Flap-necked chameleon, *Chamaleo*

*dilepis*, Slender Chameleon, *Chamaleo gracilis* and Smooth chameleon, *Chamaeleo laevigatus*) plus two chelonia (Leopard tortoise, *Stigmochelys pardalis* and William's mud terrapin, *Pelusios williamsi*) are protected in CITES appendix II.

#### 4.4.5. Threats to Ecosystem and Species

##### i) Farming activities

Farming is the community's main livelihood activity in the three counties. However, this activity takes place in some areas where they are not supposed to. The Government of Kenya requires that farming activities doesn't take place six meters from riverbanks. This is not observed in most areas which affect amphibians and reptiles' habitats. Encroachment of land on top of hills which are meant to house natural forests is another big threat to habitats for amphibians and reptiles. This was rife in Karateng and Gwasi hills where farming takes place in forest areas. Other than loss of habitats there is increased soil erosion resultant from lack of cover from farming on hills.

The net effect of this is destruction of habitats and microhabitats that are occupied by amphibians and reptiles in the affected areas. This may result in species migrating to other areas, while at the same exposing others to predation, hence a reduction in their numbers.

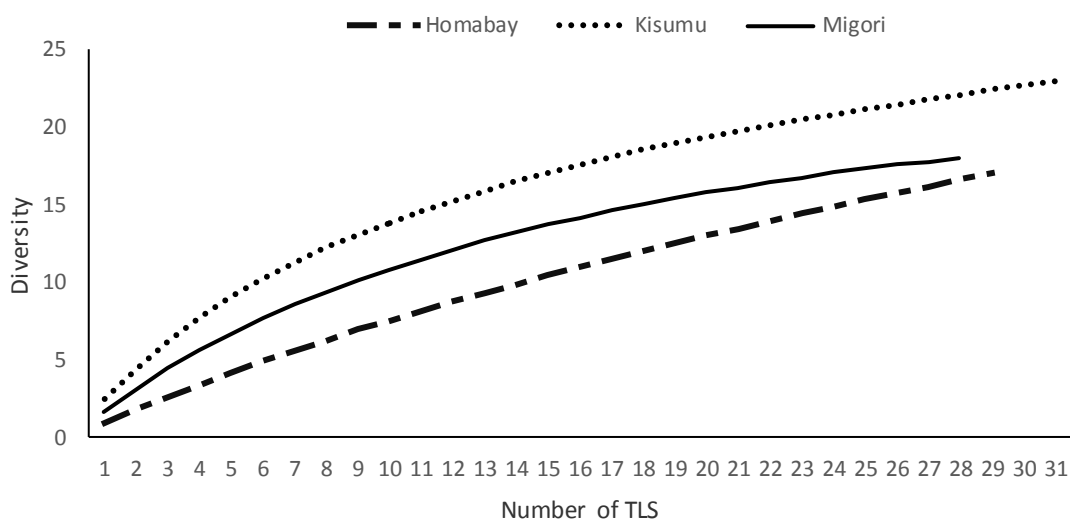


Figure 18: Species accumulation curves for the three counties

Table 14: Species recorded during the field study their common name, Habitat found, sampling and the county found

(TLS = Time Limited Searches, VES = Visual Encounter Surveys, INT=Interviews)

Species name	Common name	Type	Habitat	Sampling method	County
<i>Acanthocercus ugandaensis</i>	Uganda Blue-headed tree agama	Reptile	Trees, rocks	TLS, VES	Kisumu, Migori, Homa Bay
<i>Adolfus jacksoni</i>	Jackson's forest lizard	Reptile	Forest, trees	TLS	Migori
<i>Afrixalus fulvovittatus</i>	Banded banana frog	Amphibian	Wetland	TLS	Kisumu, Migori
<i>Agama kaimosae</i>	Kakamega agama	Reptile	Rocks	TLS	Kisumu
<i>Amietia nutti</i>	Nutt's River Frog	Amphibian	Wetland	TLS	Kisumu
<i>Bitis arietans</i>	puff adder	Reptile	Bushes, holes	VES	Homa bay
<i>Broadleysaurus major</i>	Rough-scaled Plated Lizard	Reptile	Rocks	TLS	Kisumu
<i>Chamaeleo dilepis</i>	Flap-necked chameleon	Reptile	Bushes	TLS, VES	Migori, Homa bay
<i>Chiromantis petersi</i>	Peters' Foam-nest Tree Frog	Amphibian	Wetland	TLS	Homa bay
<i>Hemidactylus mabouia</i>	Tropical house gecko	Reptile	Trees, building	TLS, VES	Kisumu, Migori, Homa Bay
<i>Hemidactylus platycephalus</i>	Baobab gecko	Reptile	Trees	TLS	Kisumu
<i>Hoplobatrachus occipitalis</i>	Crowned bullfrog	Amphibian	Wetland	TLS	Migori
<i>Hyperolius cinnamomeoventris</i>	Cinnamon-bellied Reed Frog	Amphibian	Wetland	TLS	Kisumu, Migori
<i>Hyperolius kivuensis</i>	Kivu Reed Frog	Amphibian	Wetland	TLS	Kisumu, Migori, Homa Bay
<i>Hyperolius viridiflavus</i>	Common reed frog	Amphibian	Wetland	TLS	Kisumu, Migori, Homa Bay
<i>Kassina senegalensis</i>	Bubbling Kassina	Amphibian	Wetland	TLS	Kisumu, Migori, Homa Bay
<i>Lygodactylus gutturalis</i>	Chevron-throated dwarf gecko,	Reptile	Trees	TLS	Migori, Homa bay
<i>Naja subvulva</i>	Eastern Forest Cobra	Reptile	Rock, bushes	TLS, VES, INT	Kisumu, Migori, Homa Bay
<i>Panaspis massaiensis</i>	Maasai snake-eyed skink	Reptile	Rock, bushes	TLS	Homa bay
<i>Pelusios williamsi</i>	Williams Mud Turtle	Reptile	Wetland	TLS, VES	Kisumu, Migori
<i>Philothamnus battersbyi</i>	Battersby's green snake	Reptile	Bushes	TLS, INT	Kisumu, Migori, Homa Bay
<i>Philothamnus semivariegatus</i>	Spotted bush snake	Reptile	Bushes	VES	Homa Bay
<i>Phrynobatrachus natalensis</i>	Natal dwarf puddle frog	Amphibian	Wetland, puddles	TLS, VES	Kisumu, Migori, Homa Bay
<i>Phrynobatrachus scheffleri</i>	Scheffler's Puddle Frog	Amphibian	Wetland, puddles	TLS, VES	Kisumu, Migori
<i>Ptychadena anchietae</i>	Anchieta's ridged frog	Amphibian	Wetland, puddles	TLS, VES	Kisumu, Migori, Homa Bay
<i>Ptychadena nilotica</i>	Nile Grass Frog	Amphibian	Wetland, puddles	TLS	Kisumu, Migori, Homa Bay

Species name	Common name	Type	Habitat	Sampling method	County
<i>Python sebae</i>	Central African rock python	Reptile	Bushes	IINT	Migori, Homa bay
<i>Sclerophrys kisoensis</i>	Kisolo Toad	Amphibian	Bushes, puddles, wetlands	TLS	Migori
<i>Sclerophrys pussila</i>	Lesser Cross-marked Toad	Amphibian	Bushes, puddles, wetlands	TLS, VES	Kisumu, Migori, Homa Bay
<i>Trachylepis maculilabris</i>	Speckle-lipped skink	Reptile	Bushes, rocks	TLS	Kisumu, Migori, Homa Bay
<i>Trachylepis quinquetaeniata</i>	African Five-lined Skink	Reptile	rocks	TLS	Kisumu
<i>Trachylepis striata</i>	African striped skink	Reptile	Trees, buildings, rocks	TLS, VES	Kisumu, Migori, Homa Bay
<i>Varanus nilotica</i>	Nile monitor lizard	Reptile	Bushes, wetlands	TLS	Homa bay
<i>Xenopus victorinus</i>	Lake Victoria clawed frog	Amphibian	Wetlands	TLS	Kisumu, Migori

## ii) Use of chemicals and fertilizers

Even though most of the farms under the Trees for the Future project were practicing organic farming, other farmers were using synthetic chemical pesticides and fertilizers which would end up in wetlands which are home to amphibians. Studies have shown that these chemicals affect reproduction and development of tadpoles.

## iii) Land use change

Due to pressure from population increase there is change in the land for different purposes. These include infrastructure development, reclamation of wetland for farming, farming in former forest land and construction of houses. All these affect habitats like wetlands, forests and bushes. In Homabay there were wetlands that were reclaimed for farming affecting the habitats of amphibians and some reptiles.

## iv) Destruction of forests to provide for fuel and building materials

Firewood and charcoal are the main sources of fuel in the area and with the increased population, forests and trees suffer. The same applies to sourcing of building materials.

## vii) Planting of exotic trees:

Most exotic trees affect the growth of other vegetation under its canopy leading to loss of natural habitats for amphibians and reptiles.

### 4.4.6. Recommendations

- Monitoring of amphibians and reptiles' population changes to determine and quantify the effect tree program on herpetofauna populations. This monitoring must be season conscious as herpetofauna are affected by seasonal changes.
- Encourage the farmers to protect the wetlands and any forests near them. This can be achieved through community education and being good ambassadors for the forests and the fauna therein.
- With other government agencies. Trees for the Future can engage in planting **INDIGENOUS** (emphasis on this) trees in the forests to restore the depleting forest. On top of these efforts be made to protect these lands.

- d) Encourage project and non-project farmers neighbouring farmers to plant more **INDIGENOUS** trees as compared to exotics.
- e) A good monitoring program (social economic study) to determine whether there is an increase in encounters with

problematic animals in the project farming areas. For instance, are the animals like snakes increasing and are they becoming a nuisance. If the numbers increase to levels that cause more human-wildlife conflict; a remedy like snake bite education can be applied.



Plate 11: Some of species recorded during the field study

From left to right and top to bottom: Kisolo toad, Natal puddle frog, Kivu reed frog, Nile grass frog, Anchieta’s grass frog, Puff adder, Spotted bush snake, Flap necked chameleon, William’s mud terrapin (Photo: W. Wamiti) and Maasai snake-eyed lizard.

#### 4.4.7. Discussion

One of the factors affecting the abundance and diversity of amphibians and reptiles is weather and seasonality. When it rains, the amphibians breed and are more active during this period, making them to be easily found. On the other hand, it is easier to find reptiles when it is sunny as they come out to bask in the sun, amphibians and reptiles are ectothermic animals depending on the external temperatures (Malonza & Bwong 2023, Channing & Howell 2006, Duellman & Trueb, 1986). Sampling began in Kisumu, then Migori and finally Homabay. The Kisumu sampling period was at the peak of the rainy season and therefore more amphibians recorded as compared to the reptiles. In Homabay, sampling happened as the tail end of the rainy season and therefore the fewer number of amphibians and higher reptile species as it was more sunny and drier.

There were more permanent wetlands in Kisumu and Migori as compared to Homabay where night sampling happened in puddles and roadside waterbodies, this explains the higher amphibian abundances in Kisumu and Migori. This also can be attributed to frogs congregating in wetlands where they are found in big numbers as compared to reptiles which must be searched for in different habitats where they hide. This is the same reason with a sampling index being higher in Kisumu and Migori.

The sampling period was in the middle of breeding season and captured only the wet season species. A more balanced study would entail wet season and a dry season to capture reptiles in the dry season and the amphibians in the wet season. This explains partly why the species accumulation curve didn't plateau. With continuous monitoring it is possible to increase the percentage of species recorded versus those known from a particular area (Rödel & Ernst, 2004).

#### 4.4.8 Conclusion

The three Nyanza counties of Kisumu, Migori and Homabay have a high diversity of amphibians and reptiles indicating it's a healthy and of great conservation importance. However, the area is under immense pressure from clearing of forest for agricultural land and for use as timber and fuel (charcoal and firewood). The efforts being made by the Trees for the Future to conserve and increase the tree cover is a great step towards a healthier ecosystem.

## 4.5 Taxa: Mammals

Immaculate Muthoni and Caroline Nyongesa



### 4.5.1. Introduction

A vertebrate animal that has presence of milk-producing mammary glands for feeding their young, a neocortex region of the brain, fur or hair, and three middle ear bones is the simplest way to describe a mammal. The high adaptability of mammals to different habitat conditions, food types and sources as well as short reproductive cycles, are attributed to its success and wide distribution (Grzimek, 1991). For instance, habitats occupied by different species of mammals range from deserts, semi-arid savannah grasslands, wetlands, scrublands and forest (Delany 1974; Kingdon 1974). Further, mammals are extremely diverse in their body shapes, size, diets, and lifestyle (Nedbal *et al.*, 1996). For instance, size of mammals may range from the crested porcupine (*Hystrix cristata*) weighing 20kg to the small African pygmy mouse (*Mus minutoides*) weighing only 5g and an African bush elephant (*Loxodonta africana*) that weighs approximately 6000kgs . The diet of mammals is diverse and includes roots, fruits, seeds and insects (Kingdon, 1974). Most mammals forage on plants including seeds, grains and small fruits, while omnivore species like mice and rats also feed on meat.

While Africa has 290 species of rodents, East Africa has about 101 species belonging to 12 of the 14 families in Africa (Fiedler, 1994). However, recently, Musila *et al.*, 2019, suggests about 106 species of rodents occur in Kenya. The most common rodent in the sub-Saharan Africa are the multimammate rats, belonging to the Murid genus *Mastomys* (Leirs *et al.*, 1996). Mammals are habitat specialized with each responding differently to changes in landscape complexity (Gentili *et al.*, 2014). Specifically, there are forest and open land specialists as well as habitat generalists. For, example, forest specialists avoid open patches (Tattersall *et al.*, 2002) including human-disturbed areas whereas habitat generalists, such as *Sorex araneus* (common shrew) and *Apodemus sylvaticus*, are able to thrive in a wide range of environment.

The aim of doing the biodiversity assessment of mammals in, Kisumu, Homabay and Migori (KHM) counties is to raise an appreciation and deeper understanding of mammal species, ecosystems and the interconnectedness of the living world and thereby avoid the mismanagement, misuse and destruction of biodiversity. Mammals form an important link in the ecosystem's carbon cycle by either feeding fruits, roots or carcass of other animals. With mammal conservation, it will help in efforts of protecting the health of the ecosystem.

Using 20 traps per location for two nights, the capture entailed a total of 22 individual rodents consisting of eight species dominated by *Mus domesticus* (27%), followed by *Mastomys natalensis*(18%) and *Lemniscomys striatus* and

*crocidura suaveolens* at (14%) while *Arvicanthis niloticus* and *Luphuromys ansorgei* had (9%) whereas *Cricetomys ansorgei* and *Grammomys aridulus* were the least common with (5%). The overall rodent diversity in KHM was low.

Table 15: Species of small mammals captured using Sherman trap in the sampled area

Species Name	Locality	County	Habitat Type	Geo Ref	Date
<i>Crocidura suaveolens</i>	Nyabere	Kisumu	Farmland	0.01390500, 34.63239833	02/05/2023
<i>Mus domesticus</i>	Nyabere	Kisumu	Farmland	0.01390500, 34.63239833	04/05/2023
<i>Mastomys natalensis</i>	Farmland	Kisumu	Farmland	0.87882000, 34.373665	03/05/2023
<i>Mus domesticus</i>	Nyabere	Kisumu	Forest	0.01390500, 34.63239833	04/05/2023
<i>Mus domesticus</i>	Nyabere	Kisumu	Forest	0.01390500, 34.63239833	04/05/2023
<i>Mastomys natalensis</i>	Nyabere		Forest	0.01390500, 34.63239833	04/05/2023
<i>Mastomys natalensis</i>	Nyabere	Kisumu	Forest	0.01390500, 34.63239833	04/05/2023
<i>Arvicanthis niloticus</i>	Nyabere	Kisumu	Forest	0.01390500, 34.63239833	07/05/2023
<i>Arvicanthis niloticu</i>	Nyabere	Kisumu	Forest	0.01390500, 34.63239833	09/05/2023
<i>Crocidura suaveolens</i>	Nyabere	Kisumu	Farmland	0.01390500, 34.63239833	06/05/2023
<i>Gramommys aridulus</i>	Migori	Migori	Farmland	0.73707500, 34.17654883	07/05/2023
<i>Mus domesticus</i>	Migori	Migori	Farmland	0.73707500, 34.17654883	07/05/2023
<i>Luphuromys ansorgei</i>	Migori	Migori	Farmland	0.73707500, 34.17654883	07/05/2023
<i>Lemniscomys striatus</i>	Migori	Migori	Farmland	0.73707500, 34.17654883	07/05/2023
<i>Lemniscomys striatus</i>	Migori	Migori	Farmland	0.73707500, 34.17654883	07/05/2023
<i>Luphuromys ansorgei</i>	Migori	Migori	Farmland	0.73707500, 34.17654883	08/05/2023
<i>Mastomys natalensis</i>	Migori	Migori	Farmland	0.73707500, 34.17654883	08/05/2023
<i>Mus domesticus</i>	Migori	Migori	Farmland	0.73707500, 34.17654883	08/05/2023
<i>Lemniscomys striatus</i>	Migori	Migori	Farmland	0.73707500, 34.17654883	08/05/2023
<i>Cricetomys ansorgei</i>	Mukura village	Migori	Forest	1.03405, 34.37585	09/05/2023
<i>Mus domesticus</i>	Ochola farm, homabay	Homabay	Farmland	0.68624624, 34.11939165	04/05/2023

Although there was identical trapping effort in all the site, rodent abundance and species richness varied across the 12 sampling sites. *Lophuromys ansorgei*, *Lemniscomys striatus*, *Grammomys aridulus* and *Cricetomys ansorgei* were only captured in Migori area. The area with the highest rodent diversity was Migori with 7 different species and 11 individual species only *Arvicanthis niloticus* was not captured.

Kisumu came in second with 3 species and had 10 individual species. *Arvicanthis niloticus* was only captured in Kisumu. Homabay had the least number of species. *Mus domesticus* was the only species

captured in all the sampled counties (KMH) and had the highest number tallying up to 6 individuals and mostly captures in human habitats, (Farmland).

#### 4.5.2. IUCN Listed mammals and their special concern in Kenya

All the captured and sighted mammals in KHM in this survey are widespread in Kenya and globally therefore listed as of Least Concern (LC) on the IUCN Red List of Threatened Species (IUCN, 2023). This was an indication that the species were assessed by the IUCN and were not indicated as threatened prior to the time of the survey.

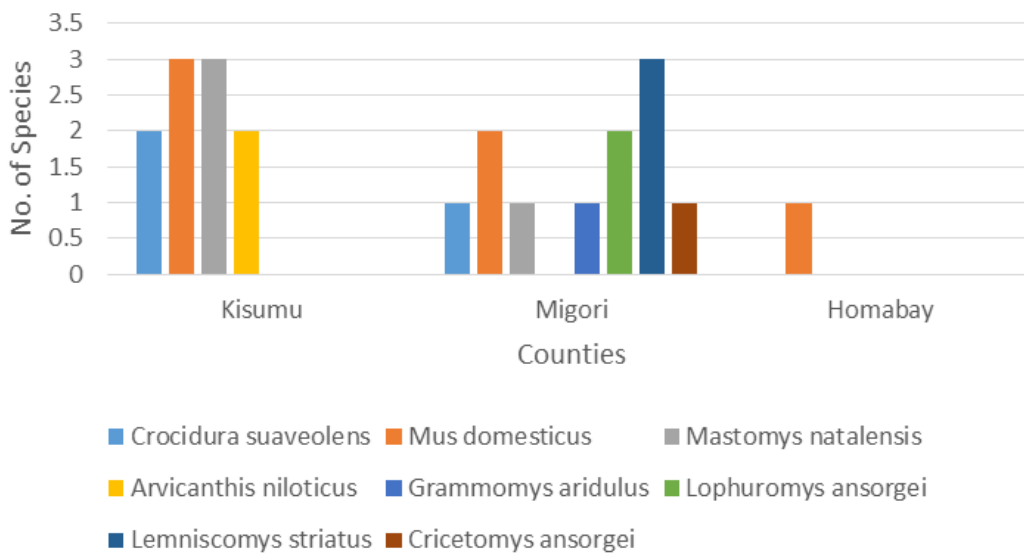


Figure 19: Distribution of rodent species in Kisumu, Migori and Homabay counties

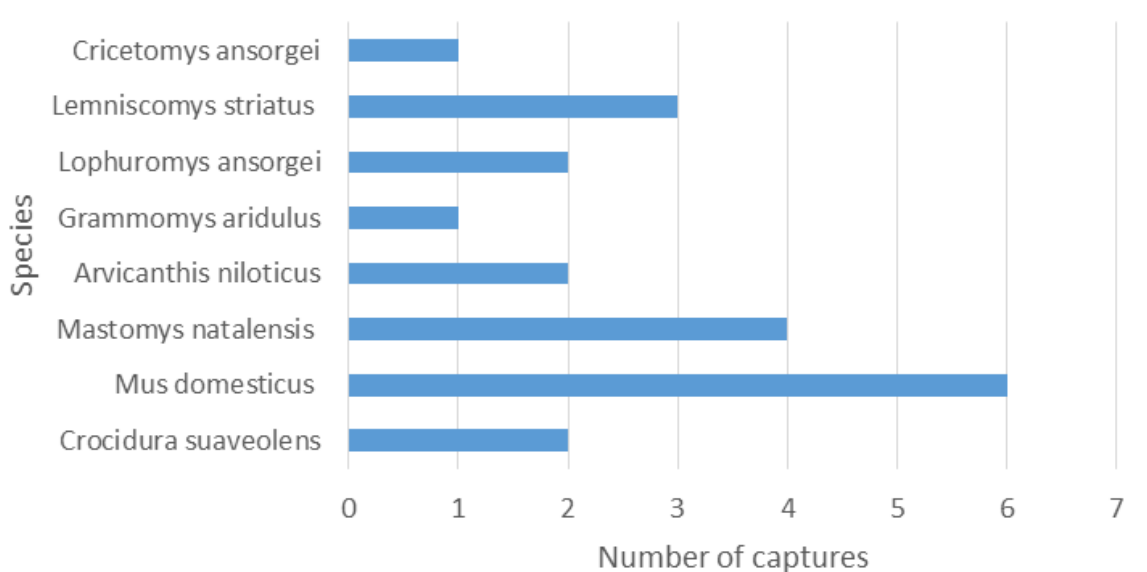


Figure 20: Number of individual species recorded captured by sherman trap in different transects in Kisumu, Migori and Homabay

### 4.5.3. Habitat Variability

The 12 sites sampled were classified into two vegetation types namely farmlands and forest. The forest sites were classified as control whereas the farms were the measured variable. The selected forests were within the sampled farms. Mostly the farmlands had farmed plantations like, maize, beans, sorghum, *Calliandra calothyrsu*, *Cajanus cajan*, *glycine max*, *Lantana camara* among others.

On the other hand, forest had shrubs mostly, plants like *Searsia natalensis*, *Olea capensis*, *Ocimum suave*, *Solanum incanum* and *Balanites aegyptiaca* were the common plants in the forest. The farmlands dominated with a high number of captures, 15 individual species. Only 7 individual species were captured in the forest capture. Of

the 8 species, *Crocidura ansorgei*, *Grammomys aridulus*, *Lophuromys ansorgei* and *Lemniscomys striatus* were only captured in farmlands while *Arvicanthis niloticus* and *Cricetomys ansorgei* were only captured in forest area. Only *Mus domesticus* and *Mastomys natalensis* were captured both in farmlands and forest.

### 4.5.4. Carbon Sequestration

Although carbon sequestration, a process of capturing and storing carbon dioxide from the atmosphere, is not directly related to mammalogy, it could indirectly affect mammals by reducing the amount of carbon dioxide in the atmosphere and mitigating climate change, which could help preserve habitat for mammals.



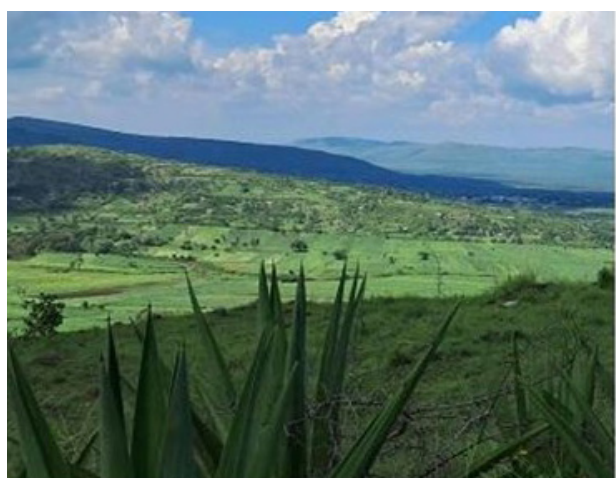
a



b



c



d

a & b -farm land, c & d -grazing land

Plate 12: Different habitat that were sampled for mammals during the survey

The presence of rodents both greatly promote humus carbon and nutrient storage relative to all other treatments, highlighting that invaders such as mole rats can alter soil carbon sequestration and nutrient capital. During the field assessment, mole rat burrowings were spotted in different farms. Rodent bioturbation is considered a vital process that impacts the soil carbon cycle. Biogeochemical effects of rodent bioturbation are still insufficient even though rodents contribute substantially to soil bioturbation and are globally distributed. Mole rats feed mostly on tubers, roots and corn. It is believed that they have enlarged hindgut for food fermentation that helps in digestion of fibrous plant material which has low nutritional value (Buffenstein, 1993). Some mammal footprints were spotted close to a very active ant hill an indication of the mammal feeding on the termites.

#### 4.5.4. Discussion

##### **Rodent species diversity (Richness, Evenness) and abundance**

The KMH has eight rodent species, of which six are native (*Lemniscomys striatus*, *Crociodura ansorgei*, *Arvicanthus niloticus*, *Grammomys aridulus*, *Lophuromys ansorgei*, *Mastomys natalensis* and *Cricetomys ansorgei*) while one was invasive/exotic commensal species (*Mus domesticus*). *Mus* sp. have a flexible social structure, but typically they live in small groups consisting of a dominant male, one or several adult females with their litters and several subordinate mice of both sexes which contributes to increase in their numbers (DeLong, 1967; Lidicker, 1976; Bronson, 1979; Berry, 1981; Singleton, 1983; Gray et al., 2000). The dominance



Plate 13: Mole rat burrowing in one of the farms

of *Mus domesticus* (house mouse) in KHM with 27% (6/22) suggests its adaptability to the current anthropogenic activities in the farm.

Therefore, the prevalent human activities, including farming, road networks and other infrastructure, account for a significant ecosystem disturbance. According to Casula *et al.*, (2017), habitat disturbance that modifies habitat structure affects small mammal populations. Overall, human disturbance seems to drive local extirpation of rodent species, especially in farmland habitats (Wan *et al.*, 2022, Granjon *et al.*, 2005).

It is also significant to note that the generalist species *Mastomys* sp contributed most to small mammal numbers at the sampled transects. *Mastomys* are largely associated with humans to the extent that they now have very inadequate tolerance for surroundings away from buildings. It is also known to be a major pest in crop plantations, where its diet is known to be grains (Mulungu *et al.*, 2011). Generalist species are favoured when the grain size of the patches is small (costs of specialisation are high) and habitat productivities are similar (profits from each habitat are about the same). Specialists have the advantage when habitats are relatively coarse grained, where costs of habitat selection are reduced (Manor 2008; Brown 1998; Morris 1996).

Species diversity is perhaps the most desirable and studied entity in conservation biology. Despite the growing concern, no consensus has emerged over the effects of habitat modification on species diversity. Even for comparatively well-studied taxa, disturbance has been reported to increase and decrease diversities with approximately equal frequency (Hill & Hamer 2004). The results of this study indicate that density dependent habitat selection processes play an important role in determining biodiversity, and that understanding the mechanisms driving these processes is necessary if changes in biodiversity in response to human disturbance are to be understood.

The pattern in abundance and diversity at KMH, where higher rodent abundance and diversity concentrated in human settled areas, suggests that anthropogenic impacts define the distribution of rodents and may select rodent species that could adapt in disturbed patches. According to

Jeffrey (1977), the clearing of forests and replacing the patches with domestic housing and cultivation increases the diversity and abundance of rodents. Vegetation structure and anthropogenic stressors may act in concert to influence the resilience, distribution, and diversity of a small mammal community (Venance, 2009; Byrom *et al.*, 2015). Most of the anthropogenic activities at KHM were in the farmland habitat and this explains the pattern in which higher rodent diversity, richness, abundance occurred in the farmlands compared to forest vegetation types.

### **Factors driving rodent abundance, species richness and diversity**

Multiple biophysical factors, such as predator risks and avoidance opportunities, intra-and inter-species competitions, resource quantity and quality, and especially the availability of water and food, influence rodent community composition, richness, abundance and diversity (Willig, *et al.*, 2003). In KMH, rodent abundance was influenced by anthropogenic activities, where farming contributed, for example, the mixed vegetation type is good grounds for nesting and source of food.

### **Habitat variability**

Vegetation type significantly influences rodent species diversity. As the food availability increased, the more diverse was the rodent diversity in KHM. Less species diversity was expected in the cleared patches for human settlements and infrastructure development in the KHM (Men *et al.*, 2015), but instead, these disturbances had large effect on rodent diversity in the farmlands than in forest areas. The findings of this work distinguish between the influence of anthropogenic activities, farming and the effect of the habitat type, forest in which such human activities occur.

Rodents like the *Cricetomys*, are usually found in forests and thickets, but also commonly in termite mounds therefore it is posited that evergreen forests provide several microhabitats and support a variety of food resources which may offer nest sites and cover to different small mammal species (Isabirye-Basuta and Kasenene 1987; Kasangaki *et al.*, 2003). In conclusion, the vegetation types influenced rodent diversity, while

species richness was only positively associated with farming activities. Vegetation and availability of food influenced rodent abundance including anthropogenic habitat disturbance.

### Carbon sequestration

The existence of rodents significantly promotes humus carbon and nutrient storage highlighting that invaders can modify soil carbon sequestration and nutrient capital. For example, some rodents are able to metabolise cellulose, the destruction of cellulose composites by rodents like mole rats and omnivorous herbivores, and there is need to protect them. Rodent bioturbation (e.g., foraging for grasses and seeds, tunnel burrowing, and excrement deposition), transfers substantial amounts of below-ground soils to the ground surface, greatly decreases the net primary productivity of the grasslands, largely reduces vegetation coverage, nutrient conditions and changes soil microclimates.

Rodent bioturbation is thus considered an important process that influences the soil carbon cycle. Although rodents contribute extensively to soil bioturbation and are globally spread, the understanding of the biogeochemical effects of rodent bioturbation is still inadequate. Surveys have shown that rodent bioturbation occurs widely across therefore showing its effect. It can therefore be postulated that rodent bioturbation significantly influences the soil organic carbon stocks of the grasslands, and further influences global climate change.

Topsoil quantification alone may prompt overestimation of the net losses in soil organic carbon, as indicators have shown that rodent burrowing activities effectively mix the soils of deeper with upper layers; additionally, rodents forage and store seeds and grasses in their nests, and they deposit urine and faeces, which returns additional organic carbon to the deeper soil layers. The patterns and extent for changes in soil organic carbon content due to rodent bioturbation may differ between different vegetation types e.g. (Tubers vs maize stalk) and rodent species (mole rat vs mus) and may be with different climate conditions. Termites play a key role in the carbon cycle by breaking down dead wood, which is a carbon sink, therefore *Cricetomys sp* which

are nocturnal omnivores, and feed on vegetation and small animals, especially insects like termites play indirect role in carbon sequestration.

### 4.5.6. Introduction

Overall, the results suggest that, for the farmer considering the benefits to biodiversity, the configuration of uncropped land set-aside is likely to make difference to small mammals. However, conservationists should look at impacts of configuration on other taxa, as well as focusing on the management of habitat patches on farmland.

Many conservation biologists argue that the application of wildlife-friendly farming methods would reduce the impact of land use intensity on biodiversity (Green *et al.*, 2005). The retention of patches of natural habitat in a mosaic of farmland habitats in a way could reduce the negative effects on wildlife. The positive association between relative human abundance and occupancy of some mammalian species suggests biodiversity could be maintained by retaining a mosaic of natural habitats within the managed landscapes. Conservation agencies should increase the level of community participation in establishment of community wildlife-conservation areas and provide incentives and compensation for wildlife damage on private properties this was in relation to primates, mostly monkeys invading some farms.

Finally, the conservation of biodiversity in subtropical natural habitat/farmland mosaics can only be successful through integrated policy and management that consider both natural and farmland ecosystems from a landscape point of view. Therefore, strategies for biodiversity conservation and management should not only target protected but also managed land which can also host significant wildlife species. Conservation science can help in political decision making and framing policies regarding land-use approaches by providing information on biodiversity value (Barlow *et al.*, 2007). There is need to conduct survey based on wet and dry season since, mammals species of dry and wet season may differ in terms of species composition between two seasons.

## 4.6 Taxa: Invertebrates

By L. Njoroge & A. Nyandiala



### 4.6.1. Introduction

Invertebrates can be found in all kinds of ecosystems both terrestrial and aquatic where they play an integral role in their functioning. They provide important ecosystem services which include pollination, nutrient recycling, indication of changes in the environments as well as control of harmful species such as pests of crops and vectors of diseases. They are also very important in food webs and chains where they form an important food source for other higher life forms such as fish, birds, reptiles and mammals. Their ability to change with changing environments has made them indicators of choice to monitor ecosystem changes (Brown, 1997; Stork & Eggleton, 1992). The advantage of using invertebrates as indicators is the fact that they are highly diverse thereby indicating diverse things.

A survey of invertebrates was carried out in May of 2023 in three counties in western Kenya namely Kisumu, Homa Bay and Migori. The main

purposes were to first document what exists and also to identify and develop faunal indicators of restoration success that more comprehensively reflect changes in biodiversity and ecosystem function. Of particular interest were faunal indicators of elevated soil and aquatic carbon to complement the existing methods that calculate carbon sequestration.

### 4.6.2. Invertebrate assemblage and diversity

A total of 231 different invertebrate species belonging to 15 different orders were recorded during this survey. Checklists are provided in Appendices. The relative abundances of the orders are given in figure 21 below. The Lepidopterans (butterflies & moths), Araneae (spiders) and the Hymenopterans (bees, wasps & ants) were the most diverse group. A great majority of species were very common and widespread in the three counties. This was as expected as sampling was done in similar habitats in farmlands. Although the



Flower feeding Rose beetles



Citrus swallowtail butterfly



Green-banded swallowtail butterfly

Plate 14: Some woodland dependent species from the three Counties

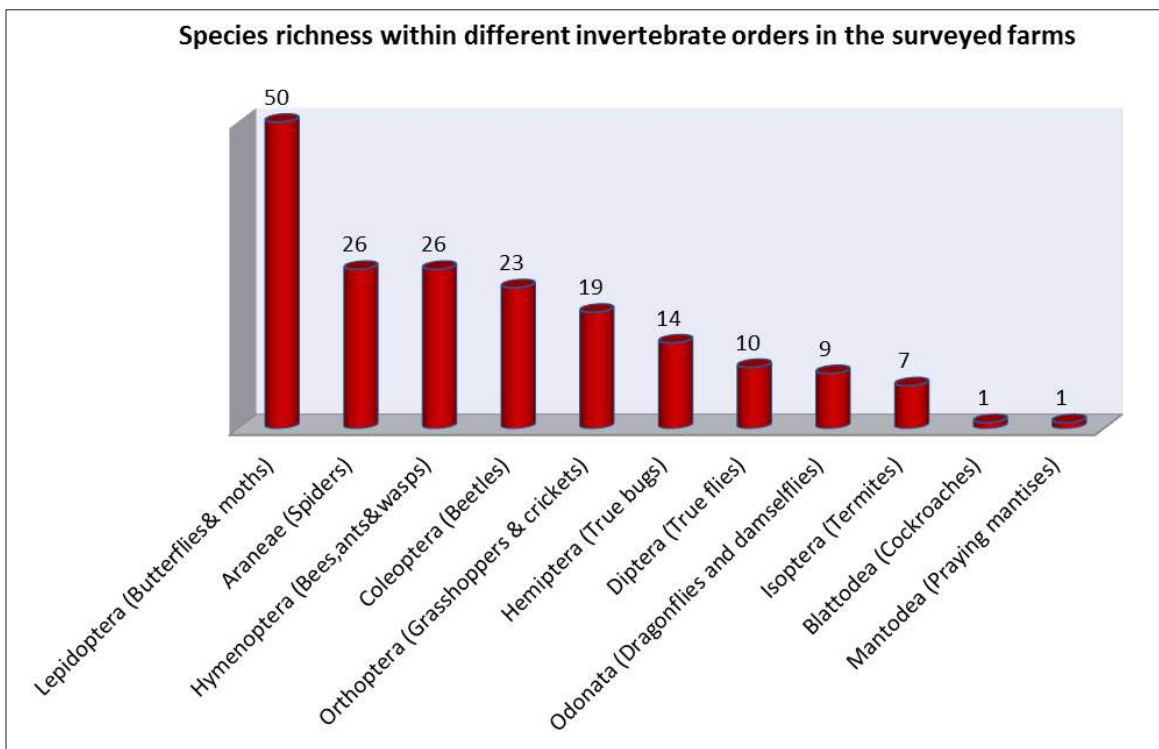


Figure 21: Relative abundances of the invertebrate orders from the three counties in May 2023

few sampled natural habitats did not necessarily have significantly higher species diversity, they had unique and highly specialist species. Groups such as swallowtail butterflies (Papilionidae) and Rose beetles (Cetoniinae) were only recorded in natural forests or in farmlands with woodlots of native species.

