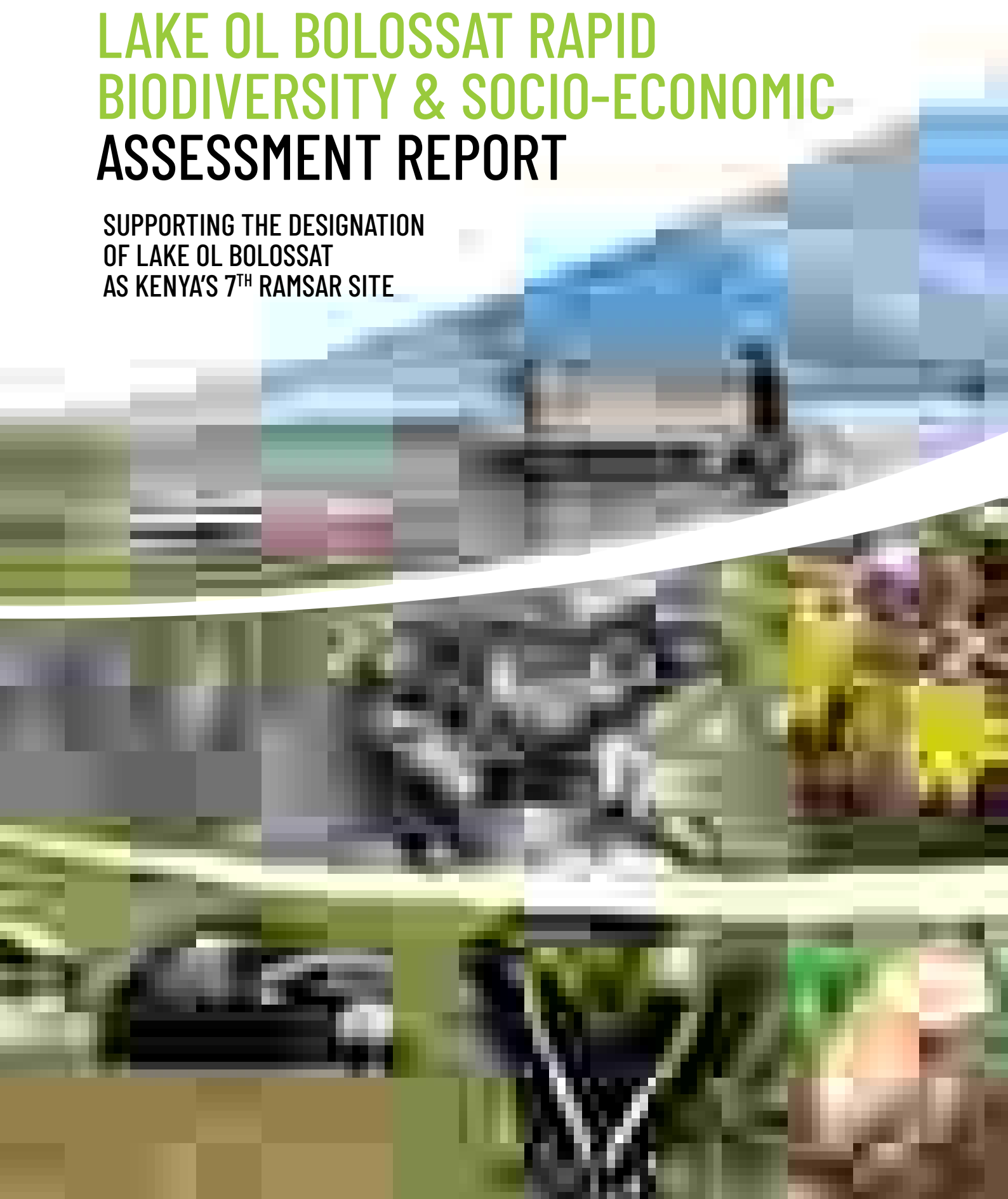




LAKE OL BOLOSSAT RAPID BIODIVERSITY & SOCIO-ECONOMIC ASSESSMENT REPORT

SUPPORTING THE DESIGNATION
OF LAKE OL BOLOSSAT
AS KENYA'S 7TH RAMSAR SITE



Disclaimer

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Abbreviations and Acronyms

AES	Auditory Encounter Surveys
AMF	Arbuscular Mycorrhiza Fungi
ANOVA	Analysis of Variance
ASL	Above Sea Level
BMU	Beach Management Unit
CAN	Calcium Ammonium Nitrate
CBD	Convention on Biological Diversity
CBO	Community-Based Organisation
CCV	Crane Conservation Volunteers
CITES	Convention on International Trade in Endangered Species
CR	Critically Endangered
DAP	Diammonium Phosphate
EA	East Africa
EAWLS	East African Wild Life Society
EC	Electrical Conductivity
ECDE	Early Childhood Development and Education
ECM	Ectomycorrhiza Fungi
EMCA	Environmental Management and Co-ordination Act
EN	Endangered
GBIF	Global Biodiversity Information Facility
GIS	Geographical Information System
GPS	Global Positioning System
IAS	Invasive Alien Species
IBA	Important Bird and Biodiversity Area
IMP	Integrated Management Plan
IPM	Integrated Pest Management
IUCN	International Union for Conservation of Nature
KCC	Kenya Co-operative Creameries
KFS	Kenya Forest Service
KNBS	Kenya National Bureau of Statistics
KWS	Kenya Wildlife Service
KWWG	Kenya Wetland Working Group
NT	Near Threatened
LULC	Land Use and Land Cover
NEMA	National Environment Management Authority
NGO	Non-Governmental Organisation
NMK	National Museums of Kenya

Abbreviations and Acronyms

NPK	Nitrogen, Phosphorus, and Potassium
PCs	Point Counts
PPM	Parts Per Million
SAPs	Structural Adjustment Policies
SASS	South African Scoring System
SPSS	Statistical Package for the Social Sciences
TDS	Total Dissolved Solids
TLS	Time Limited Search
TSC	Timed Species Count
UON	University of Nairobi
USGS	United States Geological Survey
VES	Visual Encounter Surveys
VU	Vulnerable
WHO	World Health Organization
WMI	Wangari Maathai Institute for Peace and Environmental Studies
WRA	Water Resources Authority
WRTI	Wildlife Research and Training Institute
WRUA	Water Resource Users Association

Definition of Terms

Biodiversity: The variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are apart. It's often described as a measure of variation at genetic, species and ecosystem level.

Biodiversity hotspot: Regions that contain a relatively high level of species diversity, rich in endemic species (species not found anywhere else in the world) and a significant number of threatened or endangered species. These areas are significantly threatened by human activities particularly habitat loss.

Ecosystem services: Are the many and varied benefits that humans freely gain from the natural environment and from functioning ecosystems. The direct and indirect contributions of ecosystems to human well-being.

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.

Species richness: The number of different species represented in an ecological community, landscape or region.

Species abundance: The number of individuals of a particular species in a given area or ecosystem at a specific time.

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).

Message from the Governor County Government of Nyandarua

Lake Ol Bolossat is one of Nyandarua County's most precious natural assets and a wetland of exceptional national and global significance. As Kenya's highest-altitude lake, and the only natural lake in the Central Highlands, it is an invaluable ecological treasure that sustains biodiversity, supports livelihoods and contributes to the wider hydrological systems beyond Nyandarua County.

I am therefore pleased to present this Lake Ol Bolossat Rapid Biodiversity and Socio-economic Assessment Report, which provides important scientific evidence on the ecological and Socioeconomic significance of this unique ecosystem, and the urgent actions required to secure its future.



The findings of this assessment reaffirm the exceptional biodiversity value of Lake Ol Bolossat. The lake and its surrounding landscape support a remarkable diversity of plant and animal species, including endemic, threatened and migratory species of national and international conservation importance. At the same time, the assessment presents a sobering account of the increasing pressure facing the ecosystem, including land-use change, habitat degradation, water abstraction, invasive species, pollution and unsustainable resource use.

These findings reinforce the need for urgent, coordinated and sustained action. The future of Lake Ol Bolossat cannot be secured by any one single institution. It requires strong partnerships between the National Government, County Government, local communities, research institutions, conservation organizations, development partners and the private sector.