#### 4.6.3. Indicators of ground and below ground carbon:

Several carbon dependent groups of invertebrates were chosen as good indicators of the presence of soil carbon. These are the termites (Isoptera) earthworms (Oligochaetes), millipedes (Myriapoda) and snails (Molluscs). All these groups are essential for soil health as they act as decomposers helping recycle nutrients back in to the soil. Of these, only termites were collected in sizeable numbers both in terms of abundance and species richness.

A total of 7 termite species all belonging to 1 family (Termitidae) were collected. Their distribution in the surveyed counties is given in appendix 9-12. Most colonies were found in close proximity to sources of carbon such as woody trees and shrubs. The number of species as well as the number of visible live colonies is recommended as indicators of availability of soil carbon in the future as compared to the baseline. There are other carbon dependent taxa that will be worth considering for future monitoring.

There was a small concern among some farmers regarding a possible increase in termites with increase in carbon within the farms. Termites where they occur can be problematic sometimes. However, their benefits as explained outweigh the negatives. One of the benefits is that termites are a big delicacy in the 3 counties where they provide a source of cheap proteins. Also, most farmers confessed to consuming the mushrooms associated with termite mounds (Termitocytes

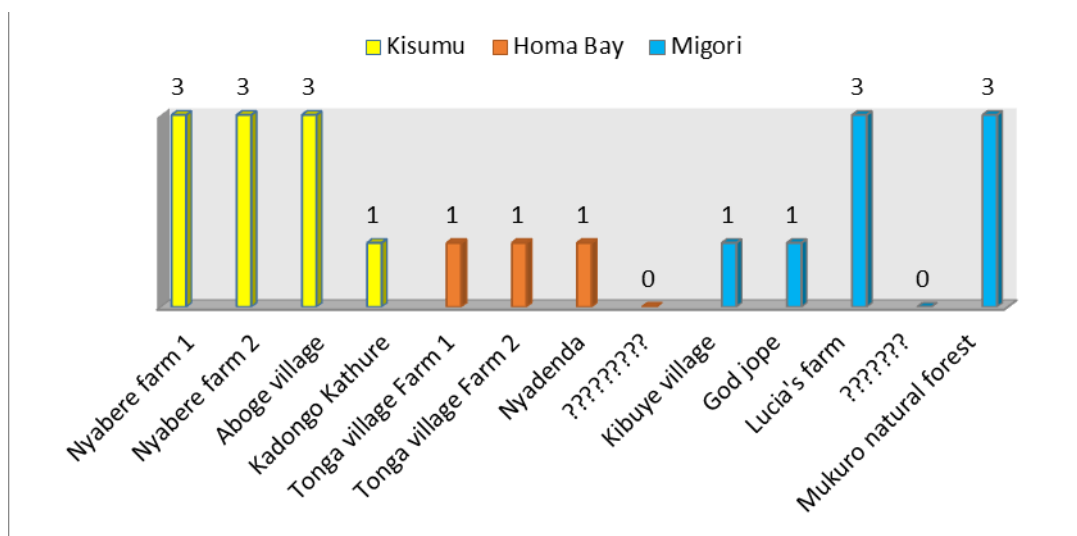


Figure 22: Species richness of termites from the three counties in May 2023



Plate 15: A collection of termite species from farmlands and natural habitats in the three Counties



Plate 16: A tree, termite mound and detritus in Nyabere village Kisumu County



Plate 17: A termite fungus comb in Migori (left), *Termitocyte* mushrooms (center) and cooked termites in Nyabere village, Kisumu County (right)

species) especially during rainy seasons.

#### 4.6.4. Indicators of above ground carbon:

##### i) Bees

A total of 18 species belonging to 3 families were collected. A checklist and their distribution are given in appendix 9-12. The diversity and also abundances of bees was low as most sampled

areas were farmlands with few native flowering plant species. There is a high interaction between flowering plants and flower visitors in general. An increase in flowering plants comes with an increase of flower visitors. A great variety of flowering plants come with a great diversity and abundance of bees for instance.

For this reason, we recommend bees as part of the taxa to be used to monitor an increase and quality of vegetation cover in the future.



A Thyrea sp. in Mukuro forest



A foraging African honey bee



A variety of carpenter bees from a farm in Nyabere village, Kisumu County

Plate 18: A variety of bees from farms and natural forests in the three surveyed counties

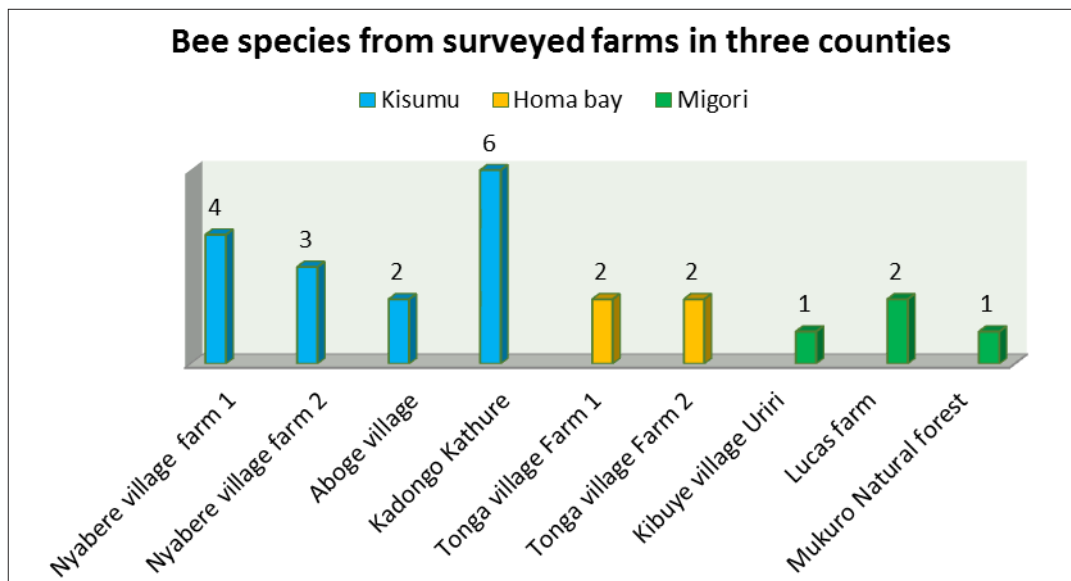


Figure 23: Species richness of bees collected in pan traps in the three counties in May 2023

**ii) Ants**

Ants are an ecologically dominant faunal group. Their interactions with many other species make them good ecosystem indicators. They are a key group in food web interactions and numerous ecosystem processes such as nutrient cycling and seed dispersal. They for instance feed on others such as spiders or make nests that double as homes for other organisms. Ant communities have been extensively used to assess a range of restored habitat types, with changes in ant species and functional composition consistently indicating

the ecological condition of restoration (Andersen & Majer, 2004). They have effectively been used as ecological indicators of rainforest restoration (Lawes et al., 2017).

The number of species and the abundances in a standardized number of pitfall traps recorded in the baseline survey will form a good basis for monitoring changes as vegetation cover changes.

**(iii) Butterflies**

A total of 47 butterflies were collected. The species richness in each of the visited farm and the natural habitats are given in figure 25 below. Majority

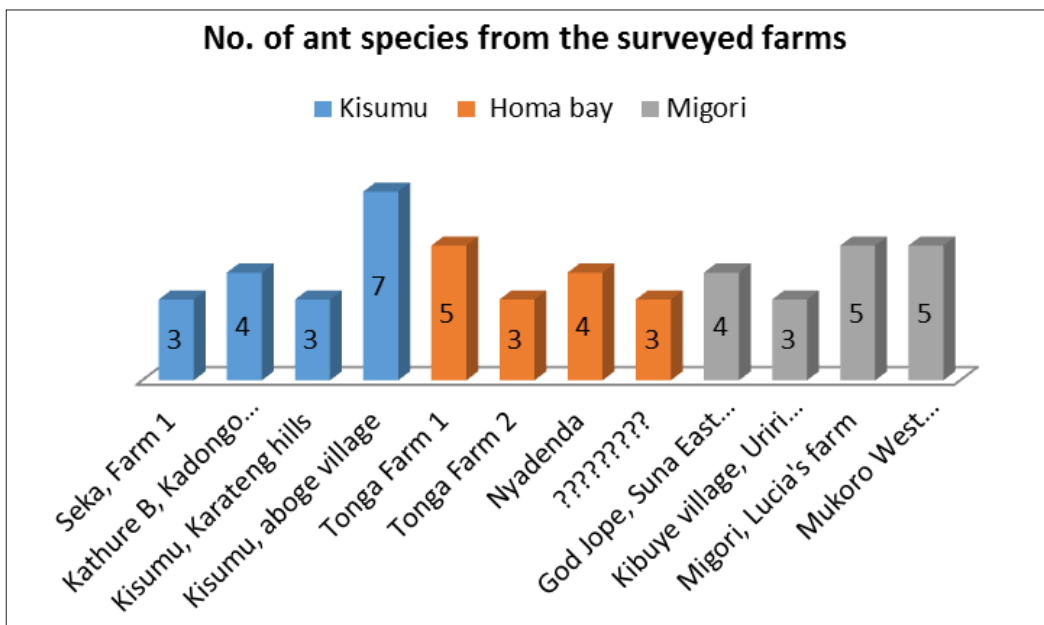


Figure 24: Species richness of ants collected in pitfall traps in the three counties in May 2023



Plate 19: Camponotus ants occupying a termite nest in Nyabere village, Kisumu County, Kenya

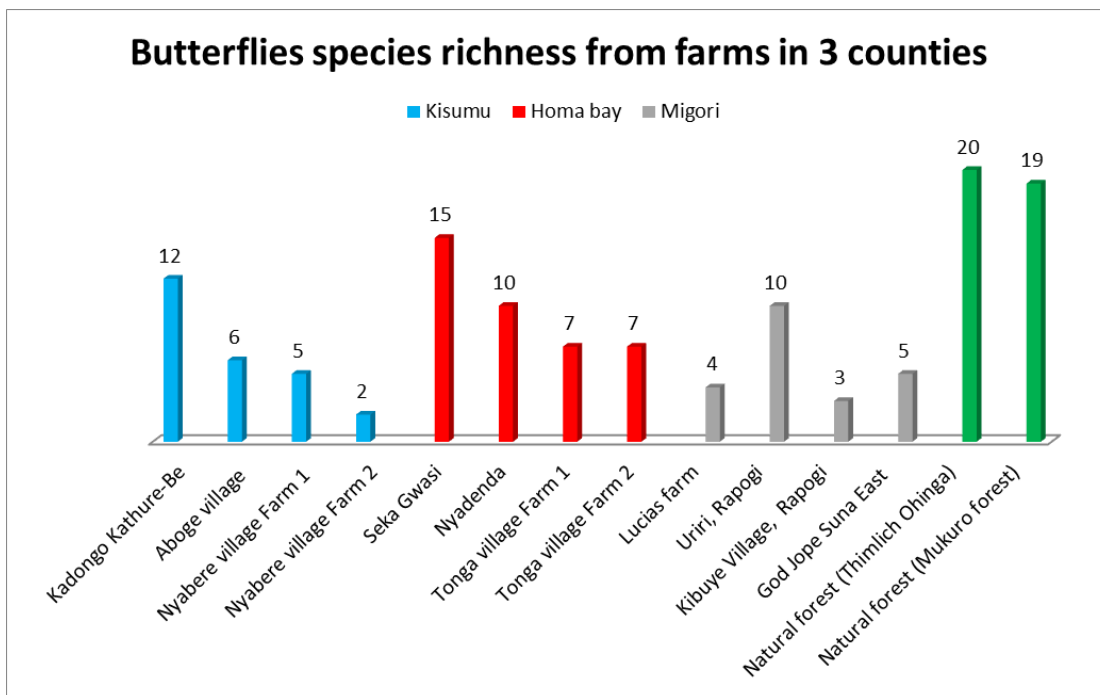


Figure 25: Species richness of butterflies in the three counties in May 2023

of the species were common and widespread occurring mainly in open areas with herbaceous flowering plants typical of most farmlands visited. Very few forests and therefore woody plants dependent species were recorded. These include genera such as Charaxes (Emperors) in the family Nymphalidae and Papilio (Swallowtails) in the family Papilionidae. An increase of these trees dependent butterfly species in established woodlots within farms will be a good measure of an improving forest cover in the future.

#### 4.6.5. Aquatic invertebrates as indicators of carbon sequestration

A total of 20 aquatic species of invertebrates were recorded from the few water sources available. The most abundant group was the lake flies (Chironomidae) especially in areas with lots of decomposing plant matter. These detritus dependent Lake flies were therefore identified as good candidates for monitoring increased carbon in aquatic systems. These were replaced by predators such as aquatic bugs and dragonflies in areas with less detritus.



Plate 20: Taking an aquatic sample in Nyabere village, Kisumu County (left) and leaves from a tree in a stream (right)

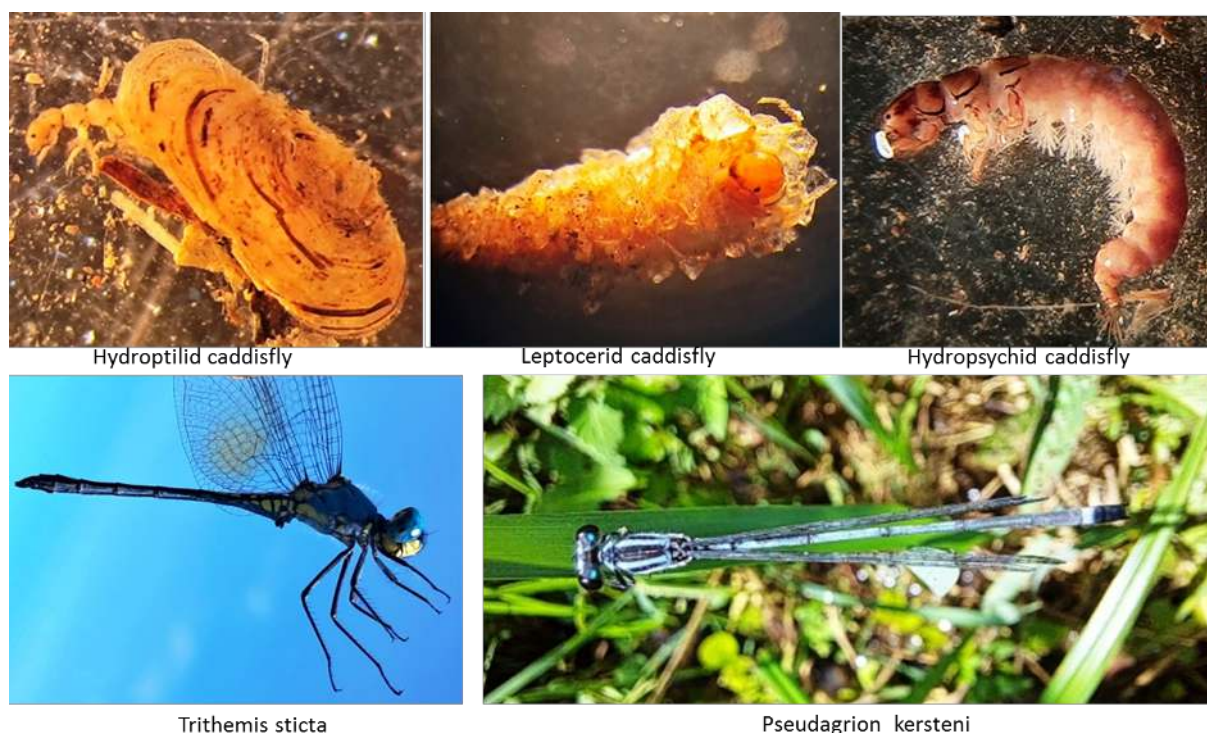


Plate 21: Different aquatic invertebrate species from Nyabere village Kisumu County May 2023

Table 16: A checklist aquatic invertebrates collected from one farm in Nyabere village, Kisumu County, Kenya in May 2023

Order	Family	Common names	Species	Total number
<b>Coleoptera</b>	Dytiscidae	Diving beetles	Laccophilus sp	1
<b>Coleoptera</b>	Gyrinidae	Whirlgig beetles	Dineutes aereus	4
<b>Coleoptera</b>	Gyrinidae	Whirlgig beetles	Dineutes subspinosus	1
<b>Coleoptera</b>	Hydrophilidae	Water scavenger beetles	Herocharis sp	3
<b>Diprea</b>	Chironomidae	Lake flies	spp	25
<b>Diptera</b>	Tabanidae	Horse flies	Haematopota sp	1
<b>Hemiptera</b>	Belastomatidae	Giant water bugs	Appasus nephoides	
<b>Hemiptera</b>	Gerridae	Pond skaters	Gerris sp	2
<b>Hemiptera</b>	Naucoridae	Saucer bugs	Laccocoris sp.	5
<b>Hemiptera</b>	Notonectidae	Back swimmers	Anisops sp.	3
<b>Odonata</b>	Coenagrionidae	Pond damsels	Pseudagrion Kersteni	15
<b>Odonata</b>	Gomphidae	Clubtail dragonflies	Paragomphus sp.	2
<b>Odonata</b>	Libellulidae	Perchers & Skimmers	Orthetrum julia	6
<b>Odonata</b>	Libellulidae	Perchers & Skimmers	Trithemis arteriosa	2

#### 4.6.6. Key recommendations:

From our preliminary findings and experiences on the ground, we make the following recommendations

1. That native as opposed to exotic species of trees (apart from fruit trees) be considered for planting
2. Farmers be encouraged to leave a portion of land uncultivated no matter how small. These areas usually have various flowering herbaceous plants that host many pollinators which provide ecosystem services in the farms. These portions as in the figure below were found to host many species of flower visitors. In instances One farm in Migori County (Lucia's farm) had a lot of *Ocimum* sp. enough for sustain bee keeping. Bee keeping can be considered for farmers in areas with good vegetation cover. Where this is not possible due to limited farm sizes, then

we recommend spacing of trees within the woodlots in a way that they allow development of undergrowths of herbaceous plants.

3. The three counties and especially Homa Bay and Migori had a high presence of earthworms in the soils. This is indicative of fertile soils high in soil carbon (humus). It will be interesting to see what the fungi team will find out regarding this. A few farms especially those more than 3 years of establishment had compost pits. We recommend that farmers can be trained on vermiculture (worm cultivation) to enhance compost production.
4. Incorporation of legumes such as pigeon peas was found to attract health varieties and populations of carpenter bees. This will not only bring diversification of the food crops in the farms but will also help increase the diversity of pollinators.



Plate 22: Flowering herbaceous plants in Migori County, May 2023



Plate 23: A compost pit in a farm in Uriri, Migori (left) and earthworms in cow dung in Lucia's farm Migori County (right)



Plate 24: A row of pigeon peas in a farm in Uriri, Rapogi, Migori County in Kenya

5. Pan traps collected *Hermatia illucens* or black soldier flies (BSFL) from the region. This fly species is gaining interest globally as an efficient way to convert bio-waste into protein-rich and fat-rich biomass suitable for animal feeding. Although studies on greenhouse gas emissions associated with BSFL rearing and bioconversion activities are limited, some studies have shown that it has a lower carbon footprint than most other sources of protein for animal feeds (Pang et al., 2020; Adeline et al., 2019). Various institutions in Kenya both government and non-government are training

farmers on how to rear the BSFL for animal feeds. One of the centres of excellence for this is indeed Jaramogi Oginga Odinga University of Science and Technology (JOOUST) in Siaya County. Collaboration with the JOOUST can be explored to train the farmers.

6. We recommend rehabilitation of any aquatic habitats within participating farms by way of restoring the riparian vegetation such as sedge grass and papyrus. Besides this vegetation contributing to the carbon sequestration, it also invites a wide range of aquatic invertebrates and especially the dragonflies.



Plate 25: Black soldier flies from Kibuye village, Rapogi, Migori County May 2023

## 4.7 Taxa: Birds

Dr Wanyoike Wamiti & Amina Kahure



### 4.7.1. Introduction

Birds are among the most diverse and widely distributed vertebrates on earth (Field, 2017), and occur in all major habitat types of the world, with forest being particularly important (BirdLife International, 2017). Kenya has a tremendous topographical diversity that support a high diversity of plants and animals, including birds (Bennun & Njoroge, 2001). The diversity of bird species in the Lake Victoria basin is thus expected to be highly influenced by the diversity of habitats and topography.

Although none of the Kenyan national endemic bird species occur in the Lake Victoria basin, Bennun & Njoroge (1999) has presented some of the key species characteristic of the Lake Victoria Basin biome and the sites that are important for birds conservation such as Kusa, Koguta, Yala and Dunga Swamps, Lake Kanyaboli, and Ruma National Park. The priority species for conservation that are endemic to this region include Papyrus Gonolek *Laniarius mufumbiri* (Near Threatened), Papyrus Yellow Warbler *Calamonastides gracilirostris* (Vulnerable), and Carruthers's Cisticola *Cisticola carruthersi* (Least Concern) (BirdLife International, 2023b).

Kenya ranks among the richest countries in Africa and the world at large in terms of bird species

diversity and richness. BirdLife International (2023a) reports that Kenya ranks 13<sup>th</sup> in the world at 1,057 species, and also presents the following statistics for this diverse avifauna: Critically Endangered species (5), Endangered (20), Vulnerable (21), and Near Threatened (29). This diversity has also attracted bird watching visitors from across the world in what is popularly known as avitourism, and thus contributing to economic growth of Kenya involved in this industry and the country in general.

### 4.7.2. Species Diversity, Abundance and Distribution

This survey recorded a total 144 bird species in 52 families from the three counties. The most diverse family was Ploceidae (weavers, bishops and widowbirds) with 12 species. Estrildidae (waxbills) followed in diversity with 8 species while Malaconotidae (helmetsrikes, bushshrikes, tchagras and puffbacks) had seven species closely followed by Cisticolidae (cisticolas and allies) and Accipitridae (diurnal birds of prey other than falcons) with six species. Appendix I3 is a checklist of all species recorded and their distribution across the sampling sites in the three counties.

Hoday Bay County had the highest number of bird species at 96 while Kisumu and Migori each had 84 and 77 species respectively (Figure 26).

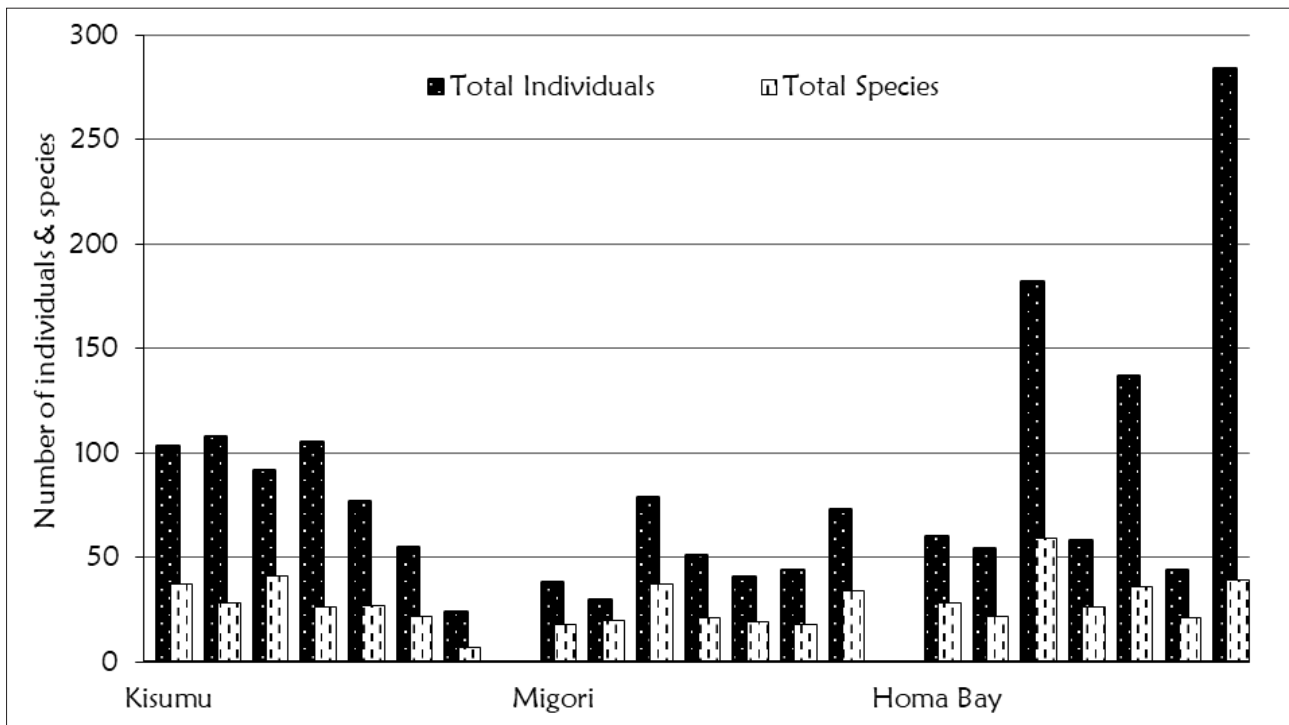


Figure 26: Overall species diversity and abundance in Kisumu, Migori, and Homa Bay counties

Figure 27 presents the abundance and total species recorded at different sites in Kisumu County. The most diverse site was Fred Otieno’s farm (KSM-03) with 41 species. It was followed by Millicent Atieno (KSM-01) with 37 species. The least diverse site was Magwar marshes, a seasonal wetland that had seven species only although it was sampled for an hour compared to other sites that were sampled for two or three hours. Appendix 13 shows the details of all the sampling sites in each county, sampling effort in terms of number of hours, time of day (morning or afternoon), and number of species recorded in each hour and overall, for each site.

The codes for the sampling sites referred to in figures 27, 28, 29 and elsewhere are as follows: **Kisumu (KSM):** KSM-01 = M.L. Otieno; KSM-02 = Joyce Kaveza; KSM-03 = Fred Otieno; KSM-04 = Joseph Juma; KSM-05 = Terrestrial habitat; KSM-06 and KSM-07 = seasonal wetlands in Migwar; **Migori (MGR):** MGR-01 = Aggrey Asiema; MGR-02 = Lucia Nyamogi; MGR-03 = Paul (Rapogi); MGR-04 = Wetland/Riverine forest; MGR-05 = Evalyne Akinyi; MGR-06 = Terrestrial/Forest habitat; and MGR-07 = terrestrial/woodland; **Homa Bay (HBY):**

HBY-01 = Kochwola; HBY-02 = Samuel Ouma; HBY-03 = Josephine Omondi; HBY-04 = Collins Otieno; HBY-05 = Kiringa Hill; HBY-06 = terrestrial/forest; HBY-07 = wetland (Lake Simbi Nyaima).

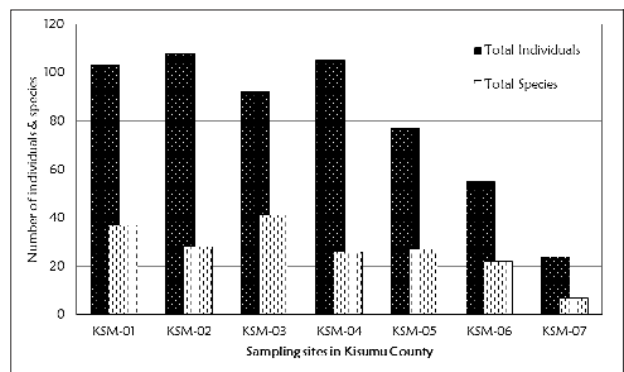


Figure 27: Species diversity and abundance in various sites in Kisumu County

In Migori County, the highest number of species was recorded in Paul’s farm in Rapogi (MGR-03) with a total of 37 species (Figure 28). Thimlich Ohinga (MGR-07), a prehistoric site preserved as a native forest habitat covering 52 acres of relatively flat land, had a total of 34 species compared to Mukoro Forest (MGR-06; 18 species) which has a bushland and exotic species plantations of Eucalyptus and Cypress.

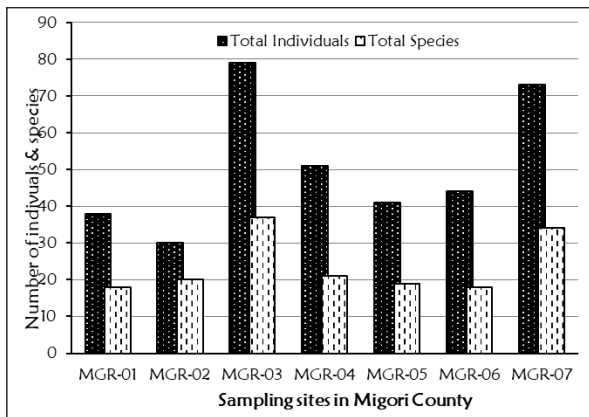


Figure 28: Species diversity and abundance in various sites in Migori County

Sites in Homa Bay County had the most species recorded when combined. The highest number of 50 species was recorded at Josephine Omondi’s (HBY-03) (Figure 29) while Lake Simbi Nyaima (HBY-07) came second with 39 species.

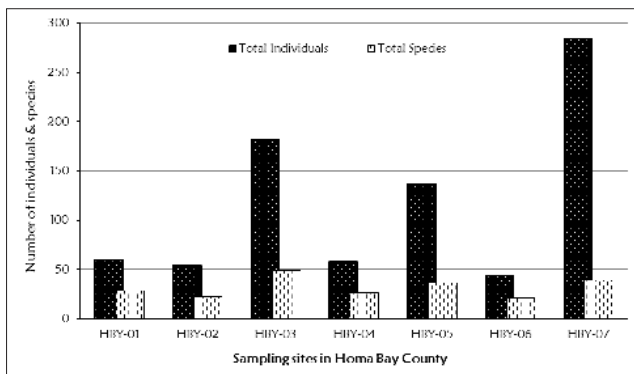


Figure 29: Species diversity and abundance in various sites in Homa Bay County

### 4.7.3. Spatial Distribution

Table 18 presents the most widely distributed species across the study sites with over 50% occurrence i.e., were found at more than half of the study sites. This proportion is expressed as a percentage. Therefore, for a species such as the Blue-spotted Wood Dove that had a 90.5% spatial distribution, it was recorded at 19 out of 21 sites.

Table 17: List of species with over 50% spatial distribution

Rank	Species common name	Percentage distribution
1	Blue-spotted Wood Dove	90.5
2	Grey-backed Camaroptera	81.0
3	Common Bulbul	81.0
4	Ring-necked Dove	76.2
5	Speckled Mousebird	76.2
6	White-browed Robin Chat	71.4
7	Tropical Boubou	66.7
8	Red-eyed Dove	61.9
9	Tawny-flanked Prinia	61.9
10	Diederik Cuckoo	57.1
11	African Paradise Flycatcher	57.1
12	Hadada Ibis	52.4
13	Common Fiscal	52.4
14	Village Weaver	52.4

### 4.7.4. Species of Conservation Concern

Three species were determined as globally threatened and therefore listed on the IUCN Red List of Threatened Species. These were: nine individuals of the Lesser Flamingo *Phoeniconaias minor* (Near Threatened) at HBY-07 (Lake Simbi Nyaima), three individuals in transit (flying) of Tawny Eagle *Aquila rapax* (Vulnerable) recorded at KSM-05 (a terrestrial habitat), KSM-06 (Magwar marshes, a seasonal wetland), and MGR-07 (a riverine woodland habitat), and the Grey Crowned Crane *Balearica regulorum* (Endangered; Figure 26) with 29 individuals at HBY-03 (Josephine Omondi’s farm neighboring Ruma National Park), and a pair flying inland over Lake Simbi Nyaima. All the other species are listed as Least Concern (LC; Appendix 13) which are species that has been evaluated against the IUCN Red List criteria and does not qualify for other threat categories, and therefore determined widespread and abundant (BirdLife International, 2023).



Plate 26: Part of the flock of 29 Grey Crowned Crane recorded foraging in Josephine Omondi's farm that neighbors Ruma National Park

#### 4.7.5. Migration status

Majority (128) of the species recorded during the survey were residents (R). The number of species in the other categories were as follows: Afrotropical migrants occurring alongside resident, non-migratory individuals (am; 9 species), Palearctic migrants (PM; 3 species), Afrotropical migrant (AM; 1 species), and one each species of am/pm (both Afrotropical and Palearctic migrants occurring alongside resident, non-migratory individuals), and am/pm/om (Afrotropical, Palearctic migrants and Oriental region migrants occurring alongside resident, non-migratory individuals). Figure 30 and Appendix 13 shows more details of species in each of these categories.

1 species), and one each species of am/pm (both Afrotropical and Palearctic migrants occurring alongside resident, non-migratory individuals), and am/pm/om (Afrotropical, Palearctic migrants and Oriental region migrants occurring alongside resident, non-migratory individuals). Figure 30 and Appendix 13 shows more details of species in each of these categories.