The County Government of Nyandarua remains firmly committed to the protection, restoration and sustainable management of Lake Ol Bolossat. We recognize that effective conservation must go hand-in-hand with sustainable livelihoods and meaningful stakeholder participation. Our responsibility is not just protecting the lake's biodiversity but also ensuring that the communities who depend on this ecosystem are part of its stewardship and benefit from its sustainable management.

This assessment report also provides valuable evidence to support the ongoing efforts towards the designation of Lake Ol Bolossat as Kenya's 7th Ramsar Site. Such recognition would further elevate the importance of this unique wetland ecosystem and strengthen opportunities for conservation, research, sustainable investment and international collaboration.

I wish to sincerely acknowledge the East African Wild Life Society, the Wangari Maathai Institute for Peace and Environmental Studies, the University of Nairobi, Wildlife Research and Training Institute, National Museums of Kenya, JRS Biodiversity Foundation, and all partners, experts and local communities who contributed to this important undertaking.

It is my hope that this report will serve as both a source of knowledge and a call to action. Lake Ol Bolossat is part of our natural heritage and a shared responsibility. Together, we must act decisively to protect and restore this extraordinary ecosystem so that it continues to sustain biodiversity, livelihoods and future generations.



H.E. (Dr.) Moses Kiarie Badilisha
Governor - County Government of Nyandarua

Foreword

Lake Ol Bolossat is one of Kenya's most unique yet vulnerable wetland ecosystems. As the country's highest-altitude lake and the only natural lake in the central highlands, it sustains critical biodiversity, regulates regional hydrological systems, and supports livelihoods extending far beyond its immediate catchment. Its designation as Kenya's 61st Important Bird and Biodiversity Area (IBA) underscores its national and international significance, in advancing biodiversity conservation, climate resilience, and the Sustainable Development Goals.



Despite this importance, Lake Ol Bolossat faces escalating pressures, including encroachment, pollution, siltation, invasive species, catchment degradation, and unsustainable water abstraction-challenges increasingly intensified by climate change and which collectively threaten the ecological integrity of the ecosystem. In 2017, BirdLife International classified Lake Ol Bolossat as a Key Biodiversity Area (KBA) in danger, signaling the urgent need for coordinated, evidence-based conservation action.

These environmental challenges are compounded by governance gaps, unclear boundaries, limited stakeholder coordination, inadequate protection status, and the absence of harmonised baseline data to guide management decisions. In response, the East African Wild Life Society (EAWLS) has consistently championed science-led conservation and policy advocacy for the Lake, including supporting the development of the Lake Ol Bolossat Integrated Management Plan (2023–2033).

Effective conservation demands credible evidence. Without reliable data, policy decisions become reactive rather than strategic. This report marks a significant milestone in strengthening the scientific foundation necessary to safeguard Lake Ol Bolossat. The evidence presented here will advance efforts to gazette the lake as a National Reserve and support its proposed designation as a Ramsar Site and a UNESCO Man and the Biosphere (MAB) Reserve. It will also strengthen national biodiversity databases and inform future conservation and restoration initiatives. By consolidating ecological, hydrological, and socio-economic data, this report equips decision-makers with the information required to guide policy, resource allocation, and adaptive management.

At EAWLS, we recognise that lasting conservation outcomes require more than research investment; they demand inclusive stakeholder engagement and strong partnerships. In this regard, we collaborated with the Wangari Maathai Institute for Peace and Environmental Studies (WMI) at the University of Nairobi, a research institution, and local stakeholders including communities, to conduct this assessment. The open accessibility of the data generated through this work further strengthens accountability and knowledge-sharing, supporting research, evidence-based policy formulation, and effective conservation practice.

I extend my sincere appreciation to the scientists from the National Museums of Kenya, local communities, WMI and all partners whose collaboration made this work possible. I am particularly grateful to the JRS Biodiversity Foundation whose generous support and steadfast commitment to science-driven conservation have made this initiative possible.

It is our hope that this report serves not merely as a scientific reference, but as a catalyst for collective action, ensuring that Lake Ol Bolossat is restored, protected, and sustainably managed for generations to come.

A handwritten signature in black ink, appearing to read 'Nancy Ogonje', with a stylized, elongated flourish extending to the right.