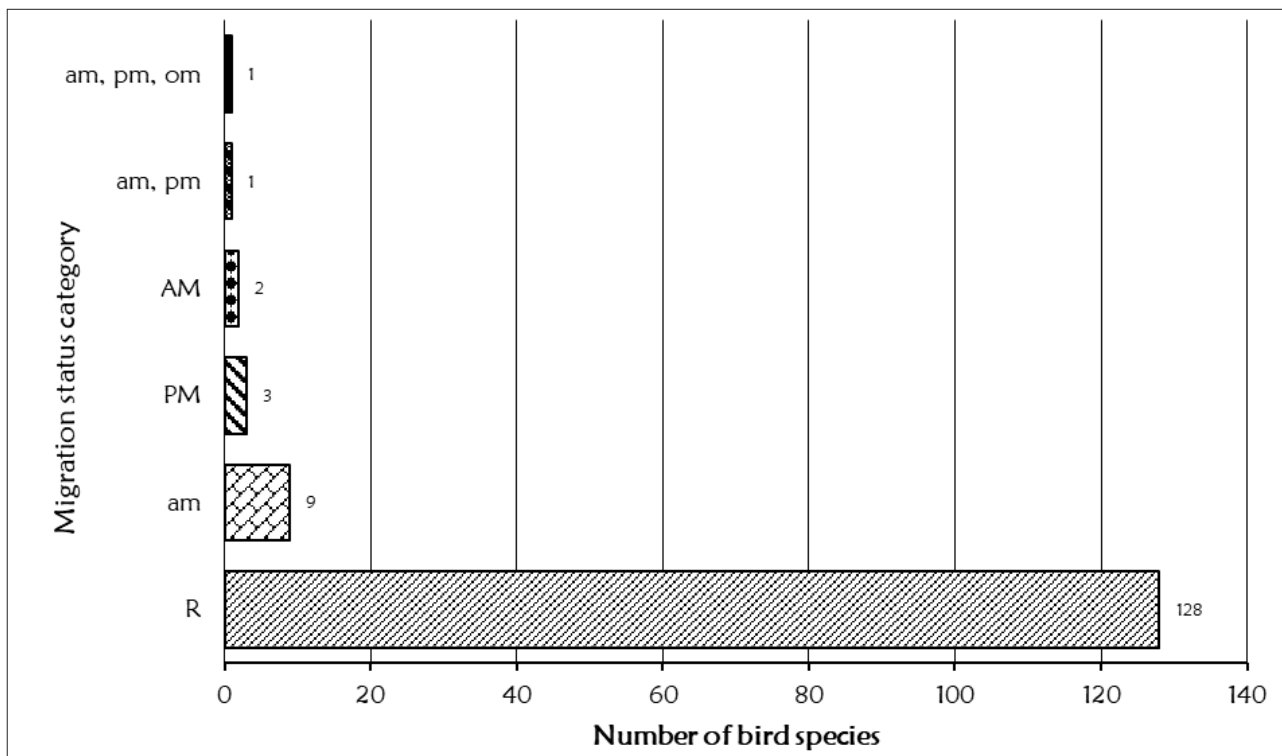


Figure 30: Number of bird species in various migration status categories

#### 4.7.6. Feeding guilds

While different bird species have more than one food items in their diet, the principal or preferred items were used to determine the feeding guild for each species. The results for all the 144 species showed that there were nine feeding guilds as follows: insectivore (insects; 50 species), carnivore (animal matter; 35 species), granivore (seeds; 22 species), omnivore (both animal and plant matter; 17 species), frugivore (fruits, 12 species), nectarinivore (nectar, 5 species), algivore (algae, 1 species), piscivore (fish, 1 species), and scavenger (food remains, 1 species). The proportions of each guild are illustrated in Figure 31.

#### 4.7.7. Forest-dependence evaluation

All the species were evaluated on their forest-dependence status following Bennun et al. (1996) to detect if there are any areas in the study areas that are still supporting species dependent on

native forested habitats. There were no forest-specialists (FF species). Two forest generalists (F species) were however recorded: Red-chested Cuckoo *Cuculus solitarius* and Northern Puffback *Dryoscopus gambensis*. The forest visitors (f species) were the majority with a total of 31 species such as the Brown-throated Wattle-eye and Blue-spotted Wood Dove (Figure 32). The rest of the species (111) are categorized as non-forest species i.e., are not dependent on forested habitats for their survival or in any stage of their life-cycle.

The number of species in each of these categories is illustrated in Figure 32.

#### 4.7.8. Discussion

This study has recorded 144 bird species in 52 families, with Homa Bay having the highest species richness at 96 species. However, Bradley & Ikawa (2023) reported a list of 476 species for

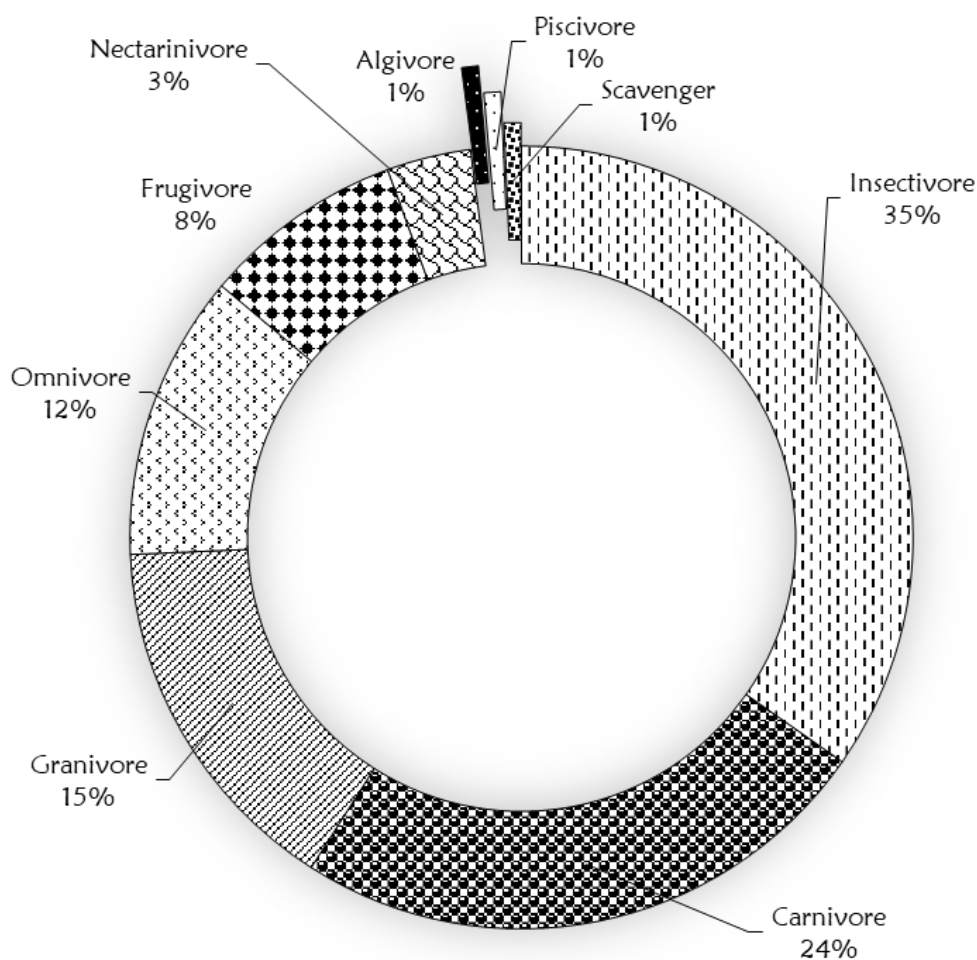


Figure 31: Distribution of feeding guilds



Plate 27: A female Brown-throated Wattle-eye (Left; photo/SS Cheema); and Blue-spotted Wood Dove (Right; photo/Fanis T.)

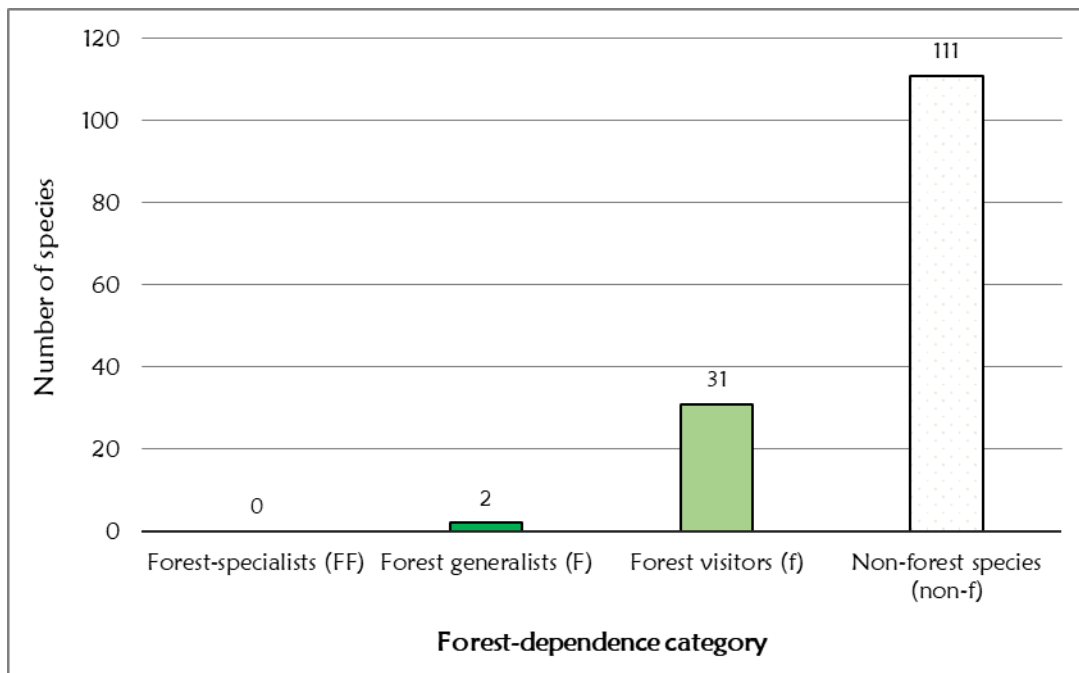


Figure 32: Number of bird species in each forest-dependence category

Homa Bay which is attributed to the county’s wide range of microclimates and habitats in the rugged valleys, hills and mountains, and its sitting astride the equator and the shores of Lake Victoria. Among the three counties, Homa Bay also has several conservation areas i.e., Ruma National Park, Gwasssi and other hills, and Lake Simbi Nyaima - an alkaline wetland – and two large islands in Lake Victoria (Rusinga and Mfangano). These conservation areas had an overall influence on species diversity and abundance since the sampling sites were located in proximity of the natural areas, while sites in Kisumu and Migori

were largely surrounded by croplands and human settlements.

Two of the three species of conservation concern, Lesser Flamingo and Grey Crowned Crane were only recorded in Homa Bay County. The cranes were observed flying to the park in the evening to roost and out in the mornings to forage in the neighboring farmlands. This species has recently been observed to adapt to croplands (Nowald et al., 2018; Wamiti et al., 2021). This shows the importance of the farms in this species conservation and survival. As demonstrated by Bradley & Ikawa

(2023), the Lake Victoria basin has a rich avifauna. Continued surveys in the selected farmlands and their surroundings may reveal additional species of conservation concern.

A majority of the species that had the widest distribution across the three counties are dominated by species that are quite vocal, hence are easy to detect from their calls and songs. Such includes the Blue-spotted Wood Dove whose call can be heard over several hundred meters. Other species, e.g., the fruit-eating Common Bulbul, occupy niches that are widespread and hence gives them advantage of being detected. Other survey techniques such as mist-netting may be useful in detection of species that aren't vocal.

Bird species whose principal food items are insects dominated the feeding guilds. The diversity of different guilds shows that species have taken up different niches in the environment to reduce inter-specific competition although there is an overlap where different species share the same food item or have more than one food source. Each of these groups of birds play critical roles (ecosystem services) in the environment such as control of harmful insects in croplands (insect pests), removal of rodents that could devour stored or standing food crops in farmlands and stores, pollination and seed dispersal, and removal of dead animals and food matter that would otherwise cause harm to public health if not attended.

The complete absence of forest specialists (FF species) shows that the area has undergone complete conversion including in areas that may have been formerly forested. This group of species are however expected and have been confirmed in the upper elevations of Gwasssi Hills (Bradley & Ikawa, 2023). These include Lemon Dove *Columba larvata* and Purple-throated Cuckooshrike *Campephaga quisqualina*. These species require native forests which is hard to find in the farmlands.

Kenya has around 170 of Kenya's bird species are Palearctic migrants mainly from eastern Europe, Russia, the Middle East and Siberia (Bennun & Njoroge, 2001). The low number of this group of migrants is due to the fact that the survey was conducted outside the Palearctic migrant's season (from late August to late April, with a peak in September). The number of Afrotropical migrants recorded was also very low despite this being the season when these are expected in Kenya. One of the species expected was the Blue Swallow *Hirundo atrocaerulea* that has been recorded frequently only in Ruma National Park although no surveys were made in the park.

#### 4.7.9. Conclusion and Recommendations

Although the species recorded in this survey was low, future surveys are needed to build checklists of individual farms and surrounding areas. Surveys should therefore be conducted in different times such as during the migration seasons. Mist netting is a suitable field ornithology technique that is used to catch birds, particularly those with cryptic or secretive behavior (Zakaria & Rajpar, 2010). It is therefore important that future surveys employ this technique in the following sites: Kisumu (Karateng Hills and Joyce Kaveza), Migori (Riverine gallery forest in Rapogi and Thimlich Ohinga), and Homa Bay (Josephine Omondi). To attract ecologically important species such as forest generalists (F species), planting of rows and pockets of indigenous tree species should be encouraged. In areas neighboring conservation areas and native vegetation, these rows could run through farmlands so that they act as corridors for species to use when moving between these areas and across the landscape.

## 4.8 Spatial Analysis

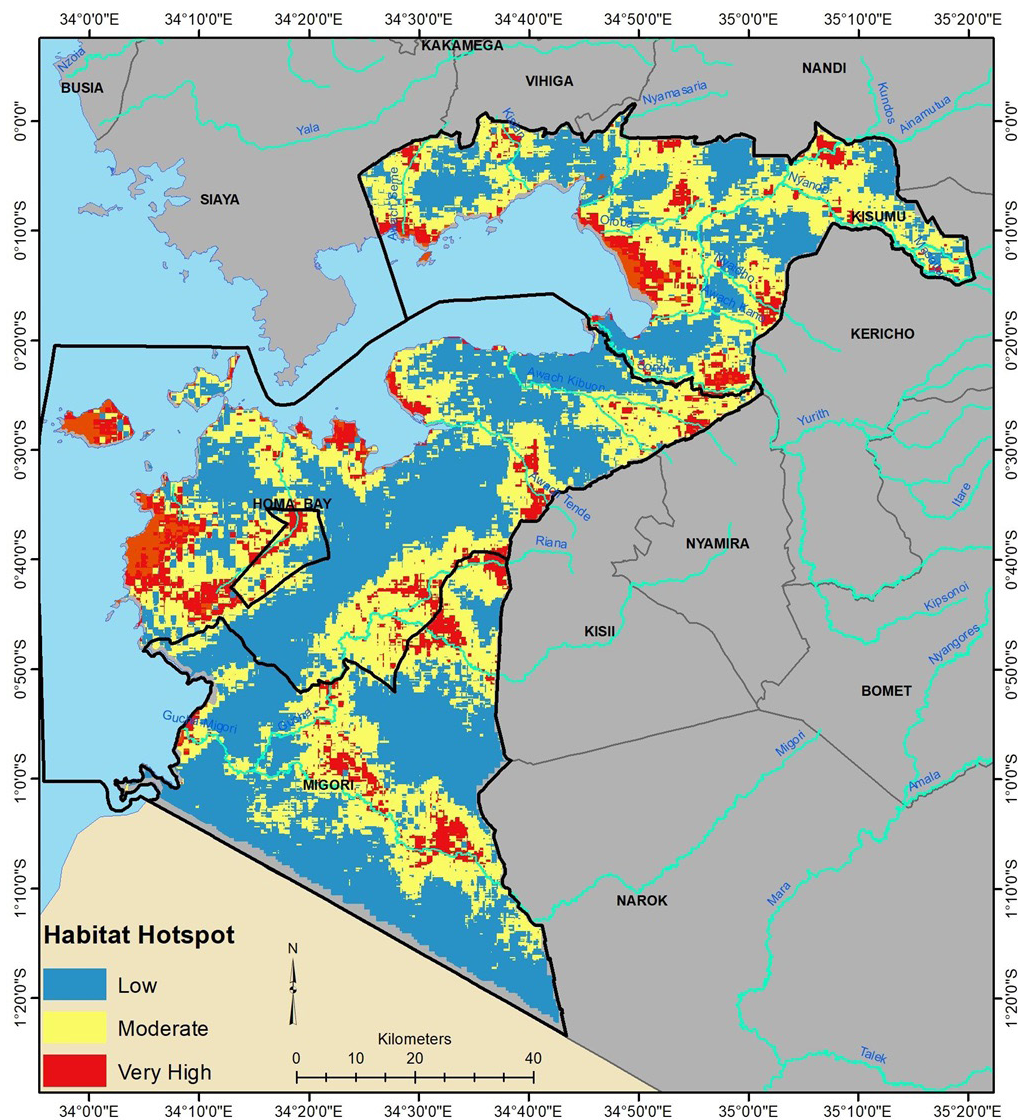
By Dickens Odeny, PhD

### 4.8.1. Predictor variable distribution

### 4.8.2. Slope angle distribution

The distribution of relatively steep areas occurs mostly in Homa Bay county, on the western area around Gwasssi Hills and areas adjacent to Lambwe valley. These are also observed in the north east of the county. In Kisumu County, the distribution is observed in the southern areas

that are neighbouring Homa Bay county. The north east and north west of Kisumu County also has considerable steep areas. While, in Migori county, the distribution of steep areas occurs in central area of the county with most moderately steep areas dominating in the county (Figure 33: - Predictor variable distribution in the project landscape A-Slope angle, B-surface reflectance, C-precipitation, D-proximity to drainage features, E-roads, F-urban centers.



a). These steep areas are deemed vulnerable to soil erosion from human activities such as agricultural activities. Sampling plots within the Trees for the Future (TFTF) Forest Garden (FG) project in the Lake Victoria varies highly in slope angle. The median of slope angles distribution tends towards the 3<sup>rd</sup> quartile. This implies most sampling points are distributed in areas with relatively high slope angles. Most of variation in slope angles occur in areas with low values ( $Q_1$ ) (Figure 34). Thus, sampling point slope angles are not normally distributed on this landscape.

#### 4.8.3. Surface Reflectance

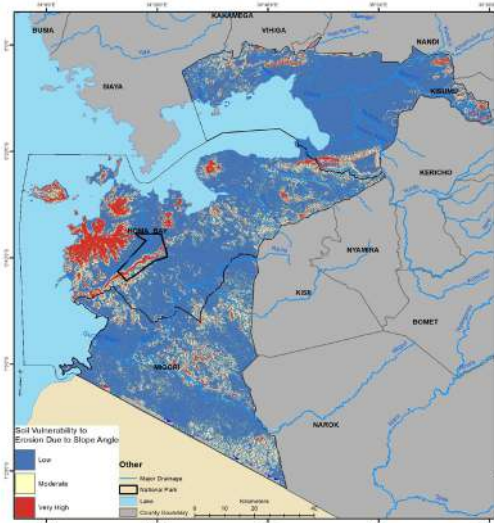
Vegetation has a profound influence on surface reflectance, primarily due to its unique optical properties and its role in the absorption and reflection of sunlight. The reflectance properties of vegetation depend on a number of factors including; optical properties of the vegetation, leaf structure, canopy density and leaf area index, seasonal changes, and species diversity. Areas with few or no vegetation differ from those with vegetation. These areas tend to have higher reflectance in the visible spectrum (e.g., green, red) and lower reflectance in the NIR spectrum because vegetation, which typically reflects strongly in NIR, is absent or reduced. Western side of Migori county has relatively higher reflectance than the eastern side. These area areas that are probably dry with typical dryland vegetation types. Similar reflectance occurs in the north eastern side of Homa Bay county. This belt of high reflectance crosses over to the southern part of Kisumu County running towards the north and isolated high surface reflectance observed in the north western side of the county (Figure 33: - Predictor variable distribution in the project landscape A-Slope angle, B-surface reflectance, C-precipitation, D-proximity to drainage features, E-roads, F-urban centers). Most of the areas sampling was conducted occurred in areas with generally low and varied surface reflectance. Variation of surface reflectance occur mostly below the 2<sup>nd</sup> quartile but also above the 3<sup>rd</sup> quartile (Figure 34b).

#### 4.8.4. Mean Annual Precipitation

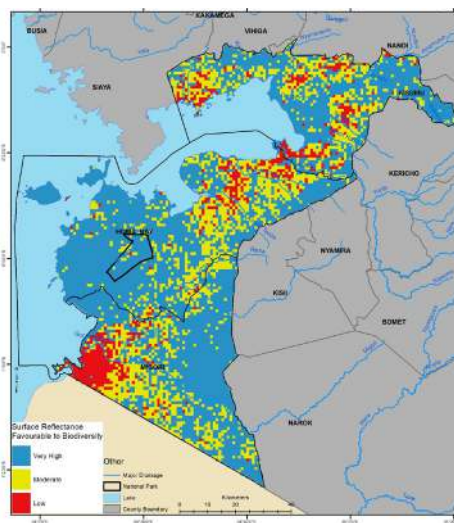
Rainfall is an important physical factor that influences vegetation distribution on a landscape. Vegetation distribution is affected by the rainfall intensity, seasonality, and variability. Besides these, plant adaptation, human influence and climate change plays a great role on vegetation distribution. In overall, rainfall influences the distribution of plant species, the structure of ecosystems, and the biodiversity on a landscape. Western part of the project area receives relatively low amount of rainfall compared to the eastern side of the three counties that receive higher amount of rainfall (Figure 33: - Predictor variable distribution in the project landscape A-Slope angle, B-surface reflectance, C-precipitation, D-proximity to drainage features, E-roads, F-urban centers). The distribution of sampling points within the TFTF project areas were biased on areas with relatively higher Mean Annual Precipitation (Pptn). The median of the distribution of MAP is closer to the 2<sup>nd</sup> quartile with higher variation occurring in data points with relatively high precipitation (Figure 34).

#### 4.8.5. Drainage proximity

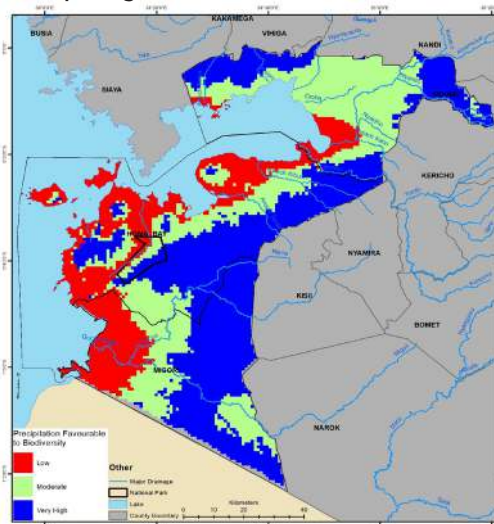
Areas near drainage features such as rivers, streams, wetlands and lake shores can attract biodiversity distribution on a landscape. These features are characterized by the riverine/riparian habitats that provide a variety of ecological benefits that supports a wide range of species. Proximity to drainage system offers numerous benefits to biodiversity by providing habitat, migration corridors, breeding sites, and foraging sites. Homa Bay county have longer drainage feature that include the rivers and lake shore areas. Kisumu county apparently has more wetlands than the two other counties (Figure 33: - Predictor variable distribution in the project landscape A-Slope angle, B-surface reflectance, C-precipitation, D-proximity to drainage features, E-roads, F-urban centers). The distribution of sampling points is relatively near the drainage features (DrainProx) with variation in proximity mostly occurring on areas considerably far from the drainage features. Though the points are relatively near to the drainage system, the median of distribution points is very close to the mean (Figure 34).



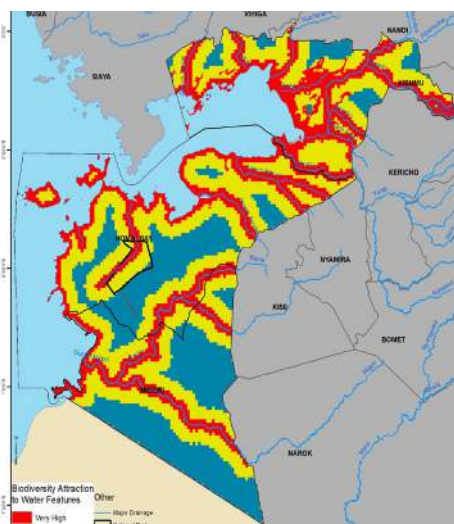
**A- Slope angle**



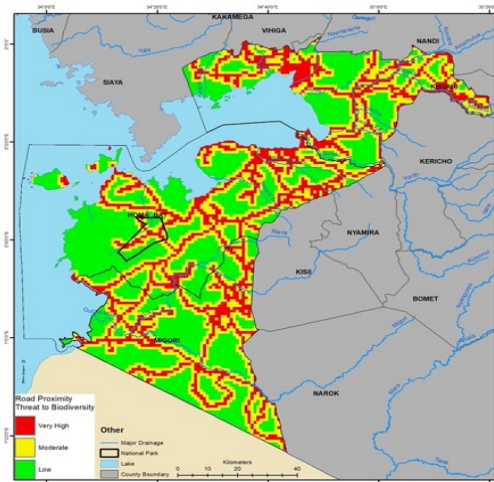
**B- Surface reflectance**



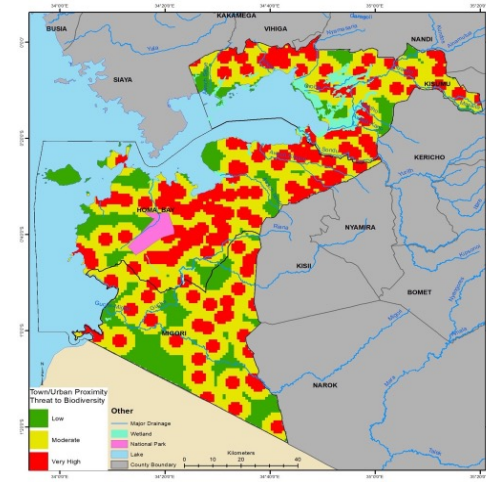
**C- Precipitation**



**D-Proximity to drainage features**



**E-Roads**



**F-Urban centers**

Figure 33: - Predictor variable distribution in the project landscape A-Slope angle, B-surface reflectance, C-precipitation, D-proximity to drainage features, E-roads, F-urban centers

#### 4.8.6. Proximity to roads

Areas in proximity to the road are likely to be affected by the infrastructure operation. Road causes fragmentation of natural habitats, isolations of plants and animals. The road poses direct threat to wild animals through collision with vehicles. This is mainly concerned with amphibians, reptiles, and mammals. Noise pollution can interfere with animal communication, breeding behaviour and feeding pattern. Nearness to road also attract settlements and agricultural activities that negatively affect vegetation covers along the major roads. Very dense road network occurs in the western side of Kisumu County followed by the northern side of Homa Bay county (Figure 33: - Predictor variable distribution in the project landscape A-Slope angle, B-surface reflectance, C-precipitation, D-proximity to drainage features, E-roads, F-urban centers). In Migori county, the north eastern side has apparently dense road network than other parts of the county. Sampling points in project areas were in proximity to the roads in the county. This is indicated by the distribution of these data points that has low values. Since the median and mean of the data values are very close to each other (Figure 34), high variation of road proximity occurs in areas far away from the road.

#### 4.8.7. Proximity to Urban/Town centers

Urban development alters natural habitat through clearing for buildings, roads, and other infrastructure. It leads to habitat fragmentation that interferes with movement of animals across landscape. With more traffic in this environment, mortality rate for animal is always high in the peri-urban areas. Light pollution also deters nocturnal animals and affects negatively the reproductive cycles, causes death due to exhaustion. With these potential impacts; thus, distance between each urban centre contribute more threat to the biodiversity conservation. Hydrological pattern on the landscape is normally altered by urban development which further affect aquatic environment on downstream. Most areas in Homa Bay county are in proximity to urban centers; with the distance between urban centers much closer than in Kisumu and Migori county (Figure 33: - Predictor variable distribution in the project landscape A-Slope angle, B-surface reflectance, C-precipitation, D-proximity to drainage features, E-roads, F-urban centers).

The distribution of these centers in Migori county is relatively sparse; showing considerably large areas are away from urban centers. Though the distribution of median and mean are the same, sampling points are relatively near urban/town centers. While distance of sites that are near the urban centers are varied in distance (Figure 34).

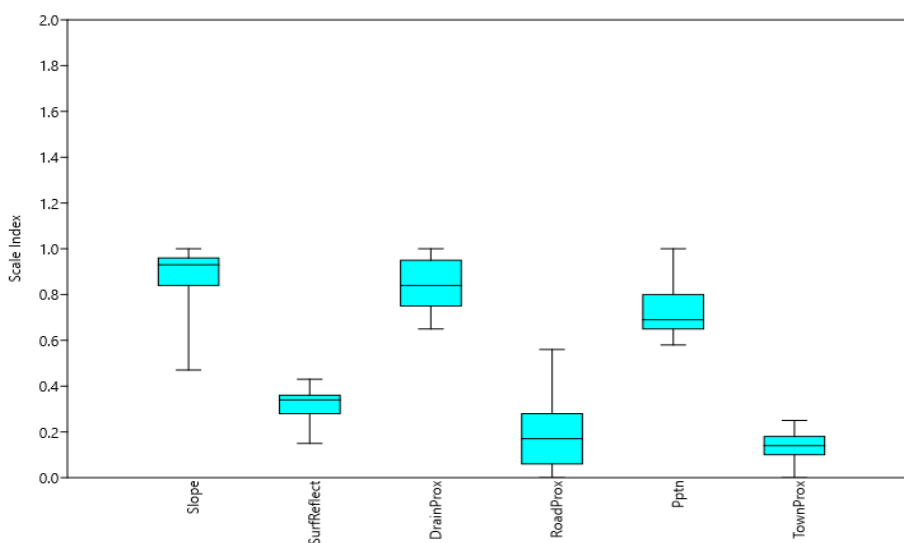


Figure 34: - Univariate distribution in boxplot for predictor variables - slope angle, surface reflectance, precipitation, proximity to drainage features, urban centers and road networks in Homa Bay, Kisumu and Migori Counties

## 4.9. Intercorrelation of predictor variables

Distribution of urban centers and road correlate positively; areas with more urban centers are significantly associated with more roads ( $R = 0.46$ ,  $p=0.00$ ) (Table 199). Areas with urban development attracts the need for roads for accessing different land uses. Roads for accessing different towns are constructed to facilitate transportation of goods and services between the urban centers. This possibly explain reason for more road network across landscape in Homa Bay county. Areas with more urban centers and roads is characterized by high surface reflectance due to the dominant land cover types that reflects most of the spectral energy in the visible. Urban and road development involves clearing of natural vegetation and trees, replacement of soil, and water bodies for construction of concrete structures. The artificial structures typically have higher albedo than natural surfaces; hence they reflect more spectrum energy in the visible range and absorb less. This explains why surface reflectance correlate positively with proximity to urban centers ( $R = 0.39$ ,  $p=0.01$ ), and roads ( $R = 0.34$ ,  $p=0.02$ ) in the project landscape (Table 199). Thus, there is high surface reflectance in areas with urban development and higher road density. High surface reflectance induced by urbanization and roads can cause increase in temperatures in urban area that can lead to more convective

activity, potentially resulting in localized afternoon thunderstorms and rainfall. Areas near urban and dense road networks are likely to experience more precipitation. The distribution of precipitation; thus, negatively correlates with areas in proximity to roads ( $R = -0.33$ ,  $p= 0.02$ ) and town ( $R = -0.37$ ,  $p= 0.01$ ) (Table 199). Topography is one of the factors that indirectly influence the location of an urban or town. Slope angle can influence several aspects of town development including risks of landslides and erosion, among others. Apparently, in the project landscape, proximity to town correlates negatively with slope angles ( $R = -0.28$ ,  $p=0.05$ ) (Table 199); most urban or towns are away from areas with high slope angles. Since slope angle correlates negatively with urban development and the latter correlates negatively with the precipitation; it is therefore, automatic that precipitation also correlates negatively with slope angle ( $R=-0.31$ ,  $p= 0.03$ ) on TFTF project area (Table 199). Road crossings over the drainage channels are nearly at  $90^\circ$  to the channel. Most areas that are in proximity to the drainage are not closer to the road. While the drainage channels run along the slope gradient, most roads run across the slope gradients. Thus, a negative correlation is observed between the proximity to drainage and proximity to road features ( $R = -0.45$ ,  $p=0.00$ ) (Table 18).

Table 18: – Intercorrelation of predictor variables – correlation/p-value

	Slope	SurfReflect	DrainProx	RoadProx	Pptn	TownProx
Slope		0.08	0.28	0.42	0.03	0.05
SurfReflect	-0.25		0.09	0.02	0.68	0.01
DrainProx	-0.16	-0.24		0.00	0.12	0.43
RoadProx	-0.12	0.34	-0.45		0.02	0.00
Pptn	-0.31	0.06	0.22	-0.33		0.01
TownProx	-0.28	0.39	0.11	0.46	-0.37	

## 4.10. Habitat suitability

About 11 of the project regions (Homa Bay, Kisumu and Migori counties) constitute areas with very high suitable habitat. These are areas with very high potential for habitat to species based on the optimal distribution of environmental conditions. Out of the three counties, Migori county seems to have few areas that are suitable habitat; with only 7 of the areas mapped as very high in habitat potential. The distribution of suitable habitat in each county varies among the subcounties. In Migori county, Suna East has 21, and 13 in Rongo subcounties are habitat hotspot areas. Most of the distribution of habitat hotspots in Suna East is high in God-Jope and Suna Central Wards, 30 and 28, respectively. While in Rongo subcounty, 50 of the distribution area occur in North Kamagambo Ward.

Subcounties with the highest areas with habitat hotspots in Kisumu County are Nyando (20), Seme and Nyakach, 15 each. Kabonyo/Kanyagwal Ward has the highest suitable habitat areas of about 63 in Nyando Subcounty. In Seme Subcounty, North Seme (16) and West Seme Ward (28) has the highest suitable Habitat areas among other wards. South East Nyakach Ward in Nyakach Subcounty has relatively higher suitable Habitat among other wards in the subcounty. Besides these subcounties, there are selected Wards with suitable habitats in Kisumu County. These include Nyalenda B Ward (18) in Kisumu Central subcounty, Kolwa Central Ward (17) in Kisumu East, North West Kisumu Ward (20) in Kisumu West subcounty, Chemelil (14) and Ombeyi Ward (12), in Nyakach subcounty suitable habitats occur in North Nyakach (16),

Suba and Mbita subcounties in Homa Bay county has considerable areas with high suitable habitat, 30 and 25, respectively. In Suba subcounty, these areas consist of Gwasssi North that has the most areas (84) suitable habitat. This is followed by Gwasssi South (30), Kaksingri West (28). Mfangano Island in Mbita subcounty has most of its area as suitable habitats (82), other areas in Mbita include Gembe (20), Lambwe (19), and Rusinga Island (13). Even though other subcounties have relatively low suitable habitats, there are Wards with considerable areas suitable for habitat. Areas in Kabondo Kasipul subcounty

that are suitable for habitat include Kabondo East Ward (19) and Kabondo West Ward (16). Suitable habitats in Karachuonyo subcounty are found in West Karachuonyo Ward (21), Kasipul subcounty are found in West Kasipul Ward (31), and in Ndhiwa subcounty it occurs in Kabuoch North Ward (30).

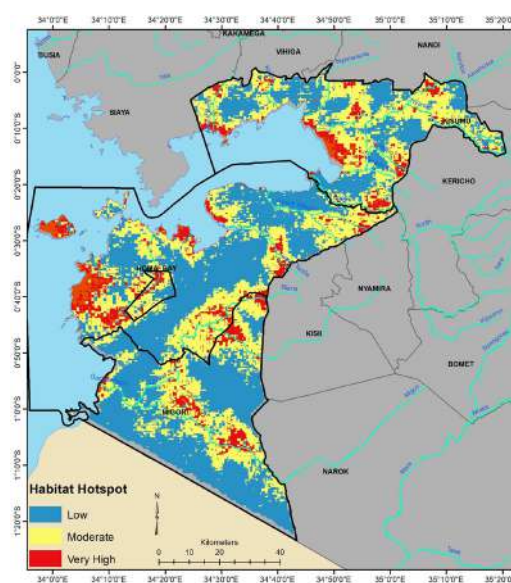


Figure 35: - Suitable biodiversity habitat distribution in Homa Bay, Kisumu and Migori regions

### 4.10.1. Linear Multiple Regression of species with predictor variables

### 4.10.2. Plant species Vs Predictor Variables

The multiple relationship of plant species with predictor variables used in the model shows fairly strong relationship ( $R^2 = 0.42$ ,  $p = 0.33$ ) but not significant. However, significant relationship is observed with the distribution of drainage and other water features ( $R^2 = 0.05$ ,  $p = 0.05$ ). Variation of plant species shows considerable number of plant species occur in areas with high slope angles, relatively high precipitation, low surface reflectance, near drainage features. The species varies highly in areas with high number of species than where they occur in low numbers. Considerable increase in plant species is observed with increase in precipitation than with slope angle, surface reflectance, nearness to drainage features.