Nancy Ogonje
Executive Director,
East African Wild Life Society

Preface

This report presents the findings of a comprehensive rapid biodiversity and socio-economic assessment of Lake Ol Bolossat conducted in 2023. Situated in central Kenya's highlands, this critical alkaline lake forms the headwaters of the Upper Ewaso Ng'iro drainage basin. Recognizing its ecological, hydrological and socio-economic significance, as well as the increasing pressures and significant data gaps, the East African Wild Life Society (EAWLS), in collaboration with the Wangari Maathai Institute for Peace and Environmental Studies (WMI), initiated this assessment to generate robust baseline data on the lake's ecological status and human influences, directly supporting policy decisions and conservation management strategies.



Technically, the assessment covered seven taxonomic groups: plants, fungi, herpetofauna (reptiles and amphibians), mammals, invertebrates, birds, and fish, alongside water quality analysis, land use and land cover change mapping, and socio-economic surveys. Scientists from the National Museums of Kenya, technical assistants, and local stakeholders, including community members who served as research assistants, participated in field surveys. This inclusive approach enabled cross-learning and knowledge exchange between researchers and community members, integrating local ecological knowledge and enhancing the quality and relevance of research outcomes. Through coordinated field surveys, spatial analysis, laboratory assessments, and stakeholder consultations, the team generated the most comprehensive dataset currently available for Lake Ol Bolossat.

Guided by open data principles, all biodiversity data were uploaded to the Global Biodiversity Information Facility (GBIF), ensuring widespread accessibility for informed decision-making and future research.

Rather than merely compiling findings, this report functions as a practical tool for action. It consolidates ecological, hydrological, and socio-economic evidence to directly guide conservation priorities, management strategies, policy decisions, long-term monitoring, and adaptive management. Policymakers, conservation practitioners, and local communities can use these findings to make informed decisions toward sustainable management of Lake Ol Bolossat.

The initiative further illustrates how interdisciplinary collaboration addresses complex environmental challenges. By bridging research, policy, and practice, we demonstrate strengthened collective capacity for safeguarding vital ecosystems. To all who contributed to this work, participants, partners, and supporters, we extend our sincere gratitude. Your commitment makes this irreplaceable wetland's future possible.



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Director

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Acknowledgement

The East African Wild Life Society (EAWLS) and project partners sincerely appreciate the JRS Biodiversity Foundation for the financial support that made this research possible. The findings from this study provide very critical data that will significantly contribute to evidence based intervention for the continued protection and sustainable management of our natural heritage.

We extend our heartfelt gratitude to the technical experts (taxa leads) engaged in the research: Dr. Paul Kirika (Lead, Plants and Research Coordinator), Dr. Mary Muchane (Lead, Fungi), Vincent Muchai (Lead, Reptiles and Amphibians), Immaculate Muthoni (Lead, Mammals), Laban Njoroge (Lead, Invertebrates), Dr. Henry Ndithia (Lead, Birds), Joseph Gathua (Lead, Fish and Water Quality), Dr. Dickens (Biodiversity Spatial Analysis), and Dr. Charity Kinyua (Lead, Socio-economics).

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Executive Summary

Lake Ol Bolossat is a high-altitude alkaline lake located in Central Kenya. It is a vital wetland ecosystem that supports the livelihoods of over two million people and provides habitat for a wide range of species, including several endangered ones. The lake also serves as a crucial water source for the broader landscapes of Laikipia and Isiolo counties.

Despite its ecological and socio-economic importance, the Lake Ol Bolossat ecosystem is under serious threat from human activities, compounded by the adverse effects of climate change. These pressures are contributing to habitat degradation, loss of biodiversity, and declining water quality and quantity.

To ensure the restoration and long-term conservation of the lake and its associated biodiversity, there is an urgent need to generate and unlock robust biodiversity data. In November 2023, a comprehensive biodiversity survey was conducted at Lake Ol Bolossat and its surrounding catchment areas. The fieldwork covered six administrative wards—Shamata, Rurii, Central, Weru, Gatimu, and Kiriita—and coincided with the early onset of the wet season, a critical period that provided optimal conditions for observing biological activity. The aim was to supplement existing checklists and gather updated information on various taxonomic groups, including flora, fauna, fungi, and aquatic systems, while identifying key threats and recommending restoration and conservation interventions. The goal of this work is to support the process of designating Lake Ol Bolossat as Kenya's seventh Ramsar Site, a recognition that would help secure both national and international support for its protection.