Table 19: - Multiple regression of all species with predictor variables; slope angle, surface reflectance, precipitation, proximity to drainage, urban/town centers and to roads

		Multiple	Slope INDEX	Refl INDEX	Drain INDEX	Road INDEX	Pptn INDEX	TownID
Plants	R <sup>2</sup>	0.419	0.005	0.012	0.051	0.003	0.103	0.005
	R	0.647	0.070	0.110	0.230	0.050	0.320	-0.070
	p-value	0.325	0.384	0.220	0.045	0.156	0.222	0.184
Birds	R <sup>2</sup>	0.540	0.019	0.049	0.195	0.007	0.140	0.147
	R	0.740	0.140	0.220	0.440	0.080	-0.380	0.380
	p-value	0.100	0.360	0.729	0.101	0.365	0.458	0.150
Herpes	R <sup>2</sup>	0.185	0.050	0.006	0.063	0.106	0.024	0.034
	R	0.430	0.230	0.080	0.250	0.330	0.150	0.180
	p-value	0.558	0.290	0.602	0.063	0.527	0.812	0.848
Invertebrate	R <sup>2</sup>	0.364	0.002	0.096	0.003	0.095	0.115	0.178
	R	0.604	0.050	0.310	0.050	0.310	0.340	0.420
	p-value	0.266	0.451	0.377	0.255	0.387	0.319	0.702
Mushroom	R <sup>2</sup>	0.182	0.007	0.072	0.038	0.025	0.136	0.007
	R	0.426	0.080	0.270	0.190	0.160	0.370	0.080
	p-value	0.173	0.947	0.309	0.515	0.726	0.032	0.624

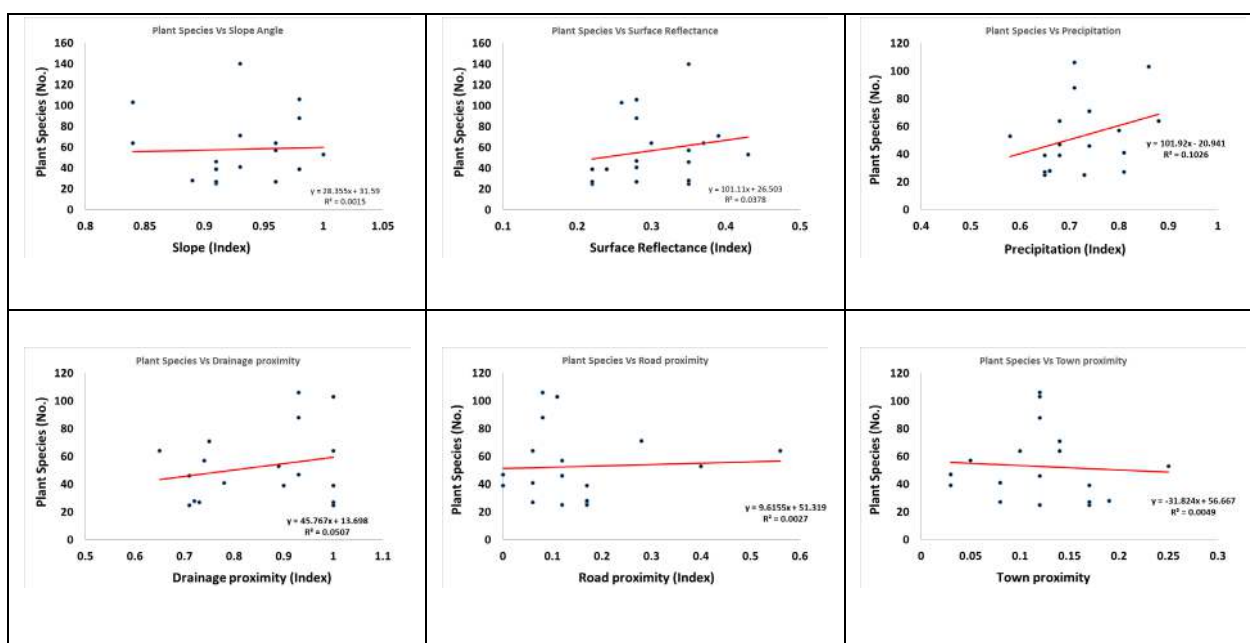


Figure 36: - Multiple regression of plant species with predictor variables; slope angle, surface reflectance, precipitation, proximity to drainage, urban/town centers and to roads

### 4.10.3. Birds Distribution Vs Predictor Variables

The multiple regression of bird species with predictor variables is fairly strong ( $R^2 = 0.54$ ,  $p=0.100$ ) but not significant. There is a relatively high and varied number of bird species in areas with high slope angles than in moderate slope angle areas. Apparently, the distribution of birds occurs in areas with low surface reflectance with relatively high amount of precipitation. The distribution of birds is evenly distributed from near the drainage features to areas away from the feature. Most of their distribution areas are apparently near the road and urban/town centers which could be due to poor distribution of sampling points around these features. A considerable change in bird species is observed with increase in precipitation, distance towards drainage features, and distance away from urban/town centers (Figure 37).

### 4.10.4. Mushroom species Vs Predictor Variables

The variation of mushroom species weakly relates with the predictor variables on the landscape ( $R^2 = 0.18$ ,  $p = 0.17$ ). Though, its distribution relates significantly with the increase of precipitation ( $R^2 = 0.14$ ,  $p = 0.03$ ). Generally, the distribution of mushroom species is more varied in areas with relatively moderate slope angle than in high slope angles. Distribution of mushroom species could be affected by spread of sampling points across the landscape. However, areas with higher number of species are more varied than in areas with low number of mushroom species with the all the predictor variables.

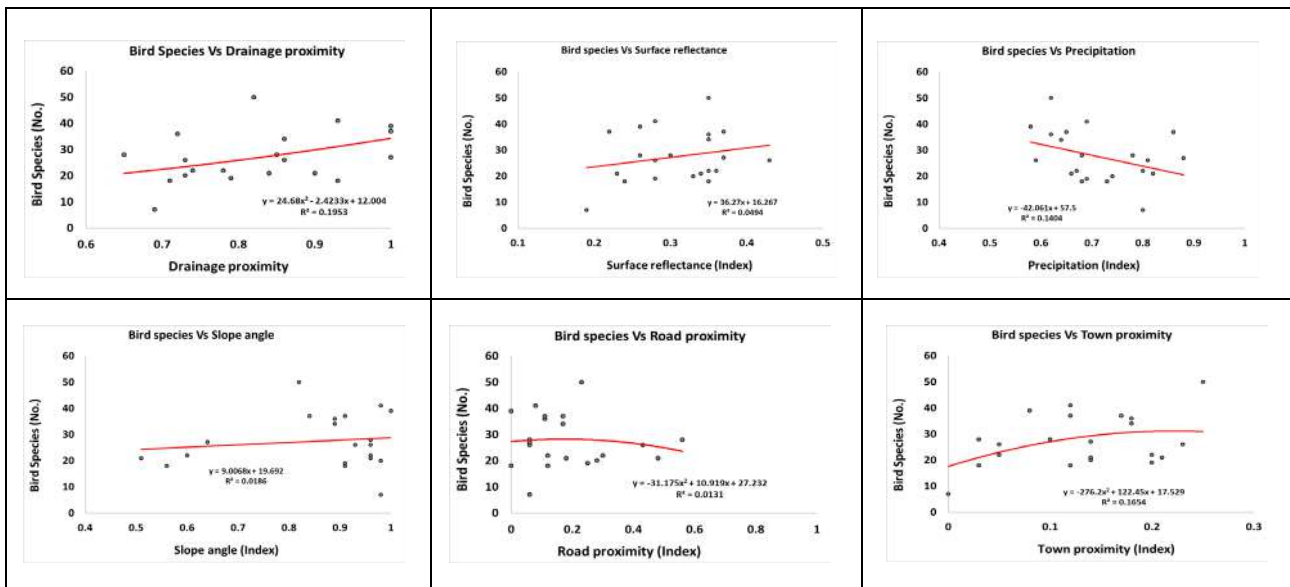


Figure 37: - Multiple regression of bird species with predictor variables; slope angle, surface reflectance, precipitation, proximity to drainage, urban/town centers and to roads

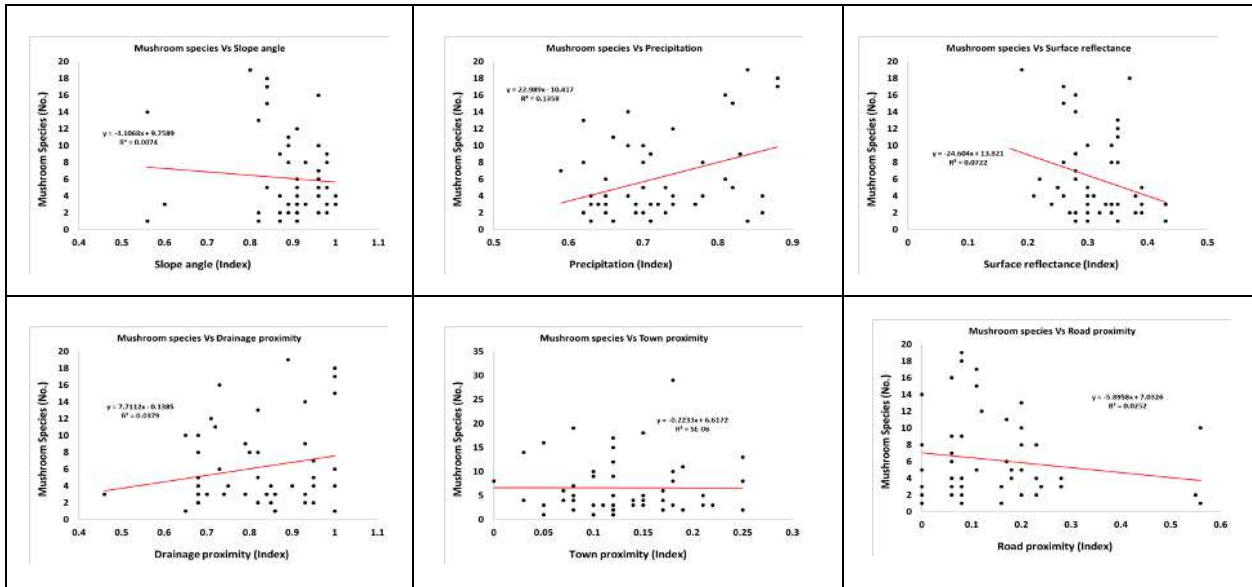


Figure 38: - Multiple regression of mushroom species with predictor variables; slope angle, surface reflectance, precipitation, proximity to drainage, urban/town centers and to roads

#### 4.10.5. Invertebrate species Vs Predictor Variables

The invertebrate distribution relates weakly with the multiple predictor variables ( $R^2 = 0.36$ ,  $p=0.27$ ). The species are more varied in areas with high species counts than areas with low counts. Relative change of invertebrate species occurs with increase in: precipitation, surface reflectance, and distance away from urban/town centers and road.

#### 4.10.6. Herpetofauna species Vs Predictor Variables

The distribution of herpetofauna with slope angle occur in areas with higher slope angles, precipitation and near water features. These distributions apparently increase with increase in slope angle, precipitation and drainage features. Though distribution in proximity to town and roads indicate more occur near town and road. This pattern is likely due to the choice of sampling points in most areas which were determined by

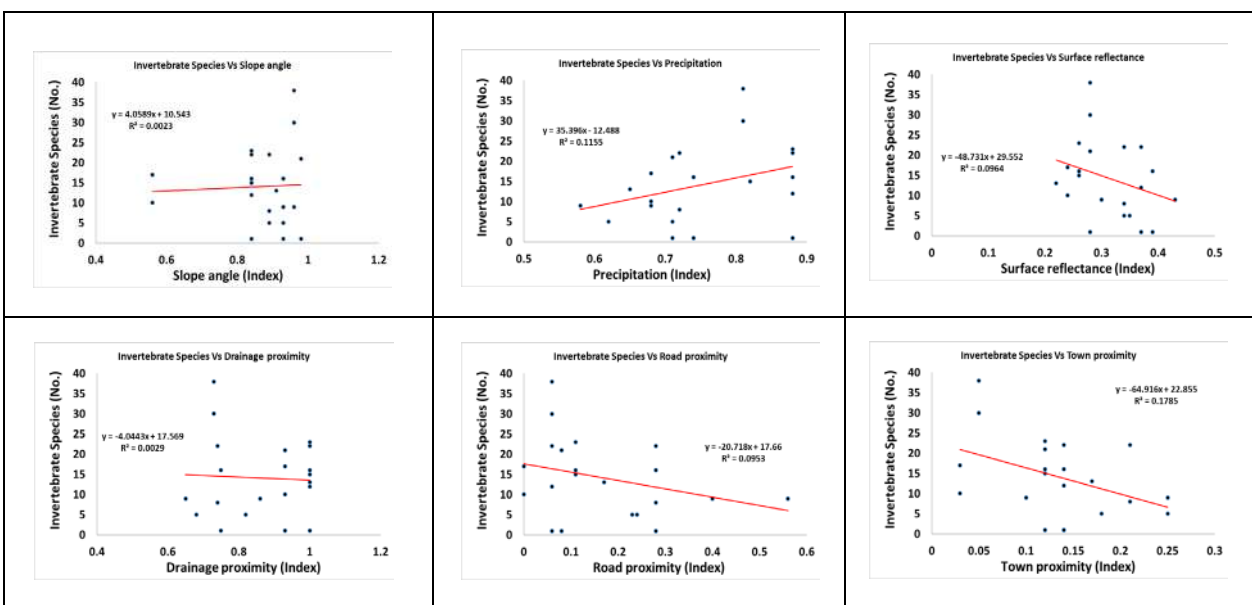


Figure 39: - Multiple regression of invertebrate species with predictor variables; slope angle, surface reflectance, precipitation, proximity to drainage, urban/town centers and to roads

accessibility. There is, however, an associated decrease of herpetofauna species with increase in surface reflectance, distance tending away from the urban/town centres and roads.

#### 4.10.7. Linear, Bivariate Analysis of Species and Habitat Suitability

Assessment on how species varies with habitat suitability show plant species increases with the increase in habitat suitability; however, no significant relationship observed. Analysis on

birds' distribution shows significant variation of the species with the variation of habitat suitability within the project landscape ( $R^2 = 0.27$ ,  $p = 0.02$ ). Variation of bird species counts occur with the increase of habitat suitability and tend to vary more with high species counts (Figure 41). No significant relationship was observed on mushroom species with variation of habitat suitability. Invertebrate species, however, show negative relationship with the variation of habitat suitability though; no significantly relationship is observed (Figure 41).

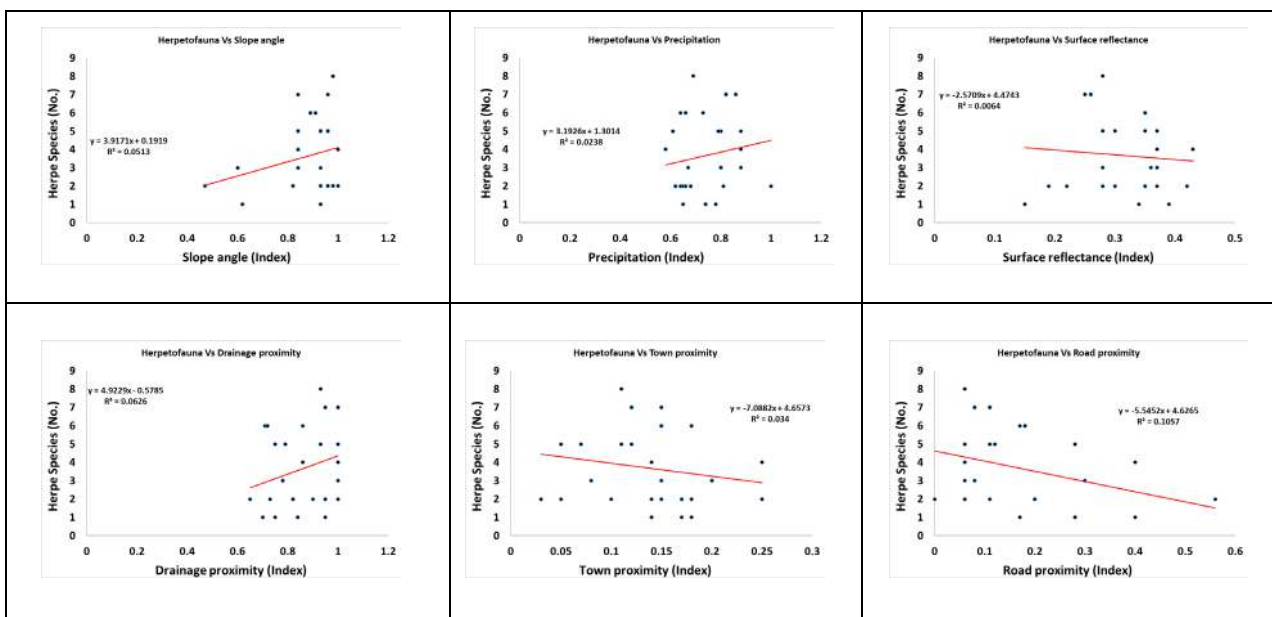


Figure 40: - Multiple regression of herpetofauna species with predictor variables; slope angle, surface reflectance, precipitation, proximity to drainage, urban/town centers and to roads

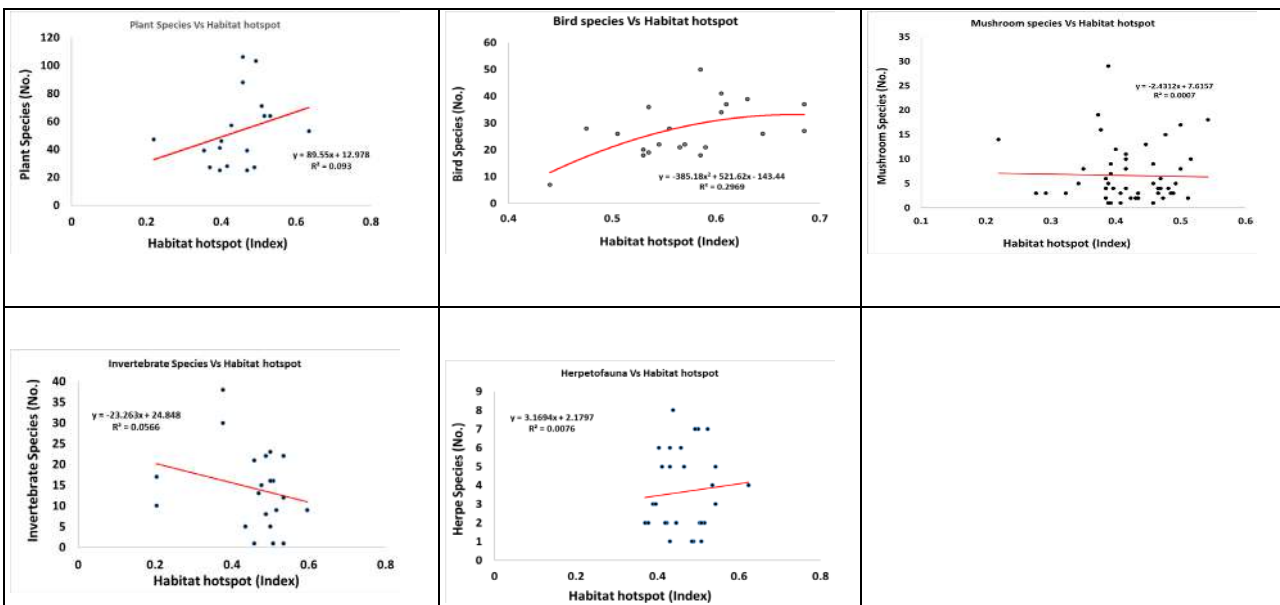


Figure 41: - Bivariate relationship of plants, birds, mushroom, invertebrates and herpetofauna with habitat suitability

#### 4.10.8. Land Use Land Cover Types

About six land use land cover types were generated through image-processing; these include grassland, farmland, shrubland, bushlands, wetlands, and woodland. The dominant land cover in the project area is bushland (bush cover) that occupy an estimated 39 of the area. This is followed by grassland that covers 21, open shrubland (18), farmlands (16), woodland (5) and wetlands with the least cover of 1 (Figure 42).

Homa Bay region has the largest area of grassland (78,492 hectares) which represent 48 of grassland in the project region (Figure 42). However, large areas of grasslands in Homa Bay region occur in Mbita, Ndhiwa and Suba subcounties (Table 19) forming 59% of grasslands in Homa Bay region. Two subcounties in Kisumu region has more of grassland in Muhoroni and Nyando subcounties. While Nyatike and Uiri subcounties in Migori county has considerable larger area of grassland.

The region with the largest area of farmland is Homa Bay region with a total of 54,020 ha, representing 44 of farmlands in the project region. Large areas of farmlands in Homa Bay county occur in Karachuonyo (13,390 ha.), Suba (12,309 ha.), and Mbita 11,314 ha (Table 19) which represent 69 of farmlands in Homa Bay region. A total of 34,218 ha of land is represented by farmland in Kisumu region; with the highest proportion of 54 occurring in Muhoroni and Nyando subcounties (Table 19). Migori region has an estimated area of 34,488 ha under farmland of which 86 occur in Nyatike subcounty (Table 19).

The open shrubland occupy a total of 139,908 ha in the project area. The occurrence of open shrubland is relatively distributed in the three regions of the project; Homa Bay 35, Kisumu 33 and Migori region 33 (Figure 426). In Homa Bay region most of open shrubland occur in Karachuonyo, Rangwe and Kasipul, and Ndhiwa

subcounties (Table 19) that makes up 72 of the shrublands in the region. The open shrubland in Kisumu region are predominant in Nyakach, Muhoroni, and Seme subcounties which forms 67 of open shrubland (Table 19). While 68 of open shrubland in Migori region occur in Nyatike, Suna West, and Kuria West (Table 19).

Migori county leads with the highest bushland which forest 43 of bushland in the project region (Figure 4242). Most of these distributions occurring in Uiri, Kuria West, and Awendo subcounties (Table 19) which forms about 45 of bush cover in Migori region. In Homa Bay region 54 of bush covers occur in Ndhiwa, and Suba subcounties (Table 19). While in Kisumu region the distribution is dominant in Muhoroni, Kisumu West and Nyakach subcounties which constitute 70 of bush covers in the region (Table 19).

Woodland distribution is dominant in Migori region with 48 covers over the project regions (Figure 426). These woodlands are relatively distributed in Kuria East, Kuria West, Suna East and Uiri subcounties (Table 21). Homa Bay region follows with an estimated woodland constituting 35 of the woodland in the project regions. Most of these woodlands occur are dominant in Mbita and Suba subcounties of Homa Bay county (Table 19). In Kisumu region, large proportion of woodland, about 72 of woodland in Kisumu, are situated in Muhoroni and Kisumu West (Table 19).

Kisumu region has more wetlands with about 6,261 hectares followed by Homa Bay county with 939 hectares, and Migori county has the least area of wetland (Figure 426). Most of wetlands in Kisumu County occur in Nyando, Nyakach, and Kisumu East subcounties which constitute 91 of wetlands in Kisumu region. Wetland predominance in Homa Bay region is observed in Karachuonyo subcounties constituting 64 of wetlands in the region. Migori region has few areas with wetland mostly occurring in Nyatike and Suna West (Table 19).

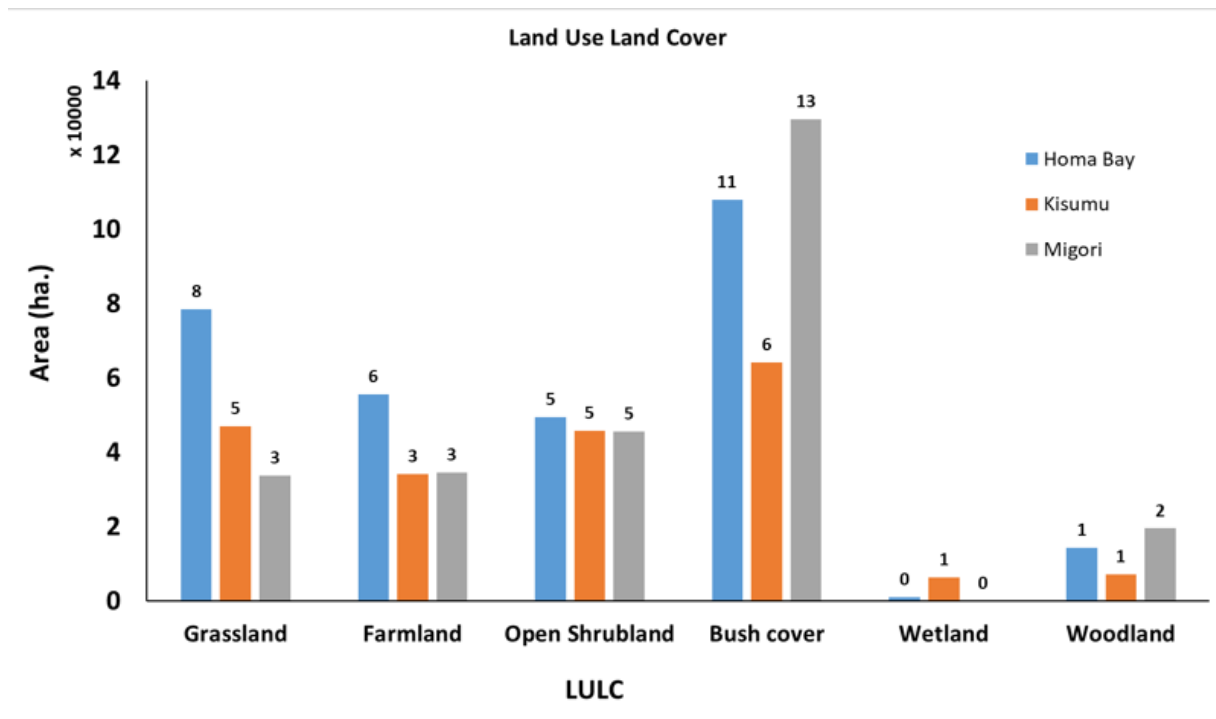
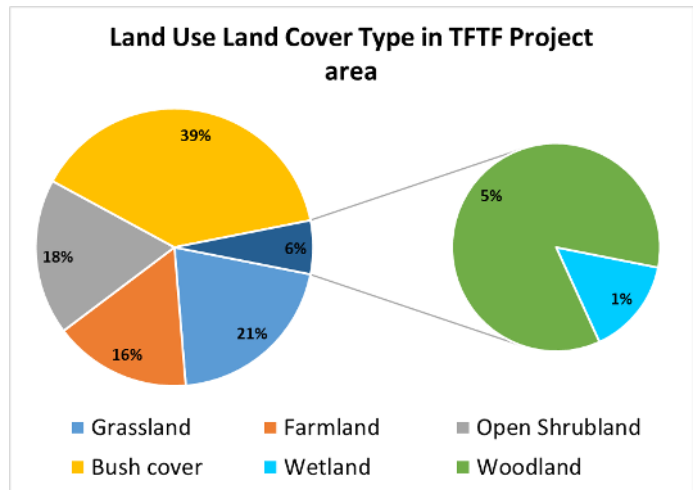
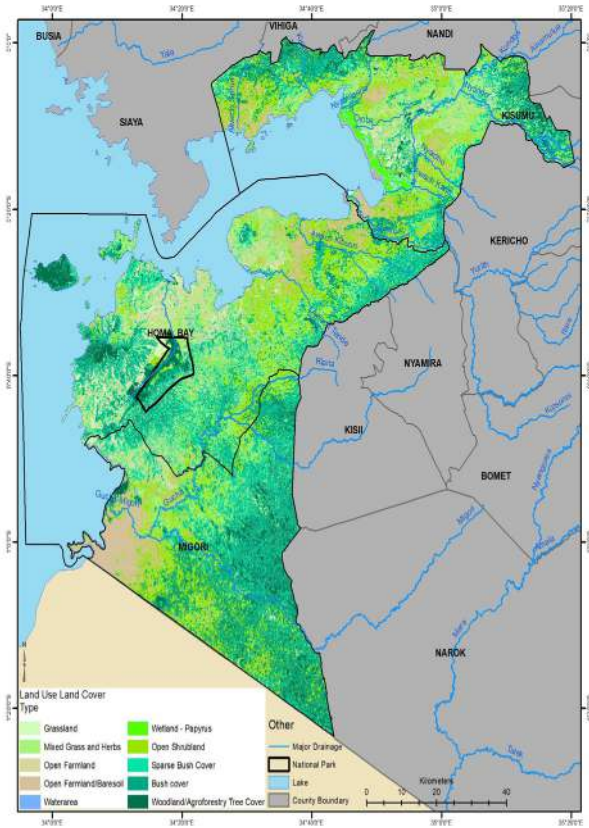


Figure 42: - Land use land cover in TFTF project regions; Homa Bay, Kisumu and Migori regions

a – Land use land cover map. b – Graph of area representation for types of land use land cover area in percentage. c - Graph of area representation for types of land use land cover area in percentage in project regions.

Table 20: - LULC distribution among subcounties in Homa Bay, Kisumu and Migori county

County	Subcounty	Grassland	Farmland	Open Shrubland	Bush cover	Wetland	Woodland
Homa Bay	Homa Bay Town	5888	3897	2812	5976	67	44
	Kabondo Kasipul	3803	1885	5912	12665	6	291
	Karachuonyo	7210	13390	9579	4374	596	236
	Kasipul	6244	890	8305	9792	0	578
	Mbita	12426	11314	1450	11346	104	6050
	Ndhiwa	18139	7344	7832	35261	0	1012
	Rangwe	8407	2991	9297	5076	164	37
	Suba	14220	12309	3253	22764	2	5999
	<b>Sub-Total</b>	<b>76337</b>	<b>54020</b>	<b>48440</b>	<b>107254</b>	<b>939</b>	<b>14247</b>
Kisumu	Kisumu Central	1577	328	530	1303	305	22
	Kisumu East	2922	2687	3642	2690	1060	165
	Kisumu West	3257	1189	3567	11727	132	1457
	Muhoroni	17364	9285	10318	22513	0	3735
	Nyakach	5037	5785	10429	10844	1973	724
	Nyando	14688	9231	7468	6806	2652	327
	Seme	2226	5713	9899	8382	140	767
		<b>Sub-Total</b>	<b>47071</b>	<b>34218</b>	<b>45853</b>	<b>64265</b>	<b>6262</b>
Migori	Awendo	3845	641	2089	16780	0	2203
	Kuria East	871	338	3842	15251	0	3859
	Kuria West	1973	955	7648	21065	0	3278
	Nyatike	11913	29652	12938	13166	5	1544
	Rongo	2309	385	2837	14394	0	1466
	Suna East	1242	247	1546	13931	0	3166
	Suna West	2298	1292	10552	14052	2	1219
	Uriri	9361	978	4163	21012	0	2794
		<b>Sub-Total</b>	<b>33812</b>	<b>34488</b>	<b>45615</b>	<b>129651</b>	<b>7</b>
<b>Grand Total</b>		<b>157,220</b>	<b>122,726</b>	<b>139,908</b>	<b>301,170</b>	<b>7,208</b>	<b>40,973</b>

#### 4.10.9. Biodiversity conservation hotspot

There is a relative similarity of areas with very suitable habitats for biodiversity with areas very hot for biodiversity hotspot conservation. Though, difference is observed in isolated areas on the landscape. For instance, West Kasipul Ward in Kasipul subcounty has considerable areas that are very hot (14%) for biodiversity conservation; however, about 31% of the ward is considered suitable for biodiversity habitat (Appendix 14). Quite a large area in Mfangano Island Ward (82%) in Mbita subcounty is suitable for biodiversity habitat but only 39% of it is very hot for biodiversity conservation. About 20% of Kabuoch North Ward is suitable for biodiversity habitat, though; 15% is very hot for biodiversity conservation hotspot.

In Kisumu region, similarities of suitable biodiversity habitats with very hot areas for biodiversity hotspot conservation are observed in various wards. For instance, Nyalenda B Ward has about 18% of the ward suitable for biodiversity habitat while, 13% are very hot for biodiversity conservation. Kolwa Central Ward has 17% that

are suitable for biodiversity habitat but only 10% is very hot for biodiversity conservation. Kisumu North West Ward in Kisumu subcounty has 20% of its area suitable for biodiversity habitat and only 6% very hot for biodiversity conservation. In Kabonyo/Kanyagwal Ward, Nyando subcounty, a considerable area is suitable for biodiversity habitat with 63% of it area suitable, and 19% of it is very hot for biodiversity conservation. This applies to West Seme Ward that has 28% suitable for biodiversity habitat and about 15% very hot for biodiversity conservation.

About 5 wards in Migori region has similarities in suitable habitat and high biodiversity conservation hotspot. These include North Sakwa which has 45% of the ward suitable for biodiversity habitat and 13% very hot for biodiversity conservation; Masaba Ward with 24% suitable and only 11%; Got Kachola Ward has 8% suitable areas for habitat and 27% very hot for biodiversity conservation; North Kamagambo Ward has 50% of its area suitable and 13% very hot for biodiversity conservation, and; West Kanyamkago in Uriri subcounty with 20% suitable habitat and about 9% very hot for biodiversity conservation.