The key findings of the survey are summarized below:

Flora

A total of 148 additional plant species were recorded, raising the known plant diversity in the Lake Ol Bolossat ecosystem from 371 to 518 species. This included two species not previously recorded in Kenya: *Calceolaria tripartita*, likely a new record for the African continent, and *Lactuca serriola*. Additionally, three regional endemic species were recorded—*Kenyacanthus ndorensis*, endemic to Kenya, as well as *Dicliptera maculata* subsp. *usambarica* and *Impatiens meruensis* subsp. *cruciata*, both restricted to eastern Africa.

A total of 65 species were identified as invasive, including 24 listed as Invasive Alien Species (IAS). Among these, *Cirsium vulgare* emerged as the most aggressive, often outcompeting native vegetation and dominating wetland margins. The presence and spread of such species underscore the significant threat they pose to the native flora, ecosystem integrity, and wetland health.

Major threats observed during the field survey included increasing land conversion, illegal harvesting of vegetation, overgrazing, abstraction of water

sources feeding into the lake, presence of IAS, and signs of climate change. These anthropogenic and ecological pressures present urgent challenges for biodiversity conservation in the basin.

Fungi

The fungal component of the survey recorded 278 species, a substantial increase from the previously documented 35 species. These spanned 121 genera, 63 families, and six divisions. The majority belonged to Basidiomycota (211 species across 46 families), particularly from families such as Agaricaceae (64 spp.), Psathyrellaceae (29 spp.), and Mycenaceae (19 spp.). Glomeromycota accounted for 47 arbuscular mycorrhizal fungi (AMF) species across 13 genera.

Ecologically, humicolous fungi were dominant (72%), followed by lignicolous fungi (14%). The critically endangered *Myriostoma cf. coliforme* was among the notable records. Species richness and abundance were highest in natural forest and grassland habitats, with Eucalyptus plantations also supporting high fungal density. However, urban-adjacent wards like Kiriita exhibited low fungal diversity, likely due to habitat degradation. These findings highlight the critical role of habitat quality in sustaining fungal biodiversity and underscore the importance of conserving undisturbed microhabitats.

Herpetofauna

A total of 17 species of amphibians and reptiles were documented—comprising nine amphibians and eight reptiles. The field observations revealed interesting shifts in herpetofaunal behavior, with species adopting less typical perching vegetation, possibly reflecting adaptations to changes in habitat structure. Five endemic species were recorded, including those of conservation concern under IUCN criteria.

Amphibian and reptile richness declined with elevation, aligning with known ecological patterns. Given their sensitivity to environmental changes, herpetofauna provide valuable bioindicators for assessing habitat integrity. The report strongly recommends the development of a long-term monitoring protocol for amphibians and reptiles, which will enhance understanding of temporal dynamics and support conservation planning.

Mammals

The mammal survey recorded seven species across five orders, with 29 individual sightings. Notable species included *Lepus capensis*, *Crocidura fumosa*, *Mus musculus*, *Crocota crocuta*, *Tachyoryctes ibeanus*, and *Dendromus insignis*. Most significant was the continued presence of *Hippopotamus amphibius*, with 126 individuals counted, a strong indicator of wetland function and a keystone species for the ecosystem.

Of concern is the presence of *Mus musculus*, which may be indicative of ecological disturbance and urban proximity. *Dendromus insignis*, typically associated with upland habitats, was recorded in riverine heath and moor vegetation, possibly

reflecting changes in woody cover. Given the dependence of these species on intact wetland and grassland systems, the report emphasizes the need for enhanced protection of water sources and curbing anthropogenic encroachment.