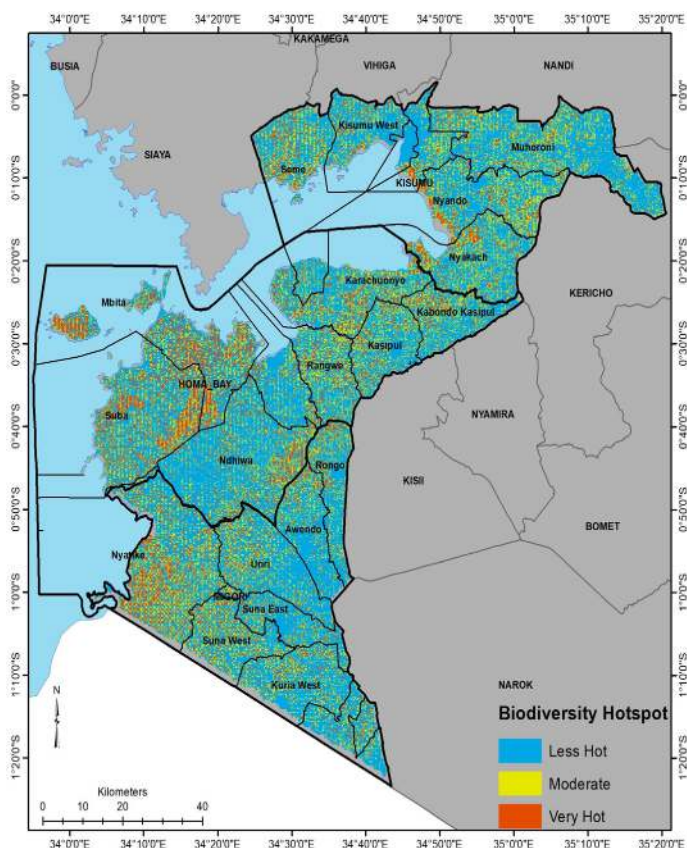


Figure 43: - Biodiversity conservation hotspot in the regions

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# Appendices

## Appendix 1: Plant species checklist

FAMILY	SPECIES	LF	IAS	Medicinal
Acanthaceae	<i>Acanthus polystachyus</i> Delile var. <i>polystachyus</i>	S		
Acanthaceae	<i>Asystasia gangetica</i> (L.) T.Anderson	H		√
Acanthaceae	<i>Asystasia mysorensis</i> T.Anderson	H		√
Acanthaceae	<i>Barleria acanthoides</i> Vahl	S		√
Acanthaceae	<i>Barleria lupulina</i> Lindl.	H		
Acanthaceae	<i>Barleria</i> sp.	H		
Acanthaceae	<i>Blepharis maderaspatensis</i> (L.) B. Heyne ex Roth	H		√
Acanthaceae	<i>Crabbea velutina</i> S.Moore	H		√
Acanthaceae	<i>Dyschoriste nagchana</i> (Nees) Benn.	H		
Acanthaceae	<i>Dyschoriste radicans</i> Nees	H		
Acanthaceae	<i>Hygrophila auriculata</i> (Schumach.) Heine	H		√
Acanthaceae	<i>Hygrophila spiciformis</i> Lindau	H		√
Acanthaceae	<i>Hypoestes forskahlii</i> (Vahl) R.Br.	H		
Acanthaceae	<i>Justicia calyculata</i> Deflers	H		√
Acanthaceae	<i>Justicia diclipteroides</i> Lindau	H		
Acanthaceae	<i>Justicia flava</i> Vahl	H		√
Acanthaceae	<i>Justicia heterocarpa</i> T.Anderson subsp. <i>praetermissa</i> Hedrén	H		
Acanthaceae	<i>Justicia striata</i> (Klotzsch) Bullock	H		
Acanthaceae	<i>Ruellia patula</i> Jacq.	H		√
Acanthaceae	<i>Ruellia</i> sp.	H		
Acanthaceae	<i>Thunbergia alata</i> Bojer ex Sims	H		√
Acanthaceae	<i>Thunbergia annua</i> Hochst. ex Nees	H		
Adiantaceae	<i>Pellaea viridis</i> (Forssk.) Prantl	H		
Agavaceae	<i>Agave sisalana</i> Perr. ex Engelm.	S	√	√
Amaranthaceae	<i>Achyranthes aspera</i> L.	H		√
Amaranthaceae	<i>Aerva lanata</i> (L.) Juss	H		√
Amaranthaceae	<i>Alternanthera caracasana</i> Kunth	H		
Amaranthaceae	<i>Alternanthera sessilis</i> (L.) DC.	H		√
Amaranthaceae	<i>Amaranthus graecizans</i> L.	H		
Amaranthaceae	<i>Amaranthus</i> sp.	H		
Amaranthaceae	<i>Amaranthus spinosus</i> L.	H		
Amaranthaceae	<i>Celosia trigyna</i> L.	H		√
Amaranthaceae	<i>Chenopodium opulifolium</i> Schrad. ex W.D.J. Koch & Ziz	H		√
Amaranthaceae	<i>Digera muricata</i> (L.) Mart.	H		
Amaranthaceae	<i>Gomphrena celosioides</i> Mart.	H		
Amaranthaceae	<i>Psilotrichum schimperi</i> Engl.	H		
Amaranthaceae	<i>Pupalia lappacea</i> (L.) A.Juss.	H		√

FAMILY	SPECIES	LF	IAS	Medicinal
Amaryllidaceae	<i>Allium cepa</i> L.	H		
Amaryllidaceae	<i>Scadoxus multiflorus</i> (Martyn) Raf.	H		
Anacardiaceae	<i>Lannea schimperi</i> (A.Rich.) Engl.	T		√
Anacardiaceae	<i>Lannea schweinfurthii</i> (Engl.) Engl.	T		√
Anacardiaceae	<i>Mangifera indica</i> L.	T		
Anacardiaceae	<i>Ozoroa insignis</i> Delile	T		√
Anacardiaceae	<i>Ozoroa insignis</i> Delile ssp. <i>reticulata</i> (Baker f.) Gillet	T		
Anacardiaceae	<i>Sclerocarya birrea</i> (A.Rich.) Hochst.	T		√
Anacardiaceae	<i>Searsia crenulata</i> (A.Rich.) Moffett	T		√
Anacardiaceae	<i>Searsia pyroides</i> (Burch.) Moffett	T		√
Anacardiaceae	<i>Searsia ruspolii</i> (Engl.) Moffett	T		
Annonaceae	<i>Annona senegalensis</i> Pers.	S		√
Annonaceae	<i>Annona</i> sp.	S		
Annonaceae	<i>Annona squamosa</i> L.	S		
Annonaceae	<i>Monanthes burchanani</i> (Engl.) Verdc.	S		
Apiaceae	<i>Centella asiatica</i> (L.) Urb.	H		√
Apiaceae	<i>Heteromorpha arborescens</i> (Spreng.) Cham. & Schltdl.	S		
Apiaceae	<i>Heteromorpha arborescens</i> (Spreng.) Cham. & Schltdl. var. <i>abyssinica</i> (Hochst. ex A.Rich.) H.Wolff	S		√
Apiaceae	<i>Hydrocotyle mannii</i> Hook.f.	H		√
Apiaceae	<i>Steganotaenia araliacea</i> Hochst.	T		√
Apocynaceae	<i>Acokanthera schimperi</i> (A.DC.) Schweinf.	T		
Apocynaceae	<i>Carissa spinarum</i> L.	S		√
Apocynaceae	<i>Cascabela thevetia</i> (L.) Lippold	S	√	
Apocynaceae	<i>Catharanthus roseus</i> (L.) G.Don	S	√	√
Apocynaceae	<i>Ceropegia nilotica</i> Kotschy var. <i>nilotica</i>	C		
Apocynaceae	<i>Ceropegia</i> sp.	C		
Apocynaceae	<i>Cynanchum insipidum</i> (E.Mey.) Liede & Khanum	C		√
Apocynaceae	<i>Cynanchum viminalis</i> (L.) L.	H		√
Apocynaceae	<i>Gomphocarpus semilunatus</i> A.Rich.	H		√
Apocynaceae	<i>Marsdenia sylvestris</i> (Retz.) P.I.Forst.	C		
Apocynaceae	<i>Nerium oleander</i> L.	T		
Apocynaceae	<i>Orbea baldratii</i> (A. C. White & B. Sloane) Bruyns	H		
Apocynaceae	<i>Orbea dummeri</i> (N.E.Br.) Bruyns	H		
Apocynaceae	<i>Pentarrhinum abyssinicum</i> Decne.	C		√
Apocynaceae	<i>Saba comorensis</i> (Bojer ex A. DC.) Pichon	C		√
Apocynaceae	<i>Secamone punctulata</i> Decne.	C		
Apocynaceae	<i>Vincetoxicum sylvaticum</i> (Decne.) Kuntze	C		
Aponogetonaceae	<i>Aponogeton abyssinicus</i> Hochst. ex A. Rich.	H		
Araliaceae	<i>Cussonia holstii</i> Harms ex Engl.	T		√
Asparagaceae	<i>Asparagus africanus</i> Lam.	S		√
Asparagaceae	<i>Asparagus flagellaris</i> (Kunth) Baker	S		√
Asparagaceae	<i>Asparagus racemosus</i> Willd.	S		√
Asparagaceae	<i>Chlorophytum comosum</i> (Thunb.) Jacq.	H		
Asparagaceae	<i>Chlorophytum</i> sp.	H		

FAMILY	SPECIES	LF	IAS	Medicinal
Asparagaceae	<i>Dracaena parva</i> (N.E.Br.) Byng & Christenh.	H		√
Asparagaceae	<i>Dracaena</i> sp.			
Asphodelaceae	<i>Aloe lateritia</i> Engl.	H		√
Asphodelaceae	<i>Aloe macrosiphon</i>	H		
Aspleniaceae	<i>Asplenium cordatum</i> (Thunb.) Sw.	H		
Aspleniaceae	<i>Asplenium</i> sp. 1			
Aspleniaceae	<i>Asplenium</i> sp. 2			
Aspleniaceae	<i>Asplenium stuhlmannii</i> Hieron.	H		
Aspleniaceae	<i>Blechnum attenuatum</i> (Sw.) Mett.	H		
Aspleniaceae	<i>Thelypteris chaseana</i> Schelpe	H		
Asteraceae	<i>Acanthospermum australe</i> (Loefl.) Kuntze	H		
Asteraceae	<i>Acanthospermum glabratum</i> (DC.) Wild	H		√
Asteraceae	<i>Acanthospermum hispidum</i> DC.	H		
Asteraceae	<i>Acmella caulirhiza</i> Delile	H		√
Asteraceae	<i>Ageratum conyzoides</i> L.	H	√	√
Asteraceae	<i>Ambrosia maritima</i> L.	H		
Asteraceae	<i>Artemisia afra</i> Jacq. ex Willd.	H		√
Asteraceae	<i>Artemisia</i> sp.	H		
Asteraceae	<i>Aspilia kotschyi</i> (Sch.Bip. ex Hochst.) Oliv.	H		√
Asteraceae	<i>Aspilia mossambicensis</i> (Oliv.) Wild	H		√
Asteraceae	<i>Aspilia pluriseta</i> Schweinf. ex Engl.	H		√
Asteraceae	<i>Baccharoides adoensis</i> (Sch.Bip. ex Walp.) H.Rob.	H		√
Asteraceae	<i>Baccharoides lasiopus</i> (O. Hoffm.) H. Rob.	S		√
Asteraceae	<i>Berkheya spekeana</i> Oliv.	H		√
Asteraceae	<i>Bidens pilosa</i> L.	H		√
Asteraceae	<i>Blumea axillaris</i> (Lam.) DC.	H		
Asteraceae	<i>Bothriocline bagshawei</i> (S.Moore) C.Jeffrey	H		
Asteraceae	<i>Chrysanthellum indicum</i> DC. subsp. <i>afroamericanum</i> B.L.Turner	H		
Asteraceae	<i>Chrysanthemum indicum</i> L.	H		
Asteraceae	<i>Conyza bonariensis</i> (L.) Cronquist	H		√
Asteraceae	<i>Conyza hochstetterii</i> Sch.Bip. ex A.Rich.	H		
Asteraceae	<i>Cotula anthemoides</i> Willd.	H		
Asteraceae	<i>Crassocephalum montuosum</i> (S.Moore) Milne-Redh.	H		
Asteraceae	<i>Crassocephalum rubens</i> (Juss. ex Jacq.) S.Moore	H		√
Asteraceae	<i>Crassocephalum vitellinum</i> (Benth.) S.Moore	H		√
Asteraceae	<i>Crepis rueppellii</i> Sch.Bip.	H		
Asteraceae	<i>Cyanthillium cinereum</i> (L.) H.Rob.	H		√
Asteraceae	<i>Eclipta prostrata</i> (L.) L.	H		
Asteraceae	<i>Emilia coccinea</i> (Sims) Sweet	H		√
Asteraceae	<i>Emilia discifolia</i> (Oliv.) C.Jeffrey	H		√
Asteraceae	<i>Flaveria trinervia</i> (Spreng.) C. Mohr	H		
Asteraceae	<i>Galinsoga parviflora</i> Cav.	H		√
Asteraceae	<i>Guizotia scabra</i> (Vis.) Chiov.	H		√
Asteraceae	<i>Gutenbergia cordifolia</i> Benth. ex Oliv.	H		√

FAMILY	SPECIES	LF	IAS	Medicinal
Asteraceae	<i>Gymnanthemum amygdalinum</i> (Delile) Sch.Bip.	S		√
Asteraceae	<i>Gymnanthemum auriculiferum</i> (Hiern) Isawumi	S		√
Asteraceae	<i>Gynura scandens</i> O. Hoffm.	C		√
Asteraceae	<i>Helichrysum globosum</i> Sch.Bip.	H		√
Asteraceae	<i>Helichrysum nudifolium</i> (L.) Less. var. <i>nudifolium</i>	H		√
Asteraceae	<i>Kleinia abyssinica</i> (A. Rich.)	H		
Asteraceae	<i>Lactuca schweinfurthii</i> Oliv. & Hiern	H		
Asteraceae	<i>Lagascea mollis</i> Cav.	H		
Asteraceae	<i>Laggera brevipes</i> Oliv. & Hiern	H		√
Asteraceae	<i>Launaea cornuta</i> (Hochst. ex Oliv. & Hiern) C.Jeffre	H		√
Asteraceae	<i>Linzia glabra</i> Steetz	H		√
Asteraceae	<i>Lipotriche scandens</i> (Schumach.) Orchard	H		√
Asteraceae	<i>Microglossa pyrifolia</i> (Lam.) Kuntze	S		√
Asteraceae	<i>Microglossa</i> sp.	S		
Asteraceae	<i>Mikania chenopodiifolia</i> Willd.	S		
Asteraceae	<i>Orbivestus karaguensis</i> (Oliv. & Hiern) H.Rob.	H		√
Asteraceae	<i>Osteospermum vaillantii</i> (Decne.) Norl.	H		√
Asteraceae	<i>Parthenium hysterophorus</i> L.	H	√	
Asteraceae	<i>Pluchea ovalis</i> (Pers.) DC.	H		
Asteraceae	<i>Psiadia punctulata</i> (DC.) Vatke	S		√
Asteraceae	<i>Schkuhria pinnata</i> (Lam.) Kuntze	H		√
Asteraceae	<i>Senecio hadiensis</i> Forssk.	H		√
Asteraceae	<i>Senecio syringifolius</i> O.Hoffm.	C		√
Asteraceae	<i>Sigesbeckia abyssinica</i> (Sch.Bip.) Oliv. & Hiern	H		
Asteraceae	<i>Solanecio mannii</i> (Hook. f.) C. Jeffrey	S		√
Asteraceae	<i>Sonchus</i> sp.	H		
Asteraceae	<i>Sphaeranthus</i> sp.	H		
Asteraceae	<i>Sphaeranthus suaveolens</i> (Forssk.) DC.	H		√
Asteraceae	<i>Synedrella nodiflora</i> Gaertn.	H		
Asteraceae	<i>Tagetes minuta</i> L.	H		√
Asteraceae	<i>Tithonia diversifolia</i> (Hemsl.) A.Gray	H	√	√
Asteraceae	<i>Tridax procumbens</i> L.	H		√
Asteraceae	<i>Vernonia galamensis</i> (Cass.) Less.	H		
Asteraceae	<i>Vernonia</i> sp.			
Asteraceae	<i>Xanthium pungens</i> Wallr.	H	√	
Basellaceae	<i>Basella alba</i> L.	H		√
Bignoniaceae	<i>Jacaranda mimosifolia</i> D.Don	T	√	
Bignoniaceae	<i>Kigelia africana</i> (Lam.) Benth.	S		√
Bignoniaceae	<i>Markhamia lutea</i> (Benth.) K.Schum.	T		√
Bignoniaceae	<i>Parmentiera aculeata</i> (Kunth) Seem.	T		
Bignoniaceae	<i>Spathodea campanulata</i> P.Beauv.	T		√
Bignoniaceae	<i>Stereospermum</i> sp.	S		
Boraginaceae	<i>Cordia monoica</i> Roxb.	S		√
Boraginaceae	<i>Cordia sinensis</i> Lam.	S		√
Boraginaceae	<i>Cynoglossum coeruleum</i> Hochst. ex A.DC.	H		√

FAMILY	SPECIES	LF	IAS	Medicinal
Boraginaceae	<i>Cynoglossum coeruleum</i> Hochst. ex A.DC. var. <i>mannii</i> (Baker & C.H. Wright) Verdc.	H		
Boraginaceae	<i>Cynoglossum lanceolatum</i> Forssk.	H		
Boraginaceae	<i>Heliotropium zeylanicum</i> (Burm. f.) Lam.	H		√
Boraginaceae	<i>Trichodesma zeylanicum</i> (Burm.f.) R.Br.	H		√
Brassicaceae	<i>Brassica oleracea</i> L.	H		
Brassicaceae	<i>Erucastrum arabicum</i> Fisch. & C.A.Mey.	H		
Burseraceae	<i>Commiphora africana</i> (A.Rich.) Engl.	S		√
Cannabaceae	<i>Celtis africana</i> Burm.f.	T		√
Cannabaceae	<i>Trema orientale</i> (L.) Blume	S		√
Capparaceae	<i>Capparis erythrocarpos</i> Isert	S		
Capparaceae	<i>Capparis fascicularis</i> DC.	S		√
Capparaceae	<i>Maerua</i> sp.	S		
Capparaceae	<i>Maerua triphylla</i> A.Rich.	S		√
Caricaceae	<i>Carica papaya</i> L.	T		
Caryophyllaceae	<i>Silene dioica</i> (L.) Clairv.	H		
Casuarinaceae	<i>Casuarina</i> sp.	T		
Celastraceae	<i>Catha edulis</i> (Vahl) Endl.	T		√
Celastraceae	<i>Gymnosporia heterophylla</i> (Eckl. & Zeyh.) Loes.	S		√
Celastraceae	<i>Gymnosporia senegalensis</i> (Lam.) Loes.	S		√
Celastraceae	<i>Myrostroylon aethiopicum</i> (Thunb.) Loes.	S		√
Chrysobalanaceae	<i>Parinari curatellifolia</i> Benth.	T		
Cleomaceae	<i>Cleome gynandra</i> L.	H		√
Cleomaceae	<i>Cleome monophylla</i> L.	H		
Colchicaceae	<i>Gloriosa superba</i> L.	H		√
Combretaceae	<i>Combretum apiculatum</i> Sond.	T		√
Combretaceae	<i>Combretum collinum</i> Fresen.	T		√
Combretaceae	<i>Combretum molle</i> G.Don	T		√
Combretaceae	<i>Terminalia brownii</i> Fresen.	T		√
Combretaceae	<i>Terminalia catappa</i> L.	T	√	
Combretaceae	<i>Terminalia mantally</i>	T		
Combretaceae	<i>Terminalia mollis</i> M.A.Lawson	T		
Commelinaceae	<i>Commelina africana</i> L.	H		√
Commelinaceae	<i>Commelina benghalensis</i> Wall.	H		√
Commelinaceae	<i>Commelina diffusa</i> Burm.f.	H		
Commelinaceae	<i>Commelina erecta</i> L.	H		
Commelinaceae	<i>Commelina foliacea</i> Chiov.	H		
Commelinaceae	<i>Commelina</i> sp.	H		
Commelinaceae	<i>Cyanotis lanata</i> Benth.	H		√
Convolvulaceae	<i>Astripomoea malvacea</i> (Klotzsch) A.Meeuse	H		√
Convolvulaceae	<i>Cuscuta reflexa</i> Roxb.	H	√	
Convolvulaceae	<i>Dichondra repens</i> J.R.Forst. & G.Forst.	H		√
Convolvulaceae	<i>Evolvulus alsinoides</i> (L.) L.	H		√
Convolvulaceae	<i>Ipomoea aitonii</i> Lindl.	C		
Convolvulaceae	<i>Ipomoea batatas</i> (L.) Lam.	H		

FAMILY	SPECIES	LF	IAS	Medicinal
Convolvulaceae	<i>Ipomoea biflora</i> (L.) Pers.	H		
Convolvulaceae	<i>Ipomoea blepharophylla</i> Hallier f.	H		
Convolvulaceae	<i>Ipomoea cairica</i> (L.) Sweet	C	√	
Convolvulaceae	<i>Ipomoea fulvicaulis</i> (Choisy) Hallier f.	H		
Convolvulaceae	<i>Ipomoea hildebrandtii</i> Vatke	S	√	√
Convolvulaceae	<i>Ipomoea kituensis</i> Vatke	H		
Crassulaceae	<i>Kalanchoe citrina</i> Schweinf.	H		
Crassulaceae	<i>Kalanchoe densiflora</i> Rolfe	H		√
Crassulaceae	<i>Kalanchoe</i> sp.	H		
Cucurbitaceae	<i>Coccinia grandiflora</i> Cogn.	C		
Cucurbitaceae	<i>Coccinia grandis</i> (L.) Voigt	C		√
Cucurbitaceae	<i>Cucumis maderaspatanus</i> L.	C		√
Cucurbitaceae	<i>Cucurbita melo</i>	C		
Cucurbitaceae	<i>Diplocyclos palmatus</i> (L.) C.Jeffrey	C		
Cucurbitaceae	<i>Momordica foetida</i> Schumach.	H		√
Cucurbitaceae	<i>Zehneria scabra</i> (L.f.) Sond.	C		√
Cupressaceae	<i>Hesperocyparis lusitanica</i> (Mill.) Bartel	T		
Cyperaceae	<i>Abildgaardia ovata</i> (Burm.f.) Kral	H		
Cyperaceae	<i>Bulbostylis hispidula</i> (Vahl) R.W.Haines	H		
Cyperaceae	<i>Cyperus alopecuroides</i> Rottb.	H		
Cyperaceae	<i>Cyperus cyperoides</i> (L.) Kuntze	H		
Cyperaceae	<i>Cyperus denudatus</i> L. f.	H		
Cyperaceae	<i>Cyperus difformis</i> L.	H		
Cyperaceae	<i>Cyperus distans</i> L.f.	H		
Cyperaceae	<i>Cyperus dives</i> Del.	H		
Cyperaceae	<i>Cyperus dubius</i> Rottb.	H		
Cyperaceae	<i>Cyperus esculentus</i> L.	H		
Cyperaceae	<i>Cyperus flavescens</i> L.	H		
Cyperaceae	<i>Cyperus macrocarpus</i> (Kunth) Boeckeler	H		
Cyperaceae	<i>Cyperus mundii</i> (Nees) Kunth var. <i>mundii</i>	H		
Cyperaceae	<i>Cyperus nigricans</i> Steud.	H		
Cyperaceae	<i>Cyperus niveus</i> Retz.	H		
Cyperaceae	<i>Cyperus polystachyos</i> Rottb.	H		
Cyperaceae	<i>Cyperus rigidifolius</i> Steud.	H		
Cyperaceae	<i>Cyperus rotundus</i> L.	H		√
Cyperaceae	<i>Cyperus rubicundus</i> Vahl	H		
Cyperaceae	<i>Cyperus</i> sp.	H		
Cyperaceae	<i>Fimbristylis dichotoma</i> (L.) Vahl	H		
Cyperaceae	<i>Fimbristylis</i> sp.	H		
Cyperaceae	<i>Kyllinga brevifolia</i> Rottb.	H		
Cyperaceae	<i>Kyllinga bulbosa</i> Koen. ex Vahl	H		
Cyperaceae	<i>Kyllinga</i> sp. 1	H		
Cyperaceae	<i>Kyllinga</i> sp. 2	H		
Cyperaceae	<i>Lipocarpha chinensis</i> (Osbeck) J. Kern	H		

FAMILY	SPECIES	LF	IAS	Medicinal
Cyperaceae	<i>Pycrus nitidus</i> (Lam.) J. Raynal	H		
Cyperaceae	<i>Schoenoplectiella confusa</i> (N.E.Br.) J.R.Starr	H		
Cyperaceae	<i>Scleria melanomphala</i> Kunth	H		
Dioscoreaceae	<i>Dioscorea schimperana</i> Kunth	C		
Ebenaceae	<i>Euclea divinatorum</i> Hiern	S		√
Ebenaceae	<i>Euclea racemosa</i> Murr	S		
Euphorbiaceae	<i>Acalypha bipartita</i> Müll.Arg.	H		
Euphorbiaceae	<i>Acalypha crenata</i> A.Rich.	H		
Euphorbiaceae	<i>Acalypha fruticosa</i> Forssk.	S		√
Euphorbiaceae	<i>Acalypha lanceolata</i> Willd.	H		
Euphorbiaceae	<i>Acalypha racemosa</i> Baill.	H		√
Euphorbiaceae	<i>Acalypha segetalis</i> Müll.Arg.	H		
Euphorbiaceae	<i>Acalypha villicaulis</i> A.Rich.	H		√
Euphorbiaceae	<i>Croton macrostachyus</i> Delile	S		√
Euphorbiaceae	<i>Croton megalocarpus</i> Hutch.	S		√
Euphorbiaceae	<i>Erythrococca bongensis</i> Pax	S		√
Euphorbiaceae	<i>Euphorbia heterophylla</i> L.	H		√
Euphorbiaceae	<i>Euphorbia hirta</i> L.	H		√
Euphorbiaceae	<i>Euphorbia inaequilatera</i> Sond.	H		√
Euphorbiaceae	<i>Euphorbia indica</i> Lam.	H		
Euphorbiaceae	<i>Euphorbia ingens</i> E.Mey. ex Boiss.	T		√
Euphorbiaceae	<i>Euphorbia prostrata</i> Aiton	H		
Euphorbiaceae	<i>Euphorbia schimperiana</i> Scheele	H		√
Euphorbiaceae	<i>Euphorbia tirucalli</i> L.	S		√
Euphorbiaceae	<i>Euphorbia umbellata</i> (Pax) Bruyns	S		√
Euphorbiaceae	<i>Jatropha curcas</i> L.	S	√	√
Euphorbiaceae	<i>Manihot esculenta</i> Crantz	H		
Euphorbiaceae	<i>Neoboutonia melleri</i> (Müll. Arg.) Prain	T		
Euphorbiaceae	<i>Ricinus communis</i> L.	T	√	√
Euphorbiaceae	<i>Sapium ellipticum</i> (Krauss) Pax	S		√
Euphorbiaceae	<i>Tragia brevipes</i> Pax	H		√
Euphorbiaceae	<i>Tragia subsessilis</i> Pax	H		
Fabaceae	<i>Abrus precatorius</i> L. ssp. <i>africanus</i> Verdc.	C		√
Fabaceae	<i>Acacia brevispica</i> Harms	T		√
Fabaceae	<i>Acacia hockii</i> De Wild.	T		√
Fabaceae	<i>Acacia nilotica</i> (L.) Willd. ex Delile ssp. <i>subalata</i> (Vatke) Brenan	T		√
Fabaceae	<i>Acacia persiciflora</i> Pax	T		
Fabaceae	<i>Acacia polyacantha</i> Willd. ssp. <i>campylacantha</i> (Hochst. ex A.Rich.) Brenan	T		√
Fabaceae	<i>Acacia senegal</i> (L.) Wild	T		√
Fabaceae	<i>Acacia seyal</i> Delile var. <i>seyal</i>	T		
Fabaceae	<i>Acacia seyal</i> Delile var. <i>fistula</i>	T		
Fabaceae	<i>Albizia coriaria</i> Welw. ex Oliv.	T		√
Fabaceae	<i>Albizia grandibracteata</i> Taub.	T		√
Fabaceae	<i>Alysicarpus glumaceus</i> (Vahl) DC.	H		√

FAMILY	SPECIES	LF	IAS	Medicinal
Fabaceae	<i>Alysicarpus rugosus</i> (Willd.) DC.	H		
Fabaceae	<i>Alysicarpus</i> sp.	H		
Fabaceae	<i>Alysicarpus vaginalis</i> (L.) DC.	H		√
Fabaceae	<i>Alysicarpus zeyheri</i> Harv.	H		
Fabaceae	<i>Arachis hypogaea</i> L.	H		
Fabaceae	<i>Caesalpinia decapetala</i> (Roth) Alston	S	√	√
Fabaceae	<i>Caesalpinia pulcherrima</i> (L.) Sw.	S		
Fabaceae	<i>Cajanus cajan</i> (L.) Millsp.	S		√
Fabaceae	<i>Calliandra ?gilbertii</i>	S		
Fabaceae	<i>Calliandra houstoniana</i> (Mill.) Standl. var. <i>calothyrsus</i> (Meisn.) Barneby	S	√	
Fabaceae	<i>Calpurnia aurea</i> (Aiton) Benth.	T		
Fabaceae	<i>Chamaecrista kirkii</i> (Oliv.) Standl.	H		√
Fabaceae	<i>Chamaecrista mimosoides</i> (L.) Greene	H		√
Fabaceae	<i>Clitoria ternatea</i> L.	H		
Fabaceae	<i>Craibia brownii</i> Dunn	T		
Fabaceae	<i>Crotalaria alexandri</i> Baker f.	H		
Fabaceae	<i>Crotalaria brevidens</i> (Kotschy) Polhill var. <i>parviflora</i>	H		
Fabaceae	<i>Crotalaria brevidens</i> Benth.	H		√
Fabaceae	<i>Crotalaria cephalotes</i> Steud. ex A. Rich.	H		
Fabaceae	<i>Crotalaria chrysochlora</i> Harms	H		
Fabaceae	<i>Crotalaria cleomifolia</i> Baker	H		√
Fabaceae	<i>Crotalaria glauca</i> Willd.	H		
Fabaceae	<i>Crotalaria incana</i> L.	S		√
Fabaceae	<i>Crotalaria ochroleuca</i> G. Don	H		
Fabaceae	<i>Crotalaria ononoides</i> Benth. var. <i>ononoides</i>	H		
Fabaceae	<i>Crotalaria pallida</i> Aiton var. <i>pallida</i>	H		√
Fabaceae	<i>Crotalaria pycnostachya</i> Benth.	H		
Fabaceae	<i>Crotalaria scassellatii</i> Chiov.	H		
Fabaceae	<i>Crotalaria spinosa</i> Benth.	H		
Fabaceae	<i>Delonix regia</i> (Bojer ex Hook.) Raf.	T	√	
Fabaceae	<i>Desmodium adscendens</i> (Sw.) DC.	H		
Fabaceae	<i>Desmodium canum</i> (J.F.Gmel.) Schinz & Thell.	H		
Fabaceae	<i>Desmodium distortum</i> (Aubl.) J.F. Macbr.	H		
Fabaceae	<i>Desmodium intortum</i> (Mill.) Urb.	H		
Fabaceae	<i>Desmodium</i> sp.	H		
Fabaceae	<i>Desmodium tortuosum</i> (Sw.) DC.	H		
Fabaceae	<i>Desmodium triflorum</i> (L.) DC.	H		
Fabaceae	<i>Desmodium velutinum</i> (Willd.) DC.	H		
Fabaceae	<i>Dichrostachys cinerea</i> (L.) Wight & Arn.	T		√
Fabaceae	<i>Dolichos oliveri</i> Schweinf.	S		
Fabaceae	<i>Entada abyssinica</i> Steud. ex A. Rich.	T		√
Fabaceae	<i>Eriosema cf. glomeratum</i> (Guill. & Perr.) Hook. f.	H		√
Fabaceae	<i>Eriosema pauciflorum</i> Klotzsch	H		
Fabaceae	<i>Eriosema psoraleoides</i> (Lam.) G. Don	H		

FAMILY	SPECIES	LF	IAS	Medicinal
Fabaceae	<i>Erythrina abyssinica</i> Lam.	T		√
Fabaceae	<i>Glycine max</i> (L.) Merr.	H		
Fabaceae	<i>Indigostrum parviflorum</i> (B. Heyne ex Wight & Arn.) Schrire	H		
Fabaceae	<i>Indigofera ambelacensis</i> Schweinf.	H		√
Fabaceae	<i>Indigofera arrecta</i> A.Rich.	H		√
Fabaceae	<i>Indigofera atriceps</i> Hook. f.	H		
Fabaceae	<i>Indigofera brevicalyx</i> Baker f.	H		
Fabaceae	<i>Indigofera colutea</i> (Burm.f.) Merr.	H		
Fabaceae	<i>Indigofera dendroides</i> Jacq.	H		
Fabaceae	<i>Indigofera hirsuta</i> L.	H		
Fabaceae	<i>Indigofera</i> sp.	H		
Fabaceae	<i>Indigofera spicata</i> Forssk.	H		
Fabaceae	<i>Indigofera spinosa</i> Forssk.	H		
Fabaceae	<i>Indigofera tanganyikensis</i> Baker f.	S		
Fabaceae	<i>Leucaena leucocephala</i> (Lam.) de Wit	T	√	√
Fabaceae	<i>Macrotyloma axillare</i> (E.Mey.) Verdc.	C		
Fabaceae	<i>Mimosa pigra</i> L.	S	√	√
Fabaceae	<i>Mimosa pudica</i> L.	H	√	
Fabaceae	<i>Neonotonia wightii</i> ((Wight & Arn.) J.A.Lackey	H		√
Fabaceae	<i>Ormocarpum trichocarpum</i> (Taub.) Engl.	S		
Fabaceae	<i>Phaseolus vulgaris</i> L.	H		
Fabaceae	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh.	T		√
Fabaceae	<i>Pseudarthria hookeri</i> Wight & Arn.	S		√
Fabaceae	<i>Pterolobium stellatum</i> (Forssk.) Brenan	S		√
Fabaceae	<i>Pycnospora lutescens</i> (Poir.) Schindl.	S		
Fabaceae	<i>Rhynchosia minima</i> (L.) DC.	H		
Fabaceae	<i>Rhynchosia</i> sp.	H		
Fabaceae	<i>Senna bicapsularis</i> (L.) Roxb.	S	√	√
Fabaceae	<i>Senna didymobotrya</i> (Fresen.) Irwin & Barneby	S	√	√
Fabaceae	<i>Senna hirsuta</i> (L.) H.S.Irwin & Barneby	S	√	
Fabaceae	<i>Senna occidentalis</i> (L.) Link	H	√	√
Fabaceae	<i>Senna septemtrionalis</i> (Viviani) Irwin & Barneby	T	√	√
Fabaceae	<i>Senna siamea</i> (Lam.) H.S.Irwin & Barneby	T	√	√
Fabaceae	<i>Senna singueana</i> (Delile) Lock	T		√
Fabaceae	<i>Senna</i> sp.			
Fabaceae	<i>Senna spectabilis</i> (DC.) H.S.Irwin & Barneby	T	√	
Fabaceae	<i>Sesbania sesban</i> (L.) Merr.	T		√
Fabaceae	<i>Stylosanthes fruticosa</i> (Retz.) Alston	S		√
Fabaceae	<i>Tamarindus indica</i> L.	T		√
Fabaceae	<i>Tephrosia linearis</i> (Willd.) Pers.	T		√
Fabaceae	<i>Tephrosia pumila</i> (Lam.) Pers.	S		√
Fabaceae	<i>Tephrosia purpurea</i> (L.) Pers. subsp. <i>leptostachya</i> (DC.) Brummitt	H		√
Fabaceae	<i>Tephrosia rhodesica</i> Baker f.	S		
Fabaceae	<i>Tephrosia villosa</i> (L.) Pers.	H		√

FAMILY	SPECIES	LF	IAS	Medicinal
Fabaceae	<i>Tephrosia villosa</i> (L.) Pers. subsp. <i>ehrenbergiana</i> (Schweinf.) Brummitt	H		
Fabaceae	<i>Teramnus labialis</i> (L.f.) Spreng.	H		
Fabaceae	<i>Trifolium</i> sp.	H		
Fabaceae	<i>Tylosema fassoglensis</i> (Schweinf.) Torre & Hillc.	C		√
Fabaceae	<i>Vigna luteola</i> (Jacq.) Benth.	C		
Fabaceae	<i>Vigna schimperii</i> Baker	S		√
Fabaceae	<i>Vigna unguiculata</i> (L.) Walp.	H		√
Fabaceae	<i>Vigna vexillata</i> (L.) A.Rich.	H		√
Fabaceae	<i>Zornia glochidiata</i> Rchb. ex DC.	H		√
Fabaceae	<i>Zornia pratensis</i> Milne-Redh.	H		
Hydrocharitaceae	<i>Ottelia ulvifolia</i> (Planch.) Walp.	H		√
Hypericaceae	<i>Harungana madagascariensis</i> Lam. ex Poir.	S		√
Hypericaceae	<i>Psorospermum febrifugum</i> Spach	S		√
Hypodematiaceae	<i>Hypodematium crenatum</i> (Forssk.) Kuhn	H		
Lamiaceae	<i>Ajuga integrifolia</i> D. Don	H		√
Lamiaceae	<i>Clerodendrum johnstonii</i> Oliv.	S		√
Lamiaceae	<i>Clerodendrum rotundifolium</i> Oliv.	S		√
Lamiaceae	<i>Clinopodium abyssinicum</i> (Benth.) Kuntze	H		
Lamiaceae	<i>Coleus affinis</i> (Gürke) A.J.Paton	H		
Lamiaceae	<i>Coleus cylindraceus</i> (Hochst. ex Benth.) A.J.Paton	S		√
Lamiaceae	<i>Coleus rotundifolius</i> (Poir.) A.Chev. & Perrot	S		
Lamiaceae	<i>Coleus welwitschii</i> Briq.	H		
Lamiaceae	<i>Fuerstia africana</i> T.C.E. Fries	H		√
Lamiaceae	<i>Hoslundia opposita</i> Vahl	H		√
Lamiaceae	<i>Hyptis pectinata</i> Poit.	H		√
Lamiaceae	<i>Hyptis suaveolens</i> Poit.	H	√	
Lamiaceae	<i>Leonotis nepetifolia</i> (L.) R.Br.	H		√
Lamiaceae	<i>Leonotis ocymifolia</i> (Burm.f.) Iwarsson	S		
Lamiaceae	<i>Leonotis ocymifolia</i> (Burm.f.) Iwarsson var. <i>ocymifolia</i>	S		
Lamiaceae	<i>Leucas calostachys</i> Oliv.	S		√
Lamiaceae	<i>Leucas cf. grandis</i> Vatke	H		
Lamiaceae	<i>Leucas deflexa</i> Hook.f.	H		
Lamiaceae	<i>Leucas glabrata</i> (Vahl) R.Br.	H		
Lamiaceae	<i>Leucas oligocephala</i> Hook. f.	H		√
Lamiaceae	<i>Ocimum africanum</i> Lour.	H		
Lamiaceae	<i>Ocimum basilicum</i> L.	H		√
Lamiaceae	<i>Ocimum gratissimum</i> Forssk.	H		√
Lamiaceae	<i>Ocimum kilimandscharicum</i> Gürke	H		√
Lamiaceae	<i>Ocimum obovatum</i> E.Mey. ex Benth.	H		
Lamiaceae	<i>Orthosiphon parvifolium</i> Vatke	H		
Lamiaceae	<i>Orthosiphon thymiflorus</i> (Roth) Sleesen	H		
Lamiaceae	<i>Platostoma denticulatum</i> Robyns	H		
Lamiaceae	<i>Platostoma rotundifolium</i> (Briq.) A.J. Paton	H		
Lamiaceae	<i>Plectranthus barbatus</i> Sims	H		√

FAMILY	SPECIES	LF	IAS	Medicinal
Lamiaceae	<i>Plectranthus prostratus</i> Gürke	S		
Lamiaceae	<i>Plectranthus</i> sp.	H		
Lamiaceae	<i>Rothea myricoides</i> (Hochst.) Steane & Mabb.	S		√
Lamiaceae	<i>Salvia nilotica</i> Jacq.	H		
Lamiaceae	<i>Tetradenia riparia</i> (Hochst.) Codd	S		√
Lamiaceae	<i>Tinnea aethiopica</i> Kotschy ex Hook.f.	S		√
Lamiaceae	<i>Vitex doniana</i> Sweet	T		√
Lamiaceae	<i>Vitex fischeri</i> Gürke var. <i>keniensis</i> (Turrill) Meerts	T		
Lauraceae	<i>Persea americana</i> Mill.	T		
Lentibulariaceae	<i>Utricularia stellaris</i> L. f.	H		
Lophiocarpaceae	<i>Corbichonia decumbens</i> (Forssk.) Exell	H		
Loranthaceae	<i>Odontella</i> sp.	H		
Loranthaceae	<i>Oncocalyx fischeri</i> (Engl.) M.G.Gilbert	S		
Loranthaceae	<i>Phragmanthera rufescens</i> (DC.) Balle	S		
Loranthaceae	<i>Phragmanthera usuiensis</i> (Oliv.) M.Gilbert	S		√
Loranthaceae	<i>Tapinanthus</i> sp.	H		
Malvaceae	<i>Abutilon fruticosum</i> Guill. & Perr.	H		√
Malvaceae	<i>Abutilon guineense</i> (Schumach.) Baker f. & Exell	H		
Malvaceae	<i>Abutilon mauritianum</i> (Jacq.) Sweet	H		√
Malvaceae	<i>Corchorus olitorius</i> L.	H		√
Malvaceae	<i>Corchorus pseudocapsularis</i> Schweinf.	H		
Malvaceae	<i>Corchorus</i> sp.	H		
Malvaceae	<i>Corchorus trilocularis</i> L.	H		√
Malvaceae	<i>Dombeya burgessiae</i> Gerr. ex Harv. & Sond.	T		√
Malvaceae	<i>Grewia bicolor</i> Juss.	S		
Malvaceae	<i>Grewia similis</i> K.Schum.	S		√
Malvaceae	<i>Grewia</i> sp.	S		
Malvaceae	<i>Grewia trichocarpa</i> Hochst. ex A.Rich.	S		√
Malvaceae	<i>Grewia villosa</i> Willd.	S		√
Malvaceae	<i>Hibiscus aethiopicus</i> L.	H		√
Malvaceae	<i>Hibiscus aponeurus</i> Sprague & Hutch.	H		√
Malvaceae	<i>Hibiscus calyphyllus</i> Cav.	S		√
Malvaceae	<i>Hibiscus diversifolius</i> Jacq.	T		
Malvaceae	<i>Hibiscus fuscus</i> Garcke	H		√
Malvaceae	<i>Hibiscus macranthus</i> A.Rich.	S		
Malvaceae	<i>Hibiscus</i> sp.	H		
Malvaceae	<i>Hibiscus trionum</i> L.	H		
Malvaceae	<i>Malvastrum coromandelianum</i> (L.) Garcke	H		
Malvaceae	<i>Melhaniania ovata</i> (Cav.) Spreng.	S		
Malvaceae	<i>Melhaniania velutina</i> Forssk.	H		√
Malvaceae	<i>Pavonia urens</i> Cav.	H		√
Malvaceae	<i>Sida acuta</i> Burm.f.	H		√
Malvaceae	<i>Sida alba</i> L.	H		√
Malvaceae	<i>Sida cordifolia</i> L.	H		√
Malvaceae	<i>Sida ovata</i> Forssk.	H		√

FAMILY	SPECIES	LF	IAS	Medicinal
Malvaceae	<i>Sida rhombifolia</i> L.	H		
Malvaceae	<i>Sida tenuicarpa</i> Vollesen	H		√
Malvaceae	<i>Sida urens</i> L.	H		
Malvaceae	<i>Triumfetta annua</i> L.	H		
Malvaceae	<i>Triumfetta brachyceras</i> K. Schum.	S		√
Malvaceae	<i>Triumfetta pilosa</i> Roth var. <i>pilosa</i>	S		
Malvaceae	<i>Triumfetta rhomboidea</i> Jacq.	H		√
Malvaceae	<i>Triumfetta tomentosa</i> Bojer	H		
Malvaceae	<i>Urena lobata</i> L.	H		
Malvaceae	<i>Waltheria indica</i> L.	S		√
Marsileaceae	<i>Marsilea gibba</i> A. Braun	H		
Marsileaceae	<i>Marsilea minuta</i> L.	H		
Melastomataceae	<i>Antherotoma irvingiana</i> (Hook.) Jacq.-Fél.	H		
Melastomataceae	<i>Dissotis speciosa</i> Taub.	H		√
Meliaceae	<i>Trichilia emetica</i> Vahl	T		√
Meliaceae	<i>Turraea robusta</i> Gurke	S		√
Melianthaceae	<i>Bersama abyssinica</i> Fresen.	T		√
Menispermaceae	<i>Cissampelos mucronata</i> A.Rich.	C		√
Molluginaceae	<i>Paramollugo nudicaulis</i> (Lam.) Thulin	H		
Moraceae	<i>Ficus asperifolia</i> Miq.	S		
Moraceae	<i>Ficus cf. ottoniifolia</i> (Miq.) Miq.	T		
Moraceae	<i>Ficus ingens</i> (Miq.) Miq.	T		
Moraceae	<i>Ficus natalensis</i> Hochst.	T		√
Moraceae	<i>Ficus ottoniifolia</i> (Miq.) Miq.	T		
Moraceae	<i>Ficus ovata</i> Vahl	T		
Moraceae	<i>Ficus sp.</i>	T		
Moraceae	<i>Ficus sur</i> Forssk.	T		√
Moraceae	<i>Ficus sycomorus</i> L.	T		√
Moraceae	<i>Ficus thonningii</i> Blume	T		√
Moraceae	<i>Ficus wakefieldii</i> Hutch.	T		
Moringaceae	<i>Moringa oleifera</i> Lam.	S		√
Musaceae	<i>Musa acuminata</i> Colla	H		
Myrtaceae	<i>Eucalyptus citriodora</i> Hook.	T		√
Myrtaceae	<i>Eucalyptus sp.</i>	T		
Myrtaceae	<i>Psidium guajava</i> L.	T	1	√
Myrtaceae	<i>Syzygium cumini</i> (L.) Skeels	T	1	
Nyctaginaceae	<i>Boerhavia erecta</i> L.	H		
Nyctaginaceae	<i>Commicarpus plumbagineus</i> (Cav.) Standl.	H		√
Nyctaginaceae	<i>Mirabilis jalapa</i> L.	H	1	
Ochnaceae	<i>Ochna holstii</i> Engl.	T		√
Olacaceae	<i>Ximenia americana</i> L.	T		√
Olacaceae	<i>Xlmenia caffra</i> Sond.	T		
Oleaceae	<i>Jasminum floribundum</i> Fres.	S		√
Oleaceae	<i>Jasminum fluminense</i> Vell.	C		√
Oleaceae	<i>Jasminum schimperi</i> Vatke	C		

FAMILY	SPECIES	LF	IAS	Medicinal
Oleaceae	<i>Jasminum sp.</i>	C		
Oleaceae	<i>Olea europaea</i> L.	T		√
Onagraceae	<i>Ludwigia adscendens</i> (L.) H.Hara subsp. <i>diffusa</i> (Forssk.) P.H. Raven	H		
Onagraceae	<i>Ludwigia leptocarpa</i> (Nutt.) H. Hara	H		
Onagraceae	<i>Ludwigia sp.</i>	H		
Opiliaceae	<i>Opilia amentacea</i> Roxb.	S		√
Orchidaceae	<i>Cyrtorchis arcuata</i> (Lindl.) Schltr.	H		
Orobanchaceae	<i>Cycnium sp.</i>	H		
Orobanchaceae	<i>Cycnium tubulosum</i> (L.f.) Engl.	H		√
Orobanchaceae	<i>Striga asiatica</i> (L.) Kuntze	H		
Orobanchaceae	<i>Striga gesnerioides</i> (Willd.) Vatke ex Engl.	H		
Orobanchaceae	<i>Striga hermonthica</i> (Delile) Benth.	H		√
Oxalidaceae	<i>Biophytum umbraculum</i> Welw.	H		√
Oxalidaceae	<i>Oxalis comiculata</i> L.	H		√
Oxalidaceae	<i>Oxalis latifolia</i> Kunth	H		
Passifloraceae	<i>Adenia venenata</i> Forssk.	S		
Passifloraceae	<i>Passiflora edulis</i> Sims	C	1	√
Passifloraceae	<i>Passiflora foetida</i> L.	C	1	
Pedaliaceae	<i>Sesamum angustifolium</i> (Oliv.) Engl.	H		
Pedaliaceae	<i>Sesamum calycinum</i> Welw. subsp. <i>baumii</i> (Stapf) Seidenst. ex Ihlenf.	H		√
Peraceae	<i>Clutia abyssinica</i> Jaub. & Spach	H		√
Phyllanthaceae	<i>Flueggea virosa</i> (Roxb. ex Willd.) Voigt	T		√
Phyllanthaceae	<i>Phyllanthus amarus</i> Schumach. & Thonn.	H		√
Phyllanthaceae	<i>Bischofia javanica</i> Blume	T		
Phyllanthaceae	<i>Breynia disticha</i> J.R.Forst. & G.Forst. var. <i>disticha</i>	S		
Phyllanthaceae	<i>Bridelia micrantha</i> (Hochst.) Baill.	S		√
Phyllanthaceae	<i>Phyllanthus maderaspatensis</i> L.	H		√
Phyllanthaceae	<i>Phyllanthus nummulariifolius</i> Poir.	H		√
Phyllanthaceae	<i>Phyllanthus ovalifolius</i> Forssk.	T		
Phyllanthaceae	<i>Phyllanthus pseudoniruri</i> Müll.Arg.	H		
Phyllanthaceae	<i>Phyllanthus rotundifolius</i> Willd.	H		√
Phyllanthaceae	<i>Phyllanthus sepialis</i> Müll.Arg.	S		
Phyllanthaceae	<i>Phyllanthus sp.</i>	H		
Pittosporaceae	<i>Pittosporum viridiflorum</i> Sims	S		√
Plantaginaceae	<i>Veronica abyssinica</i> Fresen.	H		
Plumbaginaceae	<i>Plumbago amplexicaulis</i> Oliv.	S		
Plumbaginaceae	<i>Plumbago zeylanica</i> L.	H		√
Poaceae	<i>Andropogon schirensis</i> A.Rich.	H		
Poaceae	<i>Aristida adoensis</i> Hochst.	H		
Poaceae	<i>Aristida adscensionis</i> L.	H		
Poaceae	<i>Bothriochloa insculpta</i> (A.Rich.) A.Camus	H		
Poaceae	<i>Brachiaria sp.</i>	H		
Poaceae	<i>Brachiaria subquadripara</i> (Trin.) Hitchc.	H		
Poaceae	<i>Cenchrus ciliaris</i> L.	H		

FAMILY	SPECIES	LF	IAS	Medicinal
Poaceae	<i>Cenchrus mezeianus</i> (Leeke) Morrone	H		
Poaceae	<i>Cenchrus</i> sp.	H		
Poaceae	<i>Chloris pycnothrix</i> Trin.	H		
Poaceae	<i>Cymbopogon nardus</i> (L.) Rendle	H		
Poaceae	<i>Cynodon nlemfuensis</i> Vanderyst	H		
Poaceae	<i>Dactyloctenium aegyptium</i> (L.) Willd	H		
Poaceae	<i>Digitaria abyssinica</i> (A.Rich.) Stapf	H		
Poaceae	<i>Digitaria ternata</i> (A.Rich.) Stapf	H		
Poaceae	<i>Digitaria velutina</i> (Forssk.) P.Beauv.	H		
Poaceae	<i>Dinebra retroflexa</i> (Vahl) Panz.	H		
Poaceae	<i>Echinochloa colona</i> (L.) Link	H		
Poaceae	<i>Echinochloa crus-pavonis</i> (Kunth) Schult.	H		
Poaceae	<i>Echinochloa haploclada</i> (Stapf) Stapf	H		
Poaceae	<i>Echinochloa pyramidalis</i> (Lam.) Hitchc. & Chase	H		
Poaceae	<i>Eleusine indica</i> (Kenn.-O'Byrne) S.M.Phillips	H		
Poaceae	<i>Eragrostis botryodes</i> Clayton	H		
Poaceae	<i>Eragrostis chapelieri</i> (Kunth) Nees	H		
Poaceae	<i>Eragrostis exasperata</i> Peter	H		
Poaceae	<i>Eragrostis pilosa</i> (L.) P.Beauv.	H		
Poaceae	<i>Eragrostis pseudosclerantha</i> Chiov.	H		
Poaceae	<i>Eragrostis racemosa</i> (Thunb.) Steud.	H		
Poaceae	<i>Eragrostis tenuifolia</i> (A.Rich.) Steud.	H		
Poaceae	<i>Eriochloa fatmensis</i> (Hochst. & Steud.) Clayton	H		
Poaceae	<i>Eriochloa meyeriana</i> (Nees) Pilg.	H		
Poaceae	<i>Eriochloa</i> sp.	H		
Poaceae	<i>Harpachne schimperii</i> A.Rich.	H		
Poaceae	<i>Heteropogon contortus</i> (L.) Roem. & Schult.	H		
Poaceae	<i>Hypparrhenia cymbaria</i> (L.) Stapf	H		
Poaceae	<i>Hypparrhenia filipendula</i> (Hochst.) Stapf	H		
Poaceae	<i>Hypparrhenia hirta</i> (L.) Stapf	H		
Poaceae	<i>Hyperthelia dissoluta</i> (Steud.) Clayton	H		
Poaceae	<i>Loudetia kagerensis</i> (K.Schum.) Hutch.	H		
Poaceae	<i>Megathyrsus infestus</i> (Andersson) B.K.Simon & S.W.L.Jacobs	H		
Poaceae	<i>Megathyrsus maximus</i> (Jacq.) B.K.Simon & S.W.L.Jacobs	H		
Poaceae	<i>Melinis repens</i> (Willd.) Zizka	H		
Poaceae	<i>Moorochloa eruciformis</i> (Sm.) Veldkamp	H		
Poaceae	<i>Panicum atosanguineum</i> A. Rich.	H		
Poaceae	<i>Panicum</i> sp.	H		
Poaceae	<i>Panicum trichocladum</i> Hack. ex K.Schum.	H		
Poaceae	<i>Paspalum scrobiculatum</i> L.	H		
Poaceae	<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	H		
Poaceae	<i>Rottboellia cochinchinensis</i> (Lour.) Clayton	H		
Poaceae	<i>Sacciolepis curvata</i> (L.) Chase	H		√
Poaceae	<i>Setaria geminata</i> (Forssk.) Veldkamp	H		
Poaceae	<i>Setaria kagerensis</i> Mez	H		
Poaceae	<i>Setaria nigrirostris</i> (Nees) T. Durand & Schinz	H		

FAMILY	SPECIES	LF	IAS	Medicinal
Poaceae	<i>Setaria plicatilis</i> (Hochst.) Engl.	H		
Poaceae	<i>Setaria pumila</i> (Poir.) Roem. & Schult.	H		
Poaceae	<i>Setaria sphacelata</i> (Schumach.) Moss	H		
Poaceae	<i>Setaria verticillata</i> (L.) P.Beauv.	H		√
Poaceae	<i>Sorghum arundinaceum</i> (Desv.) Stapf	H		
Poaceae	<i>sorghum bicolor</i> (L.) Moench	H		√
Poaceae	<i>Sporobolus festivus</i> Hochst. ex A. Rich.	H		√
Poaceae	<i>Sporobolus ioclados</i> (Trin.) Nees	H		
Poaceae	<i>Sporobolus pyramidalis</i> P.Beauv.	H		√
Poaceae	<i>Sporobolus</i> sp.	H		
Poaceae	<i>Sporobolus stapfianus</i> Gand.	H		
Poaceae	<i>Themeda triandra</i> Forssk.	H		
Poaceae	<i>Tragus berteronianus</i> Schult.	H		
Poaceae	<i>Urochloa arrecta</i> (Hack. ex T. Durand & Schinz) Morrone	H		
Poaceae	<i>Urochloa brizantha</i> (A.Rich.) R.D.Webster	H		
Poaceae	<i>Urochloa leersioides</i> (Hochst.) A.M.Torres & C.M.Morton	H		
Poaceae	<i>Urochloa panicoides</i> P. Beauv.	H		
Poaceae	<i>Urochloa semiundulata</i> (Hochst. ex A.Rich.) Ashal. & V.J.Nair	H		
Poaceae	<i>Zea mays</i> L.	H		
Polygalaceae	<i>Polygala albida</i> Schinz	H		
Polygalaceae	<i>Polygala erioptera</i> DC.	H		√
Polygalaceae	<i>Polygala sadebeckiana</i> Gürke	H		
Polygalaceae	<i>Polygala sphenoptera</i> Fresen.	H		√
Polygonaceae	<i>Antigonon leptopus</i> Hook. & Arn.	C		
Polygonaceae	<i>Oxygonum sinuatum</i> (Meisn.) Dammer	H		√
Polygonaceae	<i>Persicaria pulchra</i> Soják	H		√
Polygonaceae	<i>Polygonum pulchrum</i> Blume	H		√
Polypodiaceae	<i>Arthropteris orientalis</i> (J.F.Gmel.) Posth.	H		
Polypodiaceae	<i>Microsorium punctatum</i> (L.) Copel.	H		
Polypodiaceae	<i>Pleopeltis macrocarpa</i> (Willd.) Kaulf.	H		
Portulacaceae	<i>Portulaca oleracea</i> L.	H		√
Portulacaceae	<i>Portulaca</i> sp.	H		
Primulaceae	<i>Maesa lanceolata</i> Forssk.	S		√
Proteaceae	<i>Grevillea robusta</i> R.Br.	T	1	
Pteridaceae	<i>Pellaea adiantoides</i> J. Sm.	H		
Ranunculaceae	<i>Clematis brachiata</i> Thunb.	C		√
Ranunculaceae	<i>Clematis villosa</i> DC. subsp. <i>villosa</i>	H		
Rhamnaceae	<i>Rhamnus staddo</i> A.Rich.	S		√
Rhamnaceae	<i>Scutia myrtina</i> (Burm. f.) Kurz	S		√
Rhamnaceae	<i>Ziziphus abyssinica</i> A.Rich.	S		
Rhamnaceae	<i>Ziziphus mucronata</i> Willd.	S		√
Rosaceae	<i>Rubus</i> sp.	S		
Rubiaceae	<i>Coffea arabica</i> L.	T		√
Rubiaceae	<i>Gardenia ternifolia</i> Schumach. & Thonn.	S		√

FAMILY	SPECIES	LF	IAS	Medicinal
Rubiaceae	<i>Gardenia ternifolia</i> Schumach. & Thonn. subsp. <i>jovistonantis</i> (Welw.) Aubrév.	S		
Rubiaceae	<i>Hymenodictyon floribundum</i> (Hochst. & Steud.) B.L.Rob.	S		
Rubiaceae	<i>Keetia gueinzii</i> (Sond.) Bridson	S		√
Rubiaceae	<i>Kohautia attenuata</i> (Willd.) I.M.Turner	H		
Rubiaceae	<i>Mitracarpus hirtus</i> (L.) DC.	H		
Rubiaceae	<i>Mussaenda arcuata</i> Poir.	S		√
Rubiaceae	<i>Oldenlandia corymbosa</i> L.	H		
Rubiaceae	<i>Pavetta crassipes</i> K.Schum.	S		√
Rubiaceae	<i>Pavetta oliveriana</i> Hiern	S		√
Rubiaceae	<i>Pavetta oliveriana</i> Hiern var. <i>oliveriana</i>	S		
Rubiaceae	<i>Pavetta subcana</i> Hiern	S		√
Rubiaceae	<i>Psychotria kirkii</i> Hiern	S		√
Rubiaceae	<i>Psydrax schimperiana</i> (A.Rich.) Bridson	S		√
Rubiaceae	<i>Richardia brasiliensis</i> Gomes	H		
Rubiaceae	<i>Rubia cordifolia</i> L.	C		√
Rubiaceae	<i>Tricalysia niamniamensis</i> Hiern var. <i>niamniamensis</i>	S		
Rubiaceae	<i>Vangueria apiculata</i> K.Schum.	S		√
Rubiaceae	<i>Vangueria</i> sp.	S		
Rutaceae	<i>Citrus × sinensis</i> (L.) Osbeck	S		
Rutaceae	<i>Clausena anisata</i> (Willd.) Benth.	S		√
Rutaceae	<i>Teclea nobilis</i> Delile	S		√
Rutaceae	<i>Vepris nobilis</i> (Delile) Mziray	S		√
Rutaceae	<i>Zanthoxylum asiaticum</i> (L.) Appelhans, Groppo & J.Wen	C		√
Salicaceae	<i>Dovyalis abyssinica</i> (A.Rich.) Warb.	S		√
Salicaceae	<i>Dovyalis caffra</i> (Hook.f. & Harv.) Warb.	S	1	
Salicaceae	<i>Dovyalis macrocalyx</i> (Oliv.) Warb.	S		√
Salicaceae	<i>Trimeria grandifolia</i> (Hochst.) Warb.	S		√
Santalaceae	<i>Osyridicarpos schimperianus</i> A.DC.	S		
Santalaceae	<i>Osyris lanceolata</i> Hochst. & Steud.	S		√
Sapindaceae	<i>Allophylus africanus</i> P. Beauv.	T		√
Sapindaceae	<i>Allophylus ferruginus</i> Taub.	T		
Sapindaceae	<i>Allophylus rubifolius</i> (Hochst.) Engl. var. <i>dasystachys</i> (Gilg) Verdc.	T		√
Sapindaceae	<i>Cardiospermum halicacabum</i> L.	C		√
Sapindaceae	<i>Dodonaea angustifolia</i> L.f.	T		√
Sapindaceae	<i>Haplocoelum foliolosum</i> (Hiern) Bullock	S		√
Sapindaceae	<i>Pappea capensis</i> Eckl. & Zeyh.	T		√
Sapotaceae	<i>Mimusops kummel</i> Bruce ex A. DC.	T		√
Simaroubaceae	<i>Harrisonia abyssinica</i> Oliv.	T		√
Solanaceae	<i>Capsicum annuum</i> L.	H	1	
Solanaceae	<i>Cestrum aurantiacum</i> Lindl.	S	1	
Solanaceae	<i>Datura stramonium</i> L.	H	1	√
Solanaceae	<i>Nicandra physaloides</i> Gaertn.	H		
Solanaceae	<i>Physalis angulata</i> L.	H		
Solanaceae	<i>Solanum aethiopicum</i> L.	H		

FAMILY	SPECIES	LF	IAS	Medicinal
Solanaceae	<i>Solanum campylacanthum</i> Hochst. ex A.Rich.	H	1	
Solanaceae	<i>Solanum dasyphyllum</i> Schumach. & Thonn.	H		
Solanaceae	<i>Solanum lycopersicum</i> L.	H		
Solanaceae	<i>Solanum nigrum</i> L.	H		√
Solanaceae	<i>Solanum scabrum</i> Mill.	H		
Solanaceae	<i>Withania somnifera</i> (L.) Dunal	H		√
Verbenaceae	<i>Duranta erecta</i> L.	S	1	
Verbenaceae	<i>Lantana camara</i> L.	S	1	√
Verbenaceae	<i>Lantana trifolia</i> L.	S		√
Verbenaceae	<i>Lantana ukambensis</i> (Vatke) Verdc.	H		√
Verbenaceae	<i>Lippia javanica</i> (Burm.f.) Spreng.	S		√
Verbenaceae	<i>Priva curtisiae</i> Kobuski	H		√
Verbenaceae	<i>Stachytarpheta urticifolia</i> Sims	H		
Violaceae	<i>Afrohybanthus enneaspermus</i> (L.) Flicker	H		
Viscaceae	<i>Viscum hildebrandtii</i> Engl.	S		
Viscaceae	<i>Viscum tuberculatum</i> A.Rich.	S		√
Vitaceae	<i>Ampelocissus africana</i> (Lour.) Merr.	C		√
Vitaceae	<i>Cissus rotundifolia</i> (Forssk.) Vahl	C		√
Vitaceae	<i>Cyphostemma adenocaula</i> (A.Rich.) Wild & R.B.Drumm.	H		√
Vitaceae	<i>Cyphostemma cyphopetalum</i> (Fresen.) Wild & R.B.Drumm.	C		√
Vitaceae	<i>Cyphostemma serpens</i> (A.Rich.) Desc.	C		√
Vitaceae	<i>Rhoicissus revoilii</i> Planch.	C		√
Vitaceae	<i>Rhoicissus tridentata</i> (L.f.) Wild & R.B.Drumm.	S		√
Zygophyllaceae	<i>Balanites aegyptiaca</i> (L.) Delile	T		√
Zygophyllaceae	<i>Tribulus parvispinus</i> C.Presl	H		

Appendix 2: Checklist of macrofungi species in Kisumu County

Family	Species	Species Code	Sub	Kisumu																	
				North West Kisumu					Kisumu West					Seme				Forest			
				1	8	9	10	11	2	3	4	5	6	7	12	13	14	15	Kar	Wet	
Xylariaceae	<i>Xylaria filiformis</i>	X.fil	W	-	-	-	-	-	-	-	-	-	-	-	-	-	1-	-	-	-	-
	<i>Xylaria hypoxylon</i>	X.hyp	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-
	<i>Xylaria polymorpha</i>	X.poly	W	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-
Agaricaceae	<i>Agaricus augustus</i>	A.aug	S	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
	<i>Agaricus endoxanthus</i>	A.end	S	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
	<i>Agaricus impudicus</i>	A.imp	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
	<i>Agaricus martinicensis</i>	A.mart	S	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
	<i>Agaricus placomyces</i>	A.plac	S	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Agaricus rufoaurantiacus</i>	A.ruf	L	5-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Agaricus sp10</i>	A.sp10	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	<i>Agaricus sp8</i>	A.sp8	S	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-
	<i>Agaricus sp9</i>	A.sp9	S	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Agaricus trisulphuratus</i>	A.tri	S	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-
	<i>Bovista Colorata</i>	B.col	S	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
	<i>Bovista plumbea</i>	B.plu	S	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-
	<i>Cystolepiota sp1</i>	C.sp1	S	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
	<i>Lepiota sp3</i>	L.sp3	S	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Leucoagaricus sp1</i>	L.sp1	S	-	-	-	15-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Leucoagaricus sp2 (White)</i>	L.sp2	S	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Lycoperdon sp1</i>	L.sp1	S	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
	<i>Lycoperdon sp2</i>	L.sp2	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	<i>Macrolepiota sp1</i>	M.sp1	S	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-
Bolbitaceae	<i>Conocybe tenera</i>	C.ten	L	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-
	<i>Pholiotina sp1</i>	P.sp1	L	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	<i>Pholiotina rugosa</i>	P.rug	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
Entolomataceae	<i>Entoloma cuneatum</i>	E.cun	ECM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
	<i>Entoloma sp2</i>	E.sp1	ECM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-
Galeropsidaceae	<i>Panaeolus foenicicii</i>	P.foen	L	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Panaeolus olivaceus</i>	P.oliv	S	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-
Hydnangiaceae	<i>Laccaria bicolor</i>	L.bic	ECM	5-	-	-	1-	-	-	-	-	-	-	-	-	-	6	3-	-	6	-
	<i>Laccaria fraterna</i>	L.frat	ECM	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Laccaria laccata</i>	L.lac	ECM	-	-	-	-	-	-	-	-	-	-	-	29	-	-	-	-	-	-
Hygrophoraceae	<i>Hygrocybe conica</i>	H.con	S	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-
	<i>Hygrocybe ceracea</i>	H.cer	W	-	-	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hymenogastraceae	<i>Gymnopilus luteofolius</i>	G.lut	W	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	<i>Psilocybe sp1</i>	P.sp1	S	-	-	-	-	-	2-	-	-	-	-	-	-	-	-	-	-	-	-
Lyophyllaceae	<i>Gerhardtia sp1</i>	G.sp1	S	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Termitomyces aurantiacus</i>	T.aura	T	1	-	-	-	-	7	-	4	-	-	-	-	-	-	-	-	-	-
Marasmiaceae	<i>Crinipellis filiformis</i>	C.fili	W	-	-	-	-	-	-	-	1	-	-	-	-	-	1-	-	-	-	5-
	<i>Crinipellis scabella</i>	C.sca	L	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-
	<i>Crinipellis zonata</i>	M.zon	L	-	-	1	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-
	<i>Marasmius crinisequi</i>	M.cri	L	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	-
	<i>Marasmius haematocephalus</i>	M.hae	L	-	-	-	-	-	-	15	-	2	-	-	-	-	1	3-	16	-	-
	<i>Marasmius rotula</i>	M.rot	L	-	-	-	-	-	-	-	-	-	-	-	-	-	5	2-	5-	-	-
	<i>Marasmius siccus</i>	M.sic	L	-	-	-	-	-	-	-	-	1	-	-	-	4-	-	-	-	-	-
	<i>Megacollybia platyphylla</i>	M.meg	W	-	-	1-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mycenaceae	<i>Mycena arcangeliana</i>	M.arc	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	-	-	-

Family	Species	Species Code	Sub	Kisumu																		
				North West Kisumu					Kisumu West					Seme					Forest			
				1	8	9	10	11	2	3	4	5	6	7	12	13	14	15	Kar	Wet		
	<i>Mycena galericulata</i>	M.gal	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2
	<i>Mycena leaiana</i>	M.lea	W	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Mycena leptcephala</i>	M.lep	L	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Mycena sp1</i>	M.sp1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
	<i>Mycena sp2</i>	M.sp2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	<i>Mycena sp3</i>	M.sp3	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	<i>Panellus sp1</i>	P.sp1	L	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Mycenaceae sp1</i>	SP.sp1	L	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Nidulariaceae	<i>Cyathus striatus</i>	C.str	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33	-
Omphalotaceae	<i>Gymnopus dryophilus</i>	G.dry	L	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Gymnopus sp2</i>	G.sp2	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	-	-
	<i>Gymnopus sp3</i>	G.sp3	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1-	-	-
	<i>Gymnopus subsulphureus</i>	G.sub	L	-	-	-	-	-	-	-	-	-	-	-	-	5-	-	-	-	-	-	-
	<i>Mycetinis scorodoni</i>	M.sco	L	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
	<i>Neonothopanus hygrophanus</i>	N.hyg	W	7	-	-	-	-	3-	-	-	-	-	-	-	1-3	-	-	-	-	-	-
Pleurotaceae	<i>Pluerotus citrinopileatus</i>	Pl.citri	W	-	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluteaceae	<i>Volvariella volvacea</i>	V.vol	S	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psathyrellaceae	<i>Candolleomyces candolleana</i>	P.cand	L	11	-	-	-	-	-	-	88	15	-	-	-	3	-	1	3	-	-	-
Schizophyllaceae	<i>Schizophyllum commune</i>	S.com	Q	-	-	1	-	-	-	-	1-	-	-	-	-	3-	-	-	-	-	-	-
Strophariaceae	<i>Agrocybe pediades</i>	A.ped	S	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	<i>Agrocybe sp2</i>	A.sp2	S	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	<i>Agrocybe sp3</i>	A.sp3	S	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Stropharia sp1</i>	S.sp1	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Agaricomycetes	<i>Agaricomycetes sp1</i>	Ag.sp1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Auriculariaceae	<i>Auricularia auricula-judae</i>	A.aur	W	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Auricularia delicata</i>	A.del	W	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boletinellaceae	<i>Boletinellus sp1</i>	B.sp1	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
Gomphidiaceae	<i>Gomphidius sp1</i>	G.sp1	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Sclerodermataceae	<i>Scleroderma citrinum</i>	S.cit	ECM	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	3	-
Geastraceae	<i>Geastrum triplex</i>	G.tri	S	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Hymenochaetaceae	<i>Fuscoporia gilva</i>	F.gil	W	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-
	<i>Fuscoporia torulosa</i>	F.tor	W	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
	<i>Hymenochaete rubiginosa</i>	H.rub	W	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Phallaceae	<i>Phallus rubicundus</i>	P.rub	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Fomitopsidaceae	<i>Daedalea quercina</i>	D.que	W	4	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Meruliaceae	<i>Podoscypha petalodes</i>	P.pet	W	-	-	2--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polyporaceae	<i>Cerrena unicolor</i>	C.uni	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32	-	-
	<i>Ganoderma adspersum</i>	G.ads	W	-	-	-	-	-	3	-	3	-	-	-	-	-	-	-	5	-	-	-
	<i>Ganoderma applanatum</i>	G.app	W	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Ganoderma australe</i>	G.aust	W	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Ganoderma sessile</i>	G.ses	W	-	4	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-
	<i>Ganoderma tsugae</i>	G.tsug	W	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Lentinus concavus</i>	L.con	W	-	-	15-	-	-	-	-	-	-	-	36	-	-	-	-	33	-	-	-
	<i>Lentinus sp1</i>	L.sp1	W	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
	<i>Lentinus tigrinus</i>	L.tig	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48
	<i>Trametes elegans</i>	T.eleg	W	-	-	-	-	-	1-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stereaceae	<i>Stereum versicolor</i>	S.ver	W	-	-	1--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

**Key:** Numbers represent farmers visited and sampled as follows; Lucy Millicent Otieno (1), Beneditta Amollo (8), Judith Perez (9), Judith Ngeso (10), Caleb Omondi (11), David Olale (2), Fred Wamboya (3), Joseph Juma (4), Phelida Okul Owino (5), Hellen Aloo (6), Everyn Cherono (7), Agnes Adhiabo Ongech (12), Vicent Oloo Ochieng (13), Mary Ayoo Otunga (14), Joyce Atieno Onyango (15). Substrate (sub), litter dwellers (L), Soil colonizers (S), Woodrotters (W), Parasitic (P) and Termites cultivated (T). Karateng forest (Kar) and Magwara/Abuogo Swamp (Wet)