Invertebrates

A total of 206 invertebrate species from 16 orders were recorded. Orders with the highest species richness included Coleoptera, Hymenoptera, Hemiptera, Diptera, and Orthoptera. The survey identified a number of habitat specialists, such as the red-veined darter (*Sympetrum fonscolombii*), *Anopheles christyi*, and the red-clover blue butterfly. Additionally, endemic orthopterans such as *Paraspena kinangopa* (a gaudy grasshopper) and *Pezocatantops impotens* (a short-horned grasshopper) were recorded.

An unexpected finding was a crustacean species (tadpole shrimp or horseshoe shrimp), highlighting the ecological uniqueness of the wetland. Threats to invertebrate diversity included the spread of invasive plants (notably *Cirsium vulgare*), habitat degradation from agricultural expansion, and peat harvesting. To address these threats, the report recommends restoration of native vegetation, strategic removal of *C. vulgare*, and incorporation of citizen science in monitoring efforts. Incentivizing local conservation actions—such as beekeeping—could provide both ecological and livelihood benefits.

Avifauna

Bird surveys recorded 162 species within the basin. Species accumulation modeling projects that between 200 and 375 bird species could be recorded with extended survey efforts (100 survey days). This suggests the area holds significant avian biodiversity, some of which may be underrepresented in short-term assessments.

Twenty-four species of conservation concern were observed, including three endangered species, two vulnerable species, one endemic species, and several migratory species—20 Palearctic and two intra-African migrants. The richness and ecological sensitivity of the bird community underscore the importance of Lake Ol Bolossat as a refuge and breeding ground. The report calls for stronger advocacy to secure formal protection of the area, recommending Ramsar Site designation and gazettement as a protected reserve. Bird monitoring can also serve as a practical tool for evaluating ecosystem health.

Fish and Water Quality

Four fish species were identified, reaffirming the lake's importance for local fisheries and food security. However, several threats to aquatic integrity were noted, including climate-induced drying, unregulated water abstraction, nutrient enrichment, and the presence of invasive species. These stressors are altering lake hydrology and potentially shifting fish assemblage composition.

Water quality assessment, conducted using a HANNA multi-parameter probe, indicated key shifts in limnological variables. Nutrient levels (nitrate and phosphate) were analyzed to assess pollution levels, which are critical for understanding eutrophication risks. Restoration of riparian zones and community-led water protection initiatives are essential to safeguard aquatic biodiversity.

Biodiversity Spatial Analysis

The areas surrounding Lake Ol Bolossat have experienced notable changes in habitat and land cover over time, particularly due to the conversion of grassland tussocks and forest-thicket ecosystems into farmlands. This transformation poses a significant threat to species conservation in the region. The biodiversity hotspot analysis conducted for the area integrated various spatial layer variables using geoprocessing techniques to identify areas of high conservation value.

Throughout the period from 1973 to the 2020s, there has been a marked reduction in the extent of open water and macrophyte cover within the lake, reflecting the dynamic and declining nature of these habitats. Likewise, the surrounding tussocks and forested areas have undergone substantial loss over the same observation period.

It is estimated that approximately 12% of the Lake Ol Bolossat Management Plan area falls within designated biodiversity hotspots that demand prioritized conservation action. Notably, the majority of these hotspots are located in Weru, which alone accounts for 44% of the areas identified as “very hot” for biodiversity conservation. This analysis thus provides an evidence-based means for prioritizing conservation efforts around Lake Ol Bolossat.

Socio-economic Aspects

The socio-economic characteristics of a population are key drivers of land use change and play a critical role in determining the sustainability of ecosystem use. This study highlights various socio-economic dimensions relevant to the Lake Ol Bolossat area.

There is considerable human activity occurring around the lake, with rain-fed agriculture and overhead irrigation being particularly prevalent. These practices have contributed significantly to soil erosion, which, in turn, has led to the siltation of the lake and a corresponding reduction in water levels. This problem is further compounded by the abstraction of feeder springs and streams for irrigation purposes.

Crop farming in the area often involves the use of inorganic fertilizers and pesticides. Unfortunately, these inputs are frequently applied without sufficient regulation, leading to pollution of the lake’s water systems. Livestock keeping represents the second most dominant livelihood activity among residents, with animals predominantly reared through free-range systems. This mode of livestock management has negatively impacted riparian habitats, particularly those important for bird species and other wildlife.