Appendix 3: Checklist of macrofungi species in Migori County

Family	Species	Code	Species Sub	Migori																									
				God-Jope								Uriri						Kakraoi						Forest					
				16	17	18	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	Muk	Tim						
Xylariaceae	<i>Xylaria hypoxylon</i>	X.hyp	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5-	
Agaricaceae	<i>Agaricus augustus</i>	A.aug	S	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	<i>Agaricus endoxanthus</i>	A.end	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	
	<i>Agaricus haemorrhoidarius var fumosus</i>	A.haem	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	
	<i>Agaricus leptocaulis</i>	A.lept	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
	<i>Agaricus martinicensis</i>	A.mart	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	<i>Agaricus sp11</i>	A.sp11	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1-	-	-	
	<i>Agaricus sp13</i>	A.sp13	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
	<i>Agaricus sp16</i>	A.sp16	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
	<i>Agaricus sp17</i>	A.sp17	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
	<i>Agaricus sp2</i>	A.sp2	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
	<i>Agaricus sp21</i>	A.sp21	S	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Agaricus sp22</i>	A.sp22	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
	<i>Agaricus trisulphuratus</i>	A.tri	S	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Bovista Colorata</i>	B.col	S	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-
	<i>Hymenagaricus sp1</i>	H.sp1	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Lepiota sp1</i>	L.sp1	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
<i>Lepiota sp2</i>	L.sp2	S	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Lepiota sp4</i>	L.sp4	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	
<i>Leucocoprinus birnbaumii</i>	L.birn	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	
<i>Leucocoprinus cepaestipes</i>	L.cep	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	
<i>Lycoperdon pyriforme</i>	L.pyr	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2-	
<i>Macrolepiota dolichaula</i>	M.dol	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	
Cortinariaceae	<i>Cortinarius sp1</i>	C.sp1	W	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Galeropsidaceae	<i>Panaeolus antillarum</i>	P.ant	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	
Gloeophyllaceae	<i>Heliocybe sulcata</i>	H.sul	L	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Hydnangiaceae	<i>Laccaria bicolor</i>	L.bic	ECM	2-	2-	-	-	2-	5-	-	-	-	-	2-	-	-	-	1-	-	-	6	-	-	-	-	-	-	-	
	<i>Laccaria laccata</i>	L.lac	ECM	-	-	-	-	-	-	3-	-	-	15	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	
	<i>Laccaria amethysteo-occidentalis</i>	L.ame	ECM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	-	
Hygrophoraceae	<i>Hygrocybe sp1</i>	H.sp1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	
Hymenogastraceae	<i>Gymnopilus sp1</i>	G.sp1	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	
Inocybaceae	<i>Inocybe sp1</i>	I.sp1	ECM	-	-	-	-	2	-	-	-	-	1	15	-	-	-	-	-	-	1	-	-	-	-	-	-	-	
Inocybaceae	<i>Inocybe sp2</i>	I.sp2	ECM	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Lyophyllaceae	<i>Termitomyces microcarpus</i>	T.mic	T	-	-	-	-	-	-	-	-	6-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Marasmiaceae	<i>Crinipellis filiformis</i>	C.fili	W	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	<i>Marasmius armeniacus</i>	M.arm	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	
	<i>Marasmius rotula</i>	M.rot	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1-	
	<i>Marasmius sp1</i>	M.sp1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	
Omphalotaceae	<i>Campanella sp1</i>	M.sp1	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
	<i>Gymnopus erythropus</i>	G.ery	L	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	<i>Gymnopus sp1</i>	G.sp1	L	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	
	<i>Marasmiellus luxurians</i>	G.lux	L	8	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleurotaceae	<i>Pleurotus sp1</i>	P.sp1	W	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pluteaceae	<i>Pluteus chrysophaeus</i>	P.chry	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	
	<i>Pluteus sp1</i>	P.sp1	S	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Psathyrellaceae	<i>Candolleomyces candolleana</i>	P.cand	L	-	-	7	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	
	<i>Parasola plicatilis</i>	P.pli	L	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	<i>Psathyrella sp1</i>	P.sp1	L	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Schizophyllaceae	<i>Schizophyllum commune</i>	S.com	Q	6	-	25	-	-	-	-	-	23	-	3-	3-	-	-	-	-	-	-	-	-	-	-	-	-	11	
Strophariaceae	<i>Agrocybe sp1</i>	A.sp1	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	
	<i>Agrocybe sp3</i>	A.sp3	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	

Family	Species	Code	Species Sub	Migori																									
				God-Jope								Uriri						Kakraoi						Forest					
				16	17	18	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	Muk	Tim						
	<i>Hypholoma fasciculare</i>	H.fas	W	-	-	-	-	-	-	2--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricholomataceae	<i>Clitocybe deceptiva</i>	C.dec	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
	<i>Clitocybe Sp1</i>	C.sp1	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
	<i>Clitocybe sp4</i>	C.sp4	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
Sclerodermataceae	<i>Pisolithus arrhizus</i>	P.arr	ECM	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Scloderma citrinum</i>	S.cit	ECM	-	3	-	-	-	-	-	-	-	-	2	6	-	-	2	-	-	-	-	-	-	-	-	-	1	-
Hymenochaetaceae	<i>Fuscoporia gilva</i>	F.gil	W	-	-	-	-	-	-	6	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Meruliaceae	<i>Podoscypha petalodes</i>	P.pet	W	1-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polyporaceae	<i>Cerrena unicolor</i>	C.uni	W	-	-	-	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	3	2	-	
	<i>Ganoderma applanatum</i>	G.app	W	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Ganoderma curtisii</i>	G.cur	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	<i>Ganoderma tsugae</i>	G.tsug	W	-	-	-	-	-	-	-	15	-	4	1	-	-	-	3	-	-	-	-	-	-	-	-	-	4	-
	<i>Hexagonia sp1</i>	H.sp1	W	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Hexagonia tenuis</i>	M.ten	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
	<i>Hexagonia vesparia</i>	H.ves	W	-	-	-	-	-	-	-	-	-	2	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Lentinus concavus</i>	L.con	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
	<i>Lentinus crinitus</i>	L.crin	W	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Lentinus tigrinus</i>	L.tig	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-
	<i>Pycnoporus sanguineus</i>	P.sang	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
	<i>Trametes sp1</i>	T.sp1	W	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Trametes versicolor</i>	T.vers	W	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

**Key:** Numbers represent farmers visited and sampled as follows; Agrey Asiema (16), Samuel Opiyo Omondi (17), Lucia Nyamogi (18), Lucia Nyamogi (18), Dabid Onyagore (19), Peter Imbai Kihungu (20), Patrick Kisinya Omondi (21), Paul Omondi (22), Benitta Owidhi (23), Leonardus Owiti Raburu (24), Evelyne Akinyi (25), Emily Adhiambo (26), Dickens Odhiambo (27), Michael Wasonga (28), Dickson Onani (29), Alphayo Aimba Koi (30), Caroline Adisi Gao (31), John Odoyo Otieno (32). Substrate (sub), litter dwellers (L), Soil colonizers (S), Woodrotters (W), Parasitic (P) and Termites cultivated (T). Mukuro Forest (Muk) and Timlich Ohinga (TIM)

Appendix 4: Checklist of macrofungi species in Homabay County

Family	Species	Species Code	Sub	Homabay																	
				Gwasssi							Ruma Kaksingiri					Mbita/Ndhiwa					For
				33	34	35	36	42	43	44	37	38	39	40	41	46	47	48	49	50	Kir
Xylariaceae	<i>Xylaria polymorpha</i>	X.poly	W	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	<i>Xylaria sp1</i>	X.sp1	W	-	-	-	-	-	-	-	-	-	1-	-	-	-	-	-	-	-	-
	<i>Xylaria sp2</i>	X.sp2	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5-	-	-	-
	<i>Xylaria sp3</i>	X.sp3	S	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Agaricaceae	<i>Agaricus endoxanthus</i>	A.end	S	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	<i>Agaricus niveogranulatus</i>	A.niv	S	-	-	-	-	-	-	21-	-	-	-	-	-	-	-	-	-	-	-
	<i>Agaricus sp18</i>	A.sp18	S	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	<i>Agaricus sp19</i>	A.sp19	S	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Agaricus sp23</i>	A.sp23	S	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Agaricus sp24</i>	A.sp24	S	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
	<i>Agaricus sp4</i>	A.sp4	S	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
	<i>Bovista Colorata</i>	B.col	S	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Calvatia sp1</i>	C.sp1	S	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
	<i>Leucocoprinus cepaestipes</i>	L.cep	S	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	<i>Lycoperdon pyriforme</i>	L.pyr	S	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolbitaceae	<i>Bolbitius titubans</i>	B.tit	L	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	<i>Conocybe tenera</i>	C.ten	L	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hymenogastraceae	<i>Gymnopilus sp1</i>	G.sp1	W	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lyophyllaceae	<i>Termitomyces aurantiacus</i>	T.aura	T	-	-	-	-	-	1	-	5	-	-	3	-	-	-	-	-	6	-
	<i>Termitomyces sp1</i>	T.sp1	T	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-
Marasmiaceae	<i>Marasmius rotula</i>	M.rot	L	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Omphalotaceae	<i>Marasmiellus candidus</i>	M.cand	L	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psathyrellaceae	<i>Candolleomyces candolleana</i>	P.cand	L	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Parasola plicatilis</i>	P.pli	L	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Psathyrella sp2</i>	P.sp2	L	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-
Schizophyllaceae	<i>Schizophyllum commune</i>	S.com	Q	9	-	-	-	-	2	-	-	1--	1--	2-	2	5-	-	5-	-	-	-
Strophariaceae	<i>Agrocybe pediades</i>	A.ped	S	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Agrocybe praecox</i>	A.prae	S	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	<i>Stropharia melanospema</i>	S.mel	S	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Tricholomataceae	<i>Clitocybe sp2</i>	C.sp2	S	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	<i>Clitocybe sp3</i>	C.sp3	S	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
	<i>Clitocybe sp4</i>	C.sp4	S	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Geastraceae	<i>Geastrum triplex</i>	G.tri	S	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
Hymenochaetaceae	<i>Fuscoporia gilva</i>	F.gil	W	-	-	-	-	-	1-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Hydnoporia olivacea</i>	H.oli	W	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Polyporaceae	<i>Cerrena unicolor</i>	C.uni	W	-	-	-	-	-	-	-	-	4	-	-	-	5-	-	6	-	-	-
	<i>Ganoderma curtisii</i>	G.cur	W	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-
	<i>Ganoderma sp1</i>	G.sp1	W	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	<i>Ganoderma tsugae</i>	G.tsug	W	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Hexagonia sp2</i>	H.sp2	W	-	-	-	-	-	-	-	1-	-	-	-	-	-	-	-	-	-	-
	<i>Lentinus concavus</i>	L.con	W	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-
	<i>Lentinus crinitus</i>	L.crin	W	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-	14	-
	<i>Lentinus tigrinus</i>	L.tig	W	-	-	-	-	-	-	14	-	2	-	-	-	-	-	-	-	-	-
	<i>Polyporaceae sp1</i>	Ply.sp1	W	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
	<i>Skeletocutis sp1</i>	S.sp1	W	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
	<i>Spongipellis pachyodon</i>	S.pac	W	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
	<i>Trametes sp2</i>	T.sp2	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-

**Key:** Numbers represent farmers visited and sampled as follows; Patrick Ochuola (33), Morris Okenga (34), Peterlis Omollo (35), Julius Okello (36), Francis Owiti Obel (42), Naftali Ogutu (43), Peter Kimwamu Omolo (44), Samuel Ouma (37), Joseph Ngoya (38), Barack Bachu (39), Josephine Awino Omondi, (40), Stephen Steve Achieng (41), Christopher Owino Ochinywa (46), Beatrice Achieng Ouma (47), Raphael Ochungo Midida (48), Veryl Achieng (49), George Okinyi Oluto (50). Substrate (sub), litter dwellers (L), Soil colonizers (S), Woodrotters (W), Parasitic (P) and Termites cultivated (T). Kirika Hill (Kir)

Appendix 5: Checklist of Arbuscular Mycorrhiza Fungi in Kisumu County

Family	Species	Species Code	Kisumu																
			North West Kisumu					West					Seme					Forest	
			1	7	8	9	10	2	3	4	5	6	11	12	13	14	15	Kar	Wet
Acaulosporaceae	<i>Acaulospora alpina</i>	A.alpi	-	-	-	-	1	-	2	3	-	-	1	1	-	1	3	2	6
	<i>Acaulospora denticulata</i>	A.dent	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
	<i>Acaulospora excavata</i>	A.exca	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	<i>Acaulospora gegadensis</i>	A.geg	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2
	<i>Acaulospora herrerae</i>	A.herr	-	4	-	3	1-	4	-	-	-	4	-	5	1	-	24	34	12
	<i>Acaulospora mellea</i>	A.mell	2	2	1	4	-	-	7	5	2	-	6	1	-	-	8	5	5
	<i>Acaulospora morrowiae</i>	A.morr	-	-	-	-	-	2	-	-	2	-	4	-	-	-	2	11	1
	<i>Acaulospora rehmi</i>	A.rehm	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	5	1
	<i>Acaulospora rugosa</i>	A.rugo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
	<i>Acaulospora scrobiculata</i>	A.scro	3	5	3	7	-	16	1	2-	-	1	5	6	3	3	2	28	28
	<i>Acaulospora sieverdingii</i>	A.siev	5	5	-	-	-	17	22	8	2	-	1	-	-	-	1	23	17
	<i>Acaulospora sp1</i>	A.sp1	-	-	1	1	-	-	1	1	-	-	8	-	2	1	1	5	11
	<i>Acaulospora sp2</i>	A.sp2	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-
	<i>Acaulospora sp3</i>	A.sp3	-	3	2	-	4	-	-	1	-	2	-	-	1	-	3	-	2
	<i>Acaulospora sp4</i>	A.sp4	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	<i>Acaulospora sp5</i>	A.sp5	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	<i>Acaulospora sp6</i>	A.sp6	-	-	-	-	-	3	1	-	1	-	-	-	-	-	-	-	2
	<i>Acaulospora sp7</i>	A.sp7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	<i>Acaulospora sp8</i>	A.sp8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Diversisporaceae	<i>Diversispora spurca</i>	C.pell	-	1	-	-	-	-	-	-	-	-	-	-	-	4	-	7	4
	<i>Diversispora sp1</i>	Cl.etun	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	3	1
	<i>Diversispora sp2</i>	Cl.lame	-	-	-	-	-	-	-	-	-	-	4	-	-	-	3	-	-
Gigasporaceae	<i>Cetranspora pellucida</i>	Cl.sp1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
	<i>Gigaspora decipiens</i>	D.nigr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	<i>Gigaspora gigantea</i>	D.spur	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	<i>Racocetra gregaria</i>	F.coro	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
	<i>Racocetra persica</i>	F.geos	-	1	-	-	-	3	1	1	1	-	2	-	-	2	2	17	51
	<i>Scutellospora calospora</i>	F.Mos/verr	-	-	4	-	-	-	-	3	-	-	-	-	-	-	-	1	-
	<i>Scutellospora dipurpurascens</i>	Gi.deci	-	-	-	2	1	-	-	7	-	-	5	-	2	3	12	3	6
	<i>Scutellospora scutata</i>	Gi.giga	-	-	6	1	1	-	-	-	-	-	-	-	-	3	3	-	-
	<i>Scutellospora sp1</i>	G.aggr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1-
	<i>Scutellospora sp2</i>	G.ambi	1	8	-	7	13	-	-	3	4	2	1	1-	-	-	7	13	58
	<i>Scutellospora sp3</i>	G.hoi	3	-	-	-	-	-	6	-	2	-	-	1	-	-	-	4	-
Claroideoglomeraceae	<i>Claroideoglossum lamellosum</i>	G.mult	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
Glomeraceae	<i>Funnelformis coronatum</i>	G.sp2	-	-	-	-	-	3	-	-	-	-	-	-	-	-	2	-	-
	<i>Funnelformis geosporus</i>	G.sp3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-
	<i>Funnelformis verruculosum</i>	G.sp4	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
	<i>Glomus aggregatum</i>	G.sp5	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
	<i>Glomus ambisporum</i>	G.sp6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
	<i>Glomus hoi</i>	G.sp7	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	7
	<i>Glomus multicaule</i>	R.fulg	-	-	-	3	5	-	-	-	-	-	2	-	2	-	9	3	2
	<i>Glomus sp1</i>	R.greg	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	<i>Glomus sp2</i>	R.pers	-	-	-	-	6	-	1	4	-	3	-	-	2	1	13	8	2
	<i>Glomus sp3</i>	R.clar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
	<i>Glomus sp4</i>	R.sp1	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
	<i>Glomus sp5</i>	S.calo	-	-	1	7	-	15	8	29	7	-	1	3	6	-	34	7	38
	<i>Glomus sp6</i>	S.dipu	-	1	-	-	-	-	1	5	1	1	-	-	-	-	-	4	-
	<i>Glomus sp7</i>	S.scut	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	4
	<i>Glomus sp8</i>	S.sp1	-	-	-	-	-	1	-	1	1	1	-	-	-	-	2	-	3
	<i>Rhizophagus clarus</i>	S.sp3	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
	<i>Rhizophagus sp1</i>	S.sp4	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-

Key: Numbers represent farmers visited and sampled as follows; Lucy Millicent Otieno (1), Beneditta Amollo (8), Judith Perez (9), Judith Ngeso (10), Caleb Omondi (11), David Olale (2), Fred Wamboya (3), Joseph Juma (4), Phelida Okul Owino (5), Hellen Aloo (6), Everyn Cheron (7), Agnes Adhiabo Ongech (12), Vicent Oloo Ochieng (13), Mary Ayoo Otunga (14), Joyce Atieno Onyango (15). Karateng forest (Kar) and Magwara/Abuogo Swamp (Wet)

Appendix 6: Checklist of Arbuscular Mycorrhiza Fungi in Migori County

Family	Species	Species Code	Migori																		
			God-Jope						Uriri					Kakraoi						Forest	
			16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	Muk	Tim
Acaulosporaceae	<i>Acaulospora alpina</i>	A.alpi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
	<i>Acaulospora delicata</i>	A.deli	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-
	<i>Acaulospora excavata</i>	A.exca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	<i>Acaulospora gegadensis</i>	A.geg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-
	<i>Acaulospora herrerae</i>	A.herr	-	-	7	1	2	-	1	9	4	1	2	1	3	7	2	1	6	9	32
	<i>Acaulospora mellea</i>	A.mell	1	-	-	-	-	2	11	3	-	-	7	-	9	3	1	3	1	-	1
	<i>Acaulospora morrowiae</i>	A.morr	2	-	-	-	-	-	-	1	1	4	-	-	-	-	-	-	15	-	-
	<i>Acaulospora rehmi</i>	A.rehm	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-
	<i>Acaulospora scrobiculata</i>	A.scro	13	-	8	6	1	1	3	1	-	2	2	-	3	7	5	2	-	22	7
	<i>Acaulospora sieverdingii</i>	A.siev	-	-	1	1-	2	-	4	1	-	2	2	-	-	-	-	1	-	1	5
	<i>Acaulospora sp1</i>	A.sp1	1	-	2	-	-	-	1	-	1	-	-	-	-	-	-	-	-	4	6
	<i>Acaulospora sp2</i>	A.sp2	-	-	-	9	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Acaulospora sp3</i>	A.sp3	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Acaulospora sp8</i>	A.sp8	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diversisporaceae	<i>Diversispora spurca</i>	C.pell	8	-	2	-	-	-	2	-	-	-	-	1	3	1	3	1	2	1	1
	<i>Diversispora sp2</i>	Cl.lame	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Gigasporaceae	<i>Gigaspora decipiens</i>	D.nigr	-	-	-	-	1	-	1	-	-	-	-	1	-	-	-	-	-	1	-
	<i>Gigaspora gigantea</i>	D.spur	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
	<i>Denticutata nigra</i>	D.sp1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	<i>Racocetra fulgida</i>	D.sp2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	<i>Racocetra persica</i>	F.geos	-	5	1-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	13	1
	<i>Scutellospora dipurpurascens</i>	Gi.deci	15	13	5	9	-	-	-	1	3	-	-	1	-	-	1	-	5	8	11
	<i>Scutellospora scutata</i>	Gi.giga	8	-	-	4	-	-	-	1	4	1	-	1	-	1	-	3	-	-	2
	<i>Scutellospora sp1</i>	G.aggr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
	<i>Scutellospora sp2</i>	G.ambi	3	4	-	1-	6	-	-	-	-	-	6	1	-	-	-	-	-	15	4-
	<i>Scutellospora sp3</i>	G.hoi	8	-	-	1	-	3	-	-	-	-	2	-	-	-	-	-	-	-	-
Claroideoglomeraceae	<i>Claroideoglosum lamellosum</i>	G.mult	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Glomeraceae	<i>Funneliformis coronatum</i>	G.sp2	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-
	<i>Funneliformis verruculosum</i>	G.sp4	-	-	-	-	-	5	-	-	3	-	-	-	-	-	-	-	-	-	-
	<i>Glomus aggregatum</i>	G.sp5	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	4
	<i>Glomus macrocarpum</i>	G.sp8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
	<i>Glomus multicaule</i>	R.fulg	5	-	1-	-	2	-	4	-	-	-	-	-	-	-	-	-	-	2	1
	<i>Glomus sp2</i>	R.pers	6	3	-	5	-	1	1	-	-	-	-	-	1	2	4	-	1	1	-
	<i>Glomus sp5</i>	S.calo	7	-	2	8	1	-	-	-	-	-	-	-	-	1	7	4	3	1	-
	<i>Glomus sp6</i>	S.dipu	-	-	-	-	-	-	-	-	2	-	2	-	1	1	2	-	-	-	-
	<i>Glomus sp7</i>	S.scut	-	-	-	-	-	2	3	1	1	1	3	-	-	2	4	1	1-	-	-
	<i>Glomus sp8</i>	S.sp1	-	-	-	-	2	3	-	1	-	-	-	-	2	1	2	-	-	-	8
	<i>Rhizophagus sp1</i>	S.sp4	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-

**Key:** Numbers represent farmers visited and sampled as follows; Agrey Asiema (16), Samuel Opiyo Omondi (17), Lucia Nyamogi (18), Lucia Nyamogi (18), Dabid Onyalgore (19), Peter Imbai Kihungu (20), Patrick Kisinya Omondi (21), Paul Omondi (22), Benitta Owidhi (23), Leonardus Owiti Raburu (24), Evelyne Akinyi (25), Emily Adhiambo (26), Dickens Odhiambo (27), Michael Wasonga (28), Dickson Onani (29), Alphayo Aimba Koi (30), Caroline Adisi Gao (31), John Odoyo Otieno (32). Mukuro Forest (Muk) and Timlich Ohinga (TIM)

Appendix 7: Checklist of Arbuscular Mycorrhiza Fungi in Homabay County

Family	Species	Species Code	Homabay																		
			Gwassi							Ruma Kaksingiri					Mbita/Ndhiwa						
			33	34	35	36	42	43	44	45	37	38	39	40	41	46	47	48	49	50	Kir
Acaulosporaceae	<i>Acaulospora alpina</i>	A.alpi	-	-	-	-	-	7	5	-	-	-	-	-	-	3	-	-	5	1	
	<i>Acaulospora bireticulata</i>	A.bir	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-		
	<i>Acaulospora excavata</i>	A.exca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2		
	<i>Acaulospora gegadensis</i>	A.geg	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-		
	<i>Acaulospora herrerae</i>	A.herr	5	-	3	4	3	3	5	7	-	4	-	7	-	18	-	7	11	-	26
	<i>Acaulospora mellea</i>	A.mell	-	7	-	1	-	-	-	-	1	-	-	-	3	2	-	5	4	4	44
	<i>Acaulospora morrowiae</i>	A.morr	1	1	1	-	-	-	-	-	-	-	3	-	-	1	-	3	-	-	-
	<i>Acaulospora rehmi</i>	A.rehm	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	
	<i>Acaulospora rugosa</i>	A.rugo	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-
	<i>Acaulospora scrobiculata</i>	A.scro	-	2	2	2	-	-	3	1	-	1	2	-	2	21	24	7	1	48	
	<i>Acaulospora sieverdingii</i>	A.siev	-	1	2	1	-	-	-	-	1	-	-	2	-	2	19	1	1	3	23
	<i>Acaulospora sp1</i>	A.sp1	-	-	-	-	1	-	1	2	2	-	-	2	-	4	2	1	1	-	16
	<i>Acaulospora sp2</i>	A.sp2	-	-	-	-	5	-	-	3	-	-	-	-	-	5	4	14	1	-	-
	<i>Acaulospora sp3</i>	A.sp3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	<i>Acaulospora sp5</i>	A.sp5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	<i>Acaulospora sp6</i>	A.sp6	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diversisporaceae	<i>Diversispora spurca</i>	C.pell	-	-	-	-	-	7	-	-	-	-	-	-	-	1	1	-	-	-	3
	<i>Diversispora sp1</i>	Cl.etun	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	<i>Diversispora sp2</i>	Cl.lame	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-
Gigasporaceae	<i>Gigaspora decipiens</i>	D.nigr	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	<i>Gigaspora gigantea</i>	D.spur	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
	<i>Racocetra persica</i>	F.geos	-	-	3	-	-	-	5	2	-	-	3	1	-	2	-	-	6	-	58
	<i>Scutellospora dipurpurascens</i>	Gi.dec	1	-	-	-	1	2	3	-	-	1	4	-	1	-	1	4	-	2	23
	<i>Scutellospora scutata</i>	Gi.giga	3	-	3	-	-	-	-	-	8	4	-	-	-	-	-	-	2	-	-
	<i>Scutellospora sp2</i>	G.ambi	-	-	4	-	-	2	-	-	-	3	-	-	-	1	2	5	-	4	12
	<i>Scutellospora sp3</i>	G.hoi	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	4
Claroideoglomeraceae	<i>Claroideoglomerum etunicatum</i>	G.macr	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
	<i>Claroideoglomerum lamellosum</i>	G.mult	-	-	-	-	-	-	-	-	-	-	-	-	2	5	5	-	-	-	-
	<i>Claroideoglomerum sp1</i>	F.cale	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glomeraceae	<i>Funneliformis coronatum</i>	G.sp2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
	<i>Funneliformis geosporus</i>	G.sp3	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
	<i>Funneliformis verruculosum</i>	G.sp4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
	<i>Glomus ambisporum</i>	G.sp6	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
	<i>Glomus macrocarpum</i>	G.sp8	4	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Glomus multicaule</i>	R.fulg	-	-	-	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	6
	<i>Glomus sp1</i>	R.greg	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Glomus sp2</i>	R.pers	1	-	1	-	1	-	-	-	-	-	-	-	1	-	1	1	-	-	11
	<i>Glomus sp4</i>	R.sp1	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
	<i>Glomus sp5</i>	S.calo	1	2	1	-	1	5	1	1	-	1	-	5	1	2	4	3	3	-	8
	<i>Glomus sp6</i>	S.dipu	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
	<i>Glomus sp7</i>	S.scut	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
	<i>Glomus sp8</i>	S.sp1	1	1	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-

**Key:** Numbers represent farmers visited and sampled as follows; Patrick Ochuola (33), Morris Okenga (34), Peterlis Omollo (35), Julius Okello (36), Francis Owiti Obel (42), Naftali Ogutu (43), Peter Kimwamu Omolo (44), Samuel Ouma (37), Joseph Ngoya (38), Barack Bachu (39), Josephine Awino Omondi, (40), Stephen Steve Achieng (41), Christopher Owino Ochiya (46), Beatrice Achieng Ouma (47), Raphael Ochungo Midida (48), Veryl Achieng (49), George Okinyi Oluto (50), Kirika Hill (Kir)

**Appendix 1 Species list of Kisumu, Migori and Homa bay counties showing IUCN status, Endemicity CITES status and whether confirmed during the current sampling or not**

Species Name	Common name	Type	IUCN status/ Endemic/CITES	Confirmed
<i>Acanthocercus gregorii</i>	Southern tree agama	Reptile	LC	Absent
<i>Acanthocercus ugandaensis</i>	Uganda Blue-headed tree agama	Reptile	NA	Confirmed
<i>Adolfus jacksoni</i>	Jackson's forest lizard	Reptile	LC	Confirmed
<i>Afrivalus fulvovittatus</i>	Banded banana frog	Amphibian	LC	Confirmed
<i>Afrivalus septentrionalis</i>	Kenya Banana Frog	Amphibian	LC; Endemic KE&TZ	Absent
<i>Afrotyphlops lineolatus</i>	Common Lined Worm Snake	Reptile	LC	Absent
<i>Agama kaimosae</i>	Kakamega agama	Reptile	LC; Endemic KE&TZ	Confirmed
<i>Amblyodipsas unicolor</i>	Dull Purple-glossed Snake	Reptile	LC	Absent
<i>Amietia nutti</i>	Nutt's River Frog	Amphibian	LC	Confirmed
<i>Amnirana albolabris</i>	Forest White-lipped Frog	Amphibian	LC	Absent
<i>Amnirana galamensis</i>	Galam White-lipped Frog	Amphibian	LC	Absent
<i>Atractaspis irregularis</i>	Variable burrowing asp	Reptile	NA	Absent
<i>Bitis arietans</i>	Puff adder	Reptile	LC	Confirmed
<i>Broadleysaurus major</i>	Rough-scaled Plated Lizard	Reptile	LC	Confirmed
<i>Causus resimus</i>	Green Night Adder	Reptile	LC	Absent
<i>Causus rhombeatus</i>	Rhombic Night Adder	Reptile	LC	Absent
<i>Chamaeleo dilepis</i>	Flap-necked chameleon	Reptile	LC; CITES APPII	Confirmed
<i>Chamaeleo gracilis</i>	Slender Chameleon	Reptile	LC; CITES APPII	Absent
<i>Chamaeleo laevigatus</i>	Smooth chameleon	Reptile	LC; CITES APPII	Absent
<i>Chiromantis petersi</i>	Peters' Foam-nest Tree Frog	Amphibian	LC	Confirmed
<i>Crotaphopeltis degeni</i>	Degen's water snake	Reptile	LC	Absent
<i>Crotaphopeltis hotamboeia</i>	Herald snake	Reptile	LC	Absent
<i>Dendroaspis polylepis</i>	Black mamba	Reptile	LC	Absent
<i>Dispholidus typus</i>	Boomslang	Reptile	LC	Absent
<i>Elapsoidea loveridgei</i>	Loveridge's garter snake	Reptile	LC	Absent
<i>Grayia tholloni</i>	Tholloni's water snake	Reptile	LC	Absent
<i>Hemidactylus mabouia</i>	Tropical house gecko	Reptile	LC	Confirmed
<i>Hemidactylus platycephalus</i>	Baobab gecko	Reptile	LC	Confirmed
<i>Hemisis marmoratus</i>	Marbled-snout burrower	Amphibian	LC	Absent
<i>Hoplobatrachus occipitalis</i>	Groove-crowned bullfrog	Amphibian	LC	Confirmed
<i>Hyperolius cinnamomeoventris</i>	Cinnamon-bellied Reed Frog	Amphibian	LC	Confirmed
<i>Hyperolius howelli</i>	Howell's reed frog	Amphibian	LC; Endemic KE&TZ	Absent
<i>Hyperolius kivuensis</i>	Kivu Reed Frog	Amphibian	LC	Confirmed
<i>Hyperolius viridiflavus</i>	Common reed frog	Amphibian	LC	Confirmed
<i>Kassina somalica</i>	Somali running frog	Amphibian	LC	Absent
<i>Kassina senegalensis</i>	Bubbling Kassina	Amphibian	LC	Confirmed
<i>Leptopelis bocagei</i>	Bocage's tree frog	Amphibian	LC	Absent
<i>Limaformosa savorgnani</i>	Savorgnan's file snake	Reptile	LC	Absent
<i>Lygodactylus gutturalis</i>	Chevron-throated dwarf gecko	Reptile	LC	Confirmed

Species Name	Common name	Type	IUCN status/ Endemic/CITES	Confirmed
<i>Meizodon semiornatus</i>	semi-ornate snake	Reptile	LC	Absent
<i>Mochlus sundevalli</i>	Sundevall's writhing skink	Reptile	LC	Absent
<i>Naja nigricollis</i>	Black-necked spitting cobra	Reptile	LC	Absent
<i>Naja subfulva</i>	Eastern forest cobra	Reptile	NA	Confirmed
<i>Natriciteres olivacea</i>	Olive marsh snake	Reptile	LC	Absent
<i>Panaspis massaiensis</i>	Maasai snake-eyed skink	Reptile	LC	Confirmed
<i>Pelusios williamsi</i>	Williams mud terrapin	Reptile	LC; CITES APPII	Confirmed
<i>Philothamnus battersbyi</i>	Battersby's green snake	Reptile	LC	Confirmed
<i>Philothamnus heterolepidotus</i>	Slender green snake	Reptile	LC	Absent
<i>Phrynobatrachus graueri</i>	Grauer's puddle frog	Amphibian	LC	Absent
<i>Phrynobatrachus natalensis</i>	Natal dwarf puddle frog	Amphibian	LC	Confirmed
<i>Phrynobatrachus scheffleri</i>	Scheffler's Puddle Frog	Amphibian	LC	Confirmed
<i>Psammodphis lineatus</i>	Lined olympic snake	Reptile	LC	Absent
<i>Psammodphis mossambicus</i>	Olive grass snake	Reptile	LC	Absent
<i>Ptychadena anchietae</i>	Anchieta's ridged frog	Amphibian	LC	Confirmed
<i>Ptychadena nilotica</i>	Nile Grass Frog	Amphibian	LC	Confirmed
<i>Ptychadena porosissima</i>	Grassland Ridged Frog	Amphibian	LC	Absent
<i>Python sebae</i>	Central African rock python	Reptile	NT	Confirmed
<i>Sclerophrys gutturalis</i>	Guttural toad	Amphibian	LC	Absent
<i>Sclerophrys kisoensis</i>	Kisolo toad	Amphibian	LC	Confirmed
<i>Sclerophrys maculatus</i>	Hallowell's Toad	Amphibian	LC	Absent
<i>Sclerophrys pussila</i>	Lesser Cross-marked Toad	Amphibian	LC	Confirmed
<i>Sclerophrys regularis</i>	Common toad	Amphibian	LC	Absent
<i>Stigmochelys pardalis</i>	Leopard tortoise	Reptile	LC; CITES APPII	Absent
<i>Trachylepis maculilabris</i>	Speckle-lipped skink	Reptile	LC	Confirmed
<i>Trachylepis quinquetaeniata</i>	African Five-lined Skink	Reptile	LC	Confirmed
<i>Trachylepis striata</i>	Striped skink	Reptile	LC	Confirmed
<i>Trioceros ellioti</i>	Elliot's Groove-throated Chameleon	Reptile	LC; CITES APPII	Absent
<i>Varanus nilotica</i>	Nile monitor lizard	Reptile	LC	Confirmed
<i>Xenopus victorianus</i>	Lake Victoria clawed frog	Amphibian	LC	Confirmed

Appendix 9: Invertebrate- A checklist and distribution of the termites of the three surveyed counties

County	Location	Family	Genus	Species	Habitat
Homa bay	Nyadenda	Termitidae	Odontotermes	sp.	Farm 1
Homa bay	Tonga village	Termitidae	Macrotermes	subhyalinus	Farm 1
Homa bay	Tonga village	Termitidae	Pseudocanthotermes	sp.	Farm 2
Kisumu	Aboge village	Termitidae	Macrotermes	subhyalinus	Farm 2
Kisumu	Aboge village	Termitidae	Promirotermes	sp	Farm 2
Kisumu	Aboge village	Termitidae	Pseudocanthotermes	sp	Farm 2
Kisumu	Nyabera Village	Termitidae	Pseudocanthotermes	sp.	Farm 1
Kisumu	Nyabera Village	Termitidae	Pseudocanthotermes	sp.	Farm 2
Kisumu	Nyabere Karateng	Termitidae	Amitermes	sp	Farm 1
Kisumu	Nyabere Karateng	Termitidae	Macrotermes	herus	Farm 2
Kisumu	Nyabere Karateng	Termitidae	Macrotermes	Subhyalinus	Farm 1
Kisumu	Nyabere Karateng	Termitidae	Odontotermes	badius	Farm 2
Kisumu	Kadongo Kathure-B	Termitidae	Macrotermes	herus	Farm 1
Migori	Kibuye village Uriri	Termitidae	Pseudocanthotermes	sp.	Farm 2
Migori	God Jope Suna	Termitidae	Macrotermes	herus	Farm 1
Migori	Lucia's farm	Termitidae	Amitermes	sp.	Farm 2
Migori	Lucia's farm	Termitidae	Odontotermes	sp.	Farm 2
Migori	Lucia's farm	Termitidae	Pseudocanthotermes	sp.	Farm 2
Migori	Mukuro natural forest	Termitidae	Macrotermes	subhyalinus	Natural forest
Migori	Mukuro natural forest	Termitidae	Odontotermes	sp	Natural forest
Migori	Mukuro natural forest	Termitidae	Pseudocanthotermes	sp.	Natural forest

Appendix 10: Invertebrate- A checklist and distribution of the bees in pan traps in the three surveyed counties

Site		Family	ID
Homa bay	Tonga village 1	Halictidae	Lipotriches sp.1
Homa bay	Tonga village 1	Halictidae	Seladonia sp.1
Homa bay	Tonga village 2	Apidae	Melliponula ? Denoiti
Homa bay	Tonga village 2	Halictidae	Lipotriches sp.1
Homa bay	Tonga village 2	Halictidae	Nomia sp.1
Kisumu	Aboge village	Megachilidae	Megachile sp.1
Kisumu	Aboge village	Apidae	Apis mellifera
Kisumu	Kadongo Kathure	Apidae	Ceratina sp 3.
Kisumu	Kadongo Kathure	Apidae	Ceratina sp.2
Kisumu	Kadongo Kathure	Apidae	Macrogalea candida
Kisumu	Kadongo Kathure	Apidae	Macrogalea candida
Kisumu	Kadongo Kathure	Halictidae	Lasioglossum sp 1
Kisumu	Kadongo Kathure	Halictidae	Lasioglossum sp 1
Kisumu	Kadongo Kathure	Halictidae	Lasioglossum sp 1
Kisumu	Kadongo Kathure	Halictidae	Lasioglossum sp 2
Kisumu	Kadongo Kathure	Halictidae	Lasioglossum sp.1
Kisumu	Kadongo Kathure	Halictidae	Lipotriches sp.1
Kisumu	Nyabere village 1	Apidae	Amegilla sp 1.
Kisumu	Nyabere village 1	Megachilidae	Heriades sp 1
Kisumu	Nyabere village 1	Megachilidae	Megachile sp.2
Kisumu	Nyabere village 1	Apidae	Amegilla sp 1.
Kisumu	Nyabere village 2	Apidae	Ceratina sp 5
Kisumu	Nyabere village 2	Halictidae	Pseudapis sp 1
Kisumu	Nyabere village 2	Halictidae	Lasioglossum sp.1
Migori	Kibuye village Uriri	Megachilidae	Megachile sp.1
Migori	Lucas farm	Apidae	Ceratina sp 2
Migori	Lucas farm	Apidae	Ceratina viridis
Migori	Mukuro natural forest	Apidae	Ceratina viridis

Appendix 11: Invertebrate- A checklist and distribution of non- termite and non-bees terrestrial invertebrate species from the surveyed farms

Order	Family	Genus/ spp	Kisumu, Aboge village	Kisumu, Nyabere village	Homabay, Tonga village Farm 2	Homabay Seka, Gwasi	Migori, Lucas farm, Farm 2	Kisumu Karateng hill, Mbaka	Migori, Mukuro Natural forest	Migori	Migori, God Jope, Suna East	Nyadenda	Migori Uriri Rapong
Blattodea	Blattellidae	Blattella sp						x					
Coleoptera	Buprestidae	Anthaxia sp			x								
Coleoptera	Buprestidae	Acmaeodera sp						x					
Coleoptera	Cerambycidae	Mecosaspis nigricolis	x										
Coleoptera	Cerambycidae	Helymaeus sp			x								
Coleoptera	Chrysomelidae	Melitonoma bomaensis	x										
Coleoptera	Chrysomelidae	Leptaulaca bifasciata	x	x									
Coleoptera	Chrysomelidae	Chrysolina opulenta							x				
Coleoptera	Chrysomelidae	Leptaulaca fissicollis											x
Coleoptera	Coccinelidae	Cheilomenes sulphurea		x									
Coleoptera	Coccinelidae	Cheilomones sp			x								
Coleoptera	Coccinelidae	Cheilomenes lunata					x						
Coleoptera	Coccinelidae	Henosepilachna multinota					x						
Coleoptera	Curculionidae	Lixus sp			x								
Coleoptera	Lagriidae	Chrysolagria macus		x									
Coleoptera	Lycidae	Lycus sp1			x								
Coleoptera	Lycidae	Lycus sp					x						
Coleoptera	Meloidae	Zonitoschema sp			x		x					x	
Coleoptera	Prionoceridae	idgia sp1		x									
Coleoptera	Prionoceridae	Idgia sp2				x							
Coleoptera	Scarabaeidae	Diplognatha silicea	x										
Coleoptera	Scarabaeidae	Pachnoda upangirana			x								
Coleoptera	Scarabaeidae	Leucocellis sp			x		x						
Dermaptera	Forficulidae	Diaperasticus sp		x			x						
Diptera	Asilidae	Asilidae sp	x										
Diptera	Asilidae	Rhabdogaster sp			x								
Diptera	Calliphoridae	Hemipyrellia sp	x										
Diptera	Calliphoridae	Lucilia sp2			x								
Diptera	Diopsidae	Diopsis sp		x									
Diptera	Diopsidae	Diopsis ichneumones				x							
Diptera	Muscidae	Orthellia sp	x										
Diptera	Muscidae	Pseudohelina sp	x										
Diptera	Syrphidae	Phytomia natalensis				x							
Diptera	Tachnidae	Carcelia sp	x										
Hemiptera	Cercopidae	Locris auripennis		x	x	x	x						

Order	Family	Genus/ spp	Kisumu, Aboge village	Kisumu, Nyabere village	Homabay, Tonga village Farm 2	Homabay Seka, Gwasi	Migori, Lucas farm, Farm 2	Kisumu Karateng hill, Mbaka	Migori, Mukuro Natural forest	Migori	Migori, God Jope, Suna East	Nyadenda	Migori Uriri Rapong
Hemiptera	Cicadellidae	Coelidia sp		x		x			x				
Hemiptera	Coreidae	Leptocoris sordida	x										
Hemiptera	Coreidae	Mirperus jaculus						x					
Hemiptera	Gelastocoridae	Mononyx grandicollis		x									
Hemiptera	Hemiptera	Hemiptera sp			x		x			x			
Hemiptera	Parastrachiidae	Dismegistus sanguineus			x								
Hemiptera	Pentatomidae	Acoloba lanceolata			x								
Hemiptera	Pentatomidae	Agonoscelis versicolor	x	x		x			x	x			x
Hemiptera	Pentatomidae	Aspavia armigera		x			x						
Hemiptera	Pentatomidae	Aspavia hastator						x					
Hemiptera	Pyrrhocoridae	Neodindymus migratorius			x								
Hemiptera	Reduviidae	Endochus cinnamopterus						x					
Hemiptera	scutellaridae	Sphaerocoris sp		x									
Hymenoptera	Apidae	Xylocopa flavorufa										x	x
Hymenoptera	Apidae	Macrogalea candida			x							x	
Hymenoptera	Apidae	Apis mellifera	x										
Hymenoptera	Braconidae	Iphiaulax p		x									
Hymenoptera	Eumenidae	Synargris analis						x					
Hymenoptera	Formicidae	Camponotus flavomarginatus	x										
Hymenoptera	Formicidae	Camponotus maculatus	x	x							x		
Hymenoptera	Formicidae	Camponotus sp1					x						
Hymenoptera	Formicidae	Camponotus sp2	x		x		x	x					
Hymenoptera	Formicidae	Camponotus sp3			x								
Hymenoptera	Formicidae	Dorylus molestus	x										
Hymenoptera	Formicidae	Dorylus sp	x		x	x	x	x	x		x	x	x
Hymenoptera	Formicidae	Myrmecaria sp		x									
Hymenoptera	Formicidae	Pachycondyla tarsata	x					x					
Hymenoptera	Formicidae	Platythyrea cribrinodis			x								
Hymenoptera	Formicidae	Polyrhacis medusa							x				
Hymenoptera	Ichneumonidae	Ichneumonidae sp1		x		x	x						x
Hymenoptera	Ichneumonidae	Ichneumonidae sp2			x								
Hymenoptera	Pompilidae	Hemipepsis iodoptera											x
Hymenoptera	Pompilidae	Hemipepsis sp			x								
Hymenoptera	Reduviidae	Callicertes sp						x					
Hymenoptera	Sphecidae	Liris sp3			x				x				
Hymenoptera	Sphecidae	Astata sp											
Hymenoptera	Sphecidae	Cerceris iniqua								x			

Order	Family	Genus/ spp	Kisumu, Aboge village	Kisumu, Nyabere village	Homabay, Tonga village Farm 2	Homabay Seka, Gwasi	Migori, Lucas farm, Farm 2	Kisumu Karateng hill, Mbaka	Migori, Mukuro Natural forest	Migori	Migori, God Jope, Suna East	Nyadenda	Migori Uriri Rapong
Hymenoptera	Vespidae	Belanogaster sp	x	x									
Hymenoptera	Vespidae	Polistes sp2	x										
Mantodea	Mantidae	Cilnia humaralis	x										
Orthoptera	Acrididae	Acrotylus patruelis								x			
Orthoptera	Acrididae	Acrotylus sp1			x								
Orthoptera	Acrididae	Acrotylus sp3	x		x								
Orthoptera	Acrididae	Catantops melanostrictus								x			
Orthoptera	Acrididae	Catantops sp	x										
Orthoptera	Acrididae	Coryphosima sp 1	x										
Orthoptera	Acrididae	Coryphosima sp2			x								
Orthoptera	Acrididae	Coryphosima sp3	x										
Orthoptera	Acrididae	Humbe sp 1					x						
Orthoptera	Acrididae	Humbe sp3	x										
Orthoptera	Acrididae	Humbe tenuicornis									x		
Orthoptera	Acrididae	Paracoptacra sp					x		x				
Orthoptera	Acrididae	Rhaphotittha sp	x										
Orthoptera	Acrididae	Roduniella sp		x									
Orthoptera	Acrididae	Sphingonotus sp	x										
Orthoptera	Acrididae	Stenohippus sp	x										
Orthoptera	Acrididae	Truxalis sp		x			x	x					
Orthoptera	Gryllidae	Gryllus sp		x									
Orthoptera	Tettigonidae	Tylopsis sp											x

Appendix 12: Invertebrate- A collection of different invertebrate species from the farms and natural habitats in Kisumu, Homa bay and Migori Counties



A day flying moth



Julia skimmer dragonfly



Colotis sp.



Eurema brigitta



A long-horned beetle



Rose beetle



A female dragonfly



Shield bugs



Belenois creona



Dismegistus sp



Deudorix sp.



A short-horned grasshopper

Appendix 13: Checklist of all bird species recorded at different sampling sites in Kisumu, Migori and Homa Bay survey

Migration status: R = Resident; PM = Palearctic migrant; pm= Palearctic migrant that occurs alongside residents or non-migratory individuals; am = Afrotropical migrant that occurs alongside resident or non-migratory individuals; om = Oriental region migrant. Forest category: FF = forest-specialist; F = forest generalists, and f = forest visitors; Feeding guilds: Omn = Omnivore; Gra = Granivore; Car = Carnivore; Alg = Algivore; Ins = Insectivore; Fru = frugivore; Pis = piscivore; Nec = nectarinivore; and Sca = scavenger.

Family & common name		Species scientific name	Migration	Forest Category	Feeding Guild	Kisumu County						Migori County						Homa Bay County										
						M.L Otieno	Joyce Kaveza	Fred Otieno	Joseph Juma	Terrestrial	Wetland (seasonal)	Wetland (seasonal)	Aggrey Asiena	Lucia Nyamogi	Paul (Rapogi)	Wetland/Riverine	Evalyne Akinyi	Terrestrial/Forest	Terrestrial/Forest	Kochwola	Samuel Ouma	Josephine Omondi	Collins Otieno	Kiringa Hill	Terrestrial/Forest	Wetland (Lake Simbi)		
<b>Numididae: guineafowl</b>																												
1	Helmeted Guineafowl	<i>Numida meleagris</i>	R		Omn																			3				
<b>Phasianidae: quails, francolins, spurfowl and allies</b>																												
2	Crested Francolin	<i>Francolinus sephaena</i>	R		Gra									1														
<b>Anatidae: ducks and geese</b>																												
3	White-faced Whistling Duck	<i>Dendrocygna viduata</i>	R		Omn																				5			
<b>Podicipedidae: grebes</b>																												
4	Little Grebe	<i>Tachybaptus ruficollis</i>	R		Car						2																	37
<b>Phoenicopteridae: flamingos</b>																												
5	Lesser Flamingo	<i>Phoeniconaias minor</i>	am		Alg																							19
<b>Ciconiidae: storks</b>																												
6	African Open-billed Stork	<i>Anastomus lamelligerus</i>	am		Car									2												2		
7	Abdim's Stork	<i>Ciconia abdimii</i>	AM		Car						3																	
8	Woolly-necked Stork	<i>Ciconia episcopus</i>	R		Car										3													
9	White Stork	<i>Ciconia ciconia</i>	PM		Car									1														
<b>Threskiornithidae: ibises and spoonbills</b>																												
10	Sacred Ibis	<i>Threskiornis aethiopicus</i>	R		Car									5														3
11	Hadada Ibis	<i>Bostrychia hagedash</i>	R		Car	2	2	2	2	1		2	2	2										2				2
<b>Ardeidae: herons, egrets and bitterns</b>																												
12	Cattle Egret	<i>Bubulcus ibis</i>	am		Car					3	15			1	13			4						23	3	40		5
13	Black-headed Heron	<i>Ardea melanocephala</i>	R		Car				1					1														
14	Yellow-billed Egret	<i>Egretta intermedia</i>	R		Car																					1		
15	Black Heron	<i>Egretta ardesiaca</i>	R		Car									1														
16	Little Egret	<i>Egretta garzetta</i>	R		Car									1													5	
<b>Scopidae: Hamerkop</b>																												
17	Hamerkop	<i>Scopus umbretta</i>	R		Car					2				1				1						1	1			4
<b>Phalacrocoracidae: cormorants</b>																												
18	Reed Cormorant	<i>Phalacrocorax africanus</i>	R		Pis																					1		
<b>Falconidae: falcons</b>																												
19	Eleonora's Falcon	<i>Falco eleonorae</i>	PM		Car						1																	
<b>Accipitridae: diurnal birds of prey other than falcons</b>																												



					Kisumu County					Migori County					Homa Bay County												
Family & common name		Species scientific name	Migration	Forest Category	Feeding Guild	M.L. Otieno	Joyce Kaveza	Fred Otieno	Joseph Juma	Terrestrial	Wetland (seasonal)	Wetland (seasonal)	Aggrey Asiena	Lucia Nyamogi	Paul (Rapog)	Wetland/Riverine	Evalyne Akinyi	Terrestrial/Forest	Terrestrial/Forest	Kochwola	Samuel Ouma	Josephine Omondi	Collins Otieno	Kiringa Hill	Terrestrial/Forest	Wetland (Lake Simbi)	
44	Little Swift	<i>Apus affinis</i>	R		Ins	2																					
45	White-rumped Swift	<i>Apus caffer</i>	R		Ins	1																					
<b>Coliidae: mousebirds</b>																											
46	Speckled Mousebird	<i>Colius striatus</i>	R		Fru	7	18			2	2			2	2		3	10	5	6	2	4	3	9	10	21	
47	Blue-naped Mousebird	<i>Urocolius macrourus</i>	R		Fru			5							2					2	2	1	1	1	1	2	
<b>Coraciidae: rollers</b>																											
48	Lilac-breasted Roller	<i>Coracias caudatus</i>	am		Car																		1	1			
<b>Alcedinidae: kingfishers</b>																											
49	Grey-headed Kingfisher	<i>Halcyon leucocephala</i>	am	f	Ins														2							1	
50	African Pygmy Kingfisher	<i>Ceyx pictus</i>	am	f	Ins			1																1			
51	Malachite Kingfisher	<i>Alcedo cristata</i>	R		Car						1											1					
52	Pied Kingfisher	<i>Ceryle rudis</i>	R		Car																					46	
<b>Meropidae: bee-eaters</b>																											
53	Little Bee-eater	<i>Merops pusillus</i>	R		Ins	1				2																	
<b>Bucerotidae: hornbills</b>																											
54	African Grey Hornbill	<i>Tockus nasutus</i>	R		Car										1												
<b>Capitonidae: barbets and tinkerbirds</b>																											
55	Red-fronted Tinkerbird	<i>Pogoniulus pusillus</i>	R		Fru															1	3	2		1	1		
56	Yellow-fronted Tinkerbird	<i>Pogoniulus chrysoconus</i>	R		Fru			1							1												
57	Spot-flanked Barbet	<i>Tricholaema lacrymosa</i>	R		Fru			1												1		1		1			
58	Black-billed Barbet	<i>Lybius guifsobalito</i>	R		Fru														1								
59	Double-toothed Barbet	<i>Lybius bidentatus</i>	R		Fru				1																		
<b>Picidae: wrynecks and woodpeckers</b>																											
60	Nubian Woodpecker	<i>Campethera nubica</i>	R		Ins					1													3				
61	Cardinal Woodpecker	<i>Dendropicos fuscescens</i>	R	f	Ins								1														
62	Bearded Woodpecker	<i>Dendropicos namaquus</i>	R	f	Ins														1								
<b>Platysteiridae: batisses, wattle-eyes and relatives</b>																											
63	Chin-spot Batis	<i>Batis molitor</i>	R		Ins															1							
64	Brown-throated Wattle-eye	<i>Platysteira cyanea</i>	R	f	Ins			1											1								
<b>Malaconotidae: helmetshrikes, bushshrikes, tchagras &amp; puffbacks</b>																											
65	Sulphur-breasted Bushshrike	<i>Chlorophoneus sulfureopectus</i>	R	f	Ins																	2					
66	Brown-crowned Tchagra	<i>Tchagra australis</i>	R		Ins	2		1											1								
67	Black-crowned Tchagra	<i>Tchagra senegalus</i>	R		Ins			1																			
68	Northern Puffback	<i>Dryoscopus gambensis</i>	R	F	Ins		1				2																



					Kisumu County							Migori County					Homa Bay County										
Family & common name		Species scientific name	Migration	Forest Category	Feeding Guild	M.L. Otieno	Joyce Kaveza	Fred Otieno	Joseph Juma	Terrestrial	Wetland (seasonal)	Wetland (seasonal)	Aggrey Asiena	Lucia Nyamogi	Paul (Rapogi)	Wetland/Riverine	Evalyne Akinyi	Terrestrial/Forest	Terrestrial/Forest	Kochwola	Samuel Ouma	Josephine Omondi	Collins Otieno	Kiringa Hill	Terrestrial/Forest	Wetland (Lake Simbi)	
<b>Timaliidae: illadopses, babblers and chatters</b>																											
95	Black-lored Babbler	<i>Turdoides sharpei</i>	R		Car								2	4	5	3		1									
96	Brown Babbler	<i>Turdoides plebejus</i>	R		Ins			3		4	2								5								
97	Arrow-marked Babbler	<i>Turdoides jardineii</i>	R		Ins	4	2													4							
<b>Zosteropidae: white-eyes</b>																											
98	African Yellow White-eye	<i>Zosterops senegalensis</i>	R	f	Ins	4	2		4									1									
<b>Sturnidae: starlings and oxpeckers</b>																											
99	Greater Blue-eared Starling	<i>Lamprotornis chalybaeus</i>	R		Omn	1																					
100	Rüppell's Starling	<i>Lamprotornis purpuroptera</i>	R		Omn			3								3						2	4	3		2	
101	Superb Starling	<i>Lamprotornis superbus</i>	R		Omn													6			3	6				8	
102	Violet-backed Starling	<i>Cynniricinclus leucogaster</i>	AM	f	Omn			4							1			1	2	1	2						
103	Red-billed Oxpecker	<i>Buphagus erythrorhynchus</i>	R		Car	3						5	2	2				2					4		2	2	
<b>Turdidae: thrushes</b>																											
104	African Thrush	<i>Turdus pelios</i>	R	f	Omn	1	2	1							3		1		1								
<b>Muscicapidae: chats, wheatears and Old World flycatchers</b>																											
105	White-browed Robin Chat	<i>Cossypha heuglini</i>	R	f	Ins	1	2	2	5	1			1	2	1		1	1	1	2	1					3	2
106	White-browed Scrub Robin	<i>Cercotrichas leucophrys</i>	R		Ins						1							1		1			2				
107	Northern Black Flycatcher	<i>Melaenornis edoloides</i>	R		Ins		3				2																
108	Silverbird	<i>Empidonax semipartitus</i>	R		Ins																		1			2	
<b>Nectariniidae: sunbirds</b>																											
109	Scarlet-chested Sunbird	<i>Chalcomitra senegalensis</i>	R		Nec				2		1				1							2					
110	Bronze Sunbird	<i>Nectarinia kilimensis</i>	R	f	Nec	3		1	4	1				2		1	1		2							1	
111	Beautiful Sunbird	<i>Cinnyris pulchellus</i>	R		Nec																			1			
112	Marico Sunbird	<i>Cinnyris mariquensis</i>	R		Nec		2	4										2			1	3	1			6	
113	Variable Sunbird	<i>Cinnyris venustus</i>	R	f	Nec	2		1		3					1		3										
<b>Passeridae: sparrow weavers, Old World sparrows and petronias</b>																											
114	White-browed Sparrow Weaver	<i>Plocepasser mahali</i>	R		Gra			2														5	3				
115	Grey-headed Sparrow	<i>Passer griseus</i>	R		Gra		15	16				2				5					2					5	
116	Yellow-spotted Petronia	<i>Petronia pyrgita</i>	R		Gra													2									
<b>Ploceidae: weavers, bishops and widowbirds</b>																											
117	Red-billed Buffalo Weaver	<i>Bubalornis niger</i>	R		Omn																	1					
118	White-headed Buffalo Weaver	<i>Dinemellia dinemelli</i>	R		Omn			1																			

Family & common name		Species scientific name	Migration	Forest Category	Feeding Guild	Kisumu County							Migori County							Homa Bay County							
						M.L. Otieno	Joyce Kaveza	Fred Otieno	Joseph Juma	Terrestrial	Wetland (seasonal)	Wetland (seasonal)	Aggrey/Asiema	Lucia Nyamogi	Paul (Rapogi)	Wetland/Riverine	Evalyne Akinyi	Terrestrial/Forest	Terrestrial/Forest	Kochwola	Samuel Ouma	Josephine Omondi	Collins Otieno	Kiringa Hill	Terrestrial/Forest	Wetland (Lake Simbi)	
119	Speckle-fronted Weaver	<i>Sporopipes frontalis</i>	R		Gra										3												
120	Grosbeak Weaver	<i>Amblyospiza albifrons</i>	R	f	Omn					1									1								
121	Baglafaecht Weaver	<i>Ploceus baglafaecht</i>	R	f	Gra		2	3	2				5			2					1						
122	Village Weaver	<i>Ploceus cucullatus</i>	R		Omn	5	12	2	20	15	14				8				6	18			25	4			
123	Slender-billed Weaver	<i>Ploceus pelzelni</i>	R	f	Ins			1													2		1				
124	Golden-backed Weaver	<i>Ploceus jacksoni</i>	R		Ins											4									25		
125	Red-headed Weaver	<i>Anaplectes melanotis</i>	R		Ins											1											
126	Cardinal Quelea	<i>Quelea cardinalis</i>	R		Gra													4									
127	Black-winged Bishoop	<i>Euplectes hordeaceus</i>	R		Gra								2	2							2		1	2	1		
128	Fan-tailed Widowbird	<i>Euplectes axillaris</i>	R		Gra										4	2											
<b>Estrildidae: waxbills</b>																											
129	Crimson-rumped Waxbill	<i>Estrilda rhodopyga</i>	R		Gra																				2	2	
130	Common Waxbill	<i>Estrilda astrild</i>	R		Gra	3																					
131	Black-faced Waxbill	<i>Estrilda erythronotus</i>	R		Gra																					1	
132	Fawn-breasted Waxbill	<i>Estrilda paludicola</i>	R		Gra					3																	
133	Red-cheeked Cordon-bleu	<i>Uraeginthus bengalus</i>	R		Gra	1	3	4	2													1	2			2	
134	Purple Grenadier	<i>Granatina ianthinogaster</i>	R		Gra			1	12										1	1	1			1			
135	Red-billed Firefinch	<i>Lagonosticta senegala</i>	R		Gra		1											1	1								
136	Bronze Mannikin	<i>Spermestes cucullatus</i>	R		Gra	20	6	1	4	8			5	3				1	1			8					
<b>Viduidae: Parasitic Weaver, indigobirds and whydahs</b>																											
137	Pin-tailed Whydah	<i>Vidua macroura</i>	R		Gra										2	2	3										
138	Village Indigobird	<i>Vidua chalybeata</i>	R		Gra																			1			
<b>Motacillidae: wagtails, longclaws and pipits</b>																											
139	Cape Wagtail	<i>Motacilla capensis</i>	R		Ins																				2		
140	African Pied Wagtail	<i>Motacilla aguimp</i>	R		Ins	1			1	2								2								2	
141	Yellow-throated Longclaw	<i>Macronyx croceus</i>	R		Ins																						
<b>Fringillidae: canaries, citrils, seedeaters and relatives</b>																											
142	African Citril	<i>Crithagra citrinelloides</i>	R	f	Gra	2				4								2	1						2	2	
143	Reichenow's Seedeater	<i>Crithagra reichenowi</i>	R		Gra																			3			
144	Yellow-fronted Canary	<i>Crithagra mozambica</i>	R		Gra			3	1									1									
<b>Total Individuals</b>						103	108	92	105	77	55	24	38	30	79	51	41	44	73	60	54	182	58	137	44	284	
<b>Total Species</b>						39	28	41	26	27	22	7	18	20	37	21	19	18	34	28	22	49	26	36	21	39	

Appendix 14: Habitat suitability and Biodiversity Hotspots by wards, and subcounties in Homa Bay, Kisumu and Migori counties

County	Subcounty	Ward	Habitat Suitability (%)			Biodiversity Hotspot (%)			
			Low	Moderate	Very High	Less Hot	Moderate	Very Hot	
Homa Bay	Homa Bay Town	Homa Bay Arujo	77	20	4	78	16	6	
		Homa Bay Central	78	21	1	84	12	3	
		Homa Bay East	86	13	1	71	21	8	
		Homa Bay West	78	20	2	76	17	7	
	<b>Homa Bay Town Total</b>			<b>81</b>	<b>17</b>	<b>2</b>	<b>76</b>	<b>17</b>	<b>7</b>
	Kabondo Kasipul	Kabondo East	4	77	19	76	20	4	
		Kabondo West	29	55	16	62	26	11	
		Kojwach	8	88	4	77	19	3	
		Kokwanyo/Kakelo	27	66	7	59	30	12	
	<b>Kabondo Kasipul Total</b>			<b>20</b>	<b>68</b>	<b>12</b>	<b>66</b>	<b>25</b>	<b>9</b>
	Karachuonyo	Central	88	10	3	70	20	9	
		Kanyaluo	82	18	0	54	29	17	
		Kendu Bay Town	86	9	5	63	26	11	
		Kibiri	53	47	0	66	23	11	
		North Karachuonyo	76	24	0	61	27	13	
		Wangchieng	88	9	3	59	29	12	
		West Karachuonyo	19	60	21	64	23	13	
	<b>Karachuonyo Total</b>			<b>67</b>	<b>27</b>	<b>6</b>	<b>62</b>	<b>26</b>	<b>12</b>
	Kasipul	Central Kasipul	70	30	0	63	26	11	
		East Kamagak	40	60	0	68	26	6	
		South Kasipul	75	24	1	72	20	8	
		West Kamagak	97	3	0	81	16	3	
		West Kasipul	7	62	31	60	26	14	
	<b>Kasipul Total</b>			<b>49</b>	<b>41</b>	<b>10</b>	<b>66</b>	<b>24</b>	<b>10</b>
	Mbita	Gembe	25	55	20	49	21	30	
		Kasgunga	36	59	5	61	19	20	
		Lambwe	41	40	19	54	22	24	
		Mfangano Island	7	10	82	41	20	39	
		Rusinga Island	39	48	13	62	19	18	
	<b>Mbita Total</b>			<b>32</b>	<b>42</b>	<b>25</b>	<b>53</b>	<b>21</b>	<b>26</b>
	Ndhiwa	Kabuoch North	7	74	20	61	24	15	
		Kabuoch South/Pala	4	87	8	70	20	10	
Kanyadoto		66	34	0	77	17	7		
Kanyamwa Kologi		92	8	0	75	17	8		
Kanyamwa Kosewe		70	29	1	77	16	7		
Kanyikela		23	77	0	72	19	10		
Kwabwai		73	22	5	84	12	4		
<b>Ndhiwa Total</b>			<b>51</b>	<b>42</b>	<b>7</b>	<b>74</b>	<b>18</b>	<b>8</b>	

County	Subcounty	Ward	Habitat Suitability (%)			Biodiversity Hotspot (%)			
			Low	Moderate	Very High	Less Hot	Moderate	Very Hot	
	Rangwe	East Gem	81	18	1	67	24	8	
		Kagan	66	34	0	56	30	14	
		Kochia	85	13	2	60	28	12	
		West Gem	63	33	3	67	24	9	
	<b>Rangwe Total</b>			<b>74</b>	<b>25</b>	<b>1</b>	<b>62</b>	<b>27</b>	<b>11</b>
	Suba	Gwassi North	4	12	84	61	20	19	
		Gwassi South	25	45	30	66	20	14	
		Kaksingri West	46	27	28	61	20	18	
		Ruma-Kaksingri	42	47	11	50	23	27	
	<b>Suba Total</b>			<b>32</b>	<b>37</b>	<b>31</b>	<b>59</b>	<b>21</b>	<b>20</b>
	Kisumu	Kisumu Central	Kondele	100	0	0	100	0	0
			Market Milimani	55	35	10	99	1	0
			Migosi	100	0	0	100	0	0
Nyalenda 'A'			87	7	6	96	4	0	
Nyalenda B			36	46	18	69	18	13	
Railways			84	15	1	96	3	1	
Shaurimoyo Kaloleni			95	5	0	99	1	0	
<b>Kisumu Central Total</b>			<b>73</b>	<b>21</b>	<b>6</b>	<b>92</b>	<b>5</b>	<b>3</b>	
Kisumu East		Kajulu	59	40	1	83	15	3	
		Kolwa Central	33	51	17	70	21	10	
		Kolwa East	51	43	5	62	30	7	
		Manyatta 'B'	99	1	0	100	0	0	
<b>Kisumu East Total</b>			<b>49</b>	<b>43</b>	<b>7</b>	<b>71</b>	<b>23</b>	<b>6</b>	
Kisumu West		Central Kisumu	83	16	0	90	10	0	
		Kisumu North	88	12	0	80	17	3	
		North West Kisumu	8	72	20	75	19	6	
		South West Kisumu	37	56	7	71	21	8	
		West Kisumu	29	65	6	72	21	7	
<b>Kisumu West Total</b>			<b>45</b>	<b>49</b>	<b>6</b>	<b>76</b>	<b>19</b>	<b>6</b>	
Muhoroni		Chemelil	33	53	14	76	20	3	
		Masogo/Nyang'Oma	25	69	5	69	25	6	
	Miwani	44	49	7	68	26	6		
	Muhoroni/Koru	26	69	6	83	15	2		
	Ombeyi	32	55	12	76	20	4		
<b>Muhoroni Total</b>			<b>31</b>	<b>60</b>	<b>9</b>	<b>75</b>	<b>21</b>	<b>4</b>	
Nyakach	Central Nyakach	52	43	5	66	27	6		
	North Nyakach	31	52	16	64	25	11		
	South East Nyakach	20	52	29	73	20	6		
	South West Nyakach	34	47	19	71	25	4		
	West Nyakach	74	17	9	63	24	13		
<b>Nyakach Total</b>			<b>43</b>	<b>43</b>	<b>15</b>	<b>67</b>	<b>24</b>	<b>9</b>	

County	Subcounty	Ward	Habitat Suitability (%)			Biodiversity Hotspot (%)			
			Low	Moderate	Very High	Less Hot	Moderate	Very Hot	
	Nyando	Ahero	39	49	11	73	21	6	
		Awasi/Onjiko	80	19	1	69	28	3	
		East Kano/Wawidhi	30	59	12	61	30	10	
		Kabonyo/Kanyagwal	0	37	63	55	26	19	
		Kobura	23	62	15	69	23	8	
	<b>Nyando Total</b>			<b>33</b>	<b>47</b>	<b>20</b>	<b>66</b>	<b>26</b>	<b>9</b>
	Seme	Central Seme	50	41	9	64	25	12	
		East Seme	79	21	0	67	25	8	
		North Seme	24	60	16	64	23	13	
		West Seme	19	53	28	61	25	15	
	<b>Seme Total</b>			<b>42</b>	<b>44</b>	<b>15</b>	<b>64</b>	<b>24</b>	<b>12</b>
	Migori	Awendo	Central Sakwa	71	26	3	82	15	2
			North Sakwa	8	48	45	64	22	13
			South Sakwa	91	9	0	87	11	2
West Sakwa			38	48	14	71	22	7	
<b>Awendo Total</b>			<b>57</b>	<b>30</b>	<b>13</b>	<b>77</b>	<b>17</b>	<b>6</b>	
Kuria East		Gokeharaka/Getambwega	100	0	0	80	17	4	
		Ntimaru East	100	0	0	80	17	3	
		Ntimaru West	100	0	0	84	14	2	
		Nyabasi East	67	33	0	67	23	10	
		Nyabasi West	80	20	0	72	20	7	
<b>Kuria East Total</b>			<b>86</b>	<b>14</b>	<b>0</b>	<b>75</b>	<b>19</b>	<b>6</b>	
Kuria West		Bukira Centrl/Ikerege	78	22	0	76	19	5	
		Bukira East	69	31	0	81	17	3	
		Isibania	100	0	0	98	0	2	
		Makerero	99	1	0	82	15	2	
		Masaba	11	66	24	68	21	11	
		Nyamosense/Komosoko	99	1	0	72	21	7	
		Tagare	71	29	0	68	24	9	
<b>Kuria West Total</b>			<b>63</b>	<b>30</b>	<b>7</b>	<b>73</b>	<b>20</b>	<b>7</b>	
Nyatike	Got Kachola	75	18	8	44	30	27		
	Kachien'G	57	42	2	66	22	12		
	Kaler	84	16	0	54	27	19		
	Kanyasa	67	30	3	74	18	8		
	Macalder/Kanyarwanda	63	35	2	54	28	18		
	Muhuru	94	4	2	55	23	23		
	North Kadem	76	22	2	61	23	16		
<b>Nyatike Total</b>			<b>72</b>	<b>26</b>	<b>3</b>	<b>58</b>	<b>25</b>	<b>17</b>	
Rongo	Central Kamagambo	85	15	0	80	13	6		
	East Kamagambo	18	77	5	64	22	13		
	North Kamagambo	0	50	50	63	24	13		
	South Kamagambo	51	45	3	82	16	2		
<b>Rongo Total</b>			<b>35</b>	<b>52</b>	<b>13</b>	<b>72</b>	<b>19</b>	<b>8</b>	

County	Subcounty	Ward	Habitat Suitability (%)			Biodiversity Hotspot (%)			
			Low	Moderate	Very High	Less Hot	Moderate	Very Hot	
	Suna East	God Jope	6	63	30	80	15	5	
		Kakrao	15	68	17	72	20	8	
		Kwa	16	68	17	76	18	6	
		Suna Central	24	48	28	84	12	4	
	<b>Suna East Total</b>			<b>14</b>	<b>64</b>	<b>21</b>	<b>76</b>	<b>18</b>	<b>6</b>
	Suna West	Ragana-Oruba	12	75	13	77	19	4	
		Wasimbete	98	2	0	64	26	10	
		Wasweta li	77	23	0	64	26	11	
		Wiga	55	44	1	57	27	16	
	<b>Suna West Total</b>			<b>69</b>	<b>29</b>	<b>2</b>	<b>63</b>	<b>25</b>	<b>12</b>
	Urii	Central Kanyamkago	79	21	0	76	19	5	
		East Kanyamkago	85	15	0	84	13	3	
		North Kanyamkago	57	35	7	70	21	9	
		South Kanyamkago	84	15	1	82	14	4	
		West Kanyamkago	19	61	20	67	24	9	
	<b>Urii Total</b>			<b>56</b>	<b>35</b>	<b>8</b>	<b>73</b>	<b>20</b>	<b>7</b>