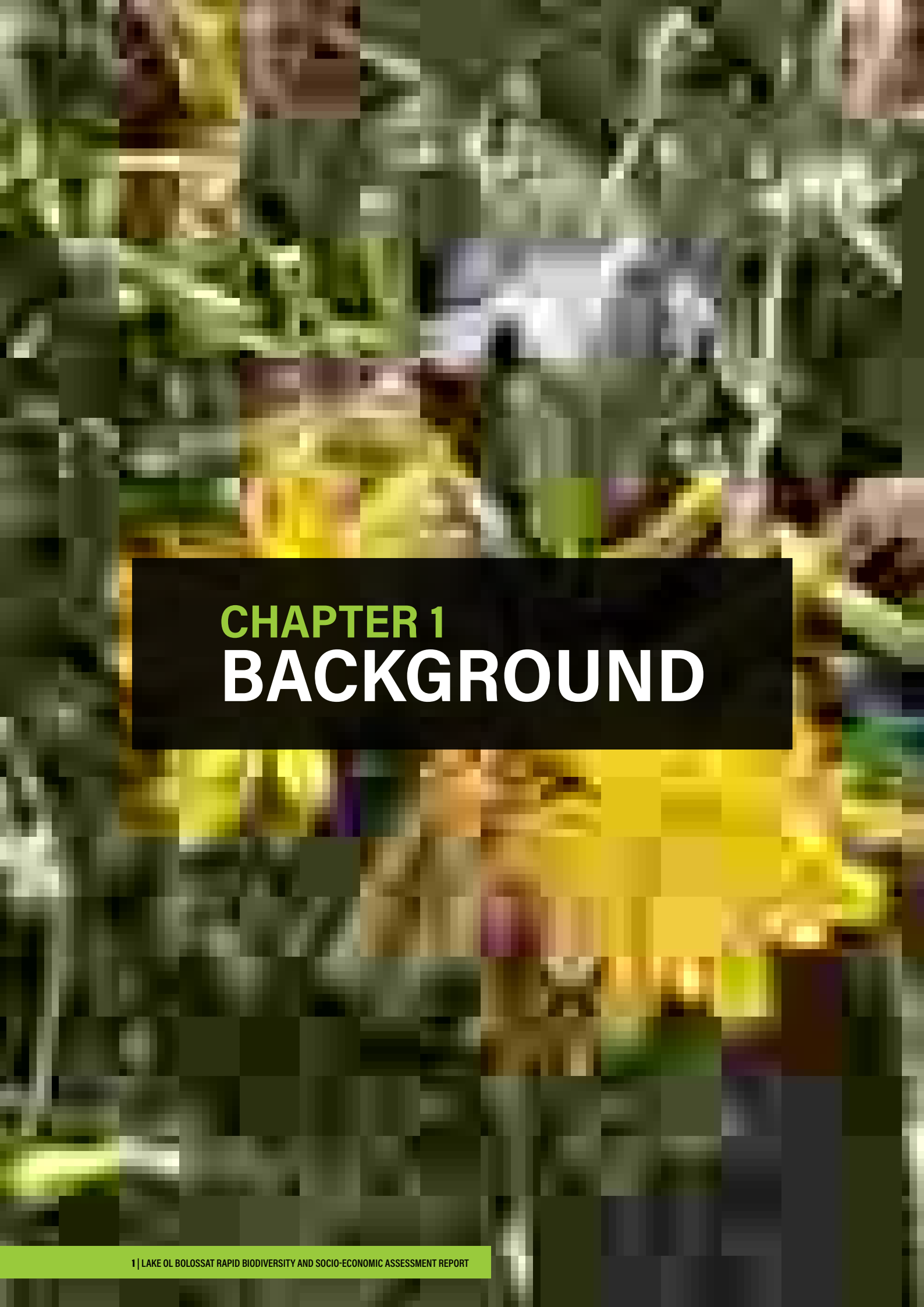
Other anthropogenic pressures include the hunting of hippopotamus, fishing for consumption, and the collection and sale of bird eggs—all of which adversely affect local biodiversity. Human-wildlife conflict, especially involving hippopotamus, remains a common occurrence in the area.

Lake ecosystem management has shifted over time. Agencies such as Kenya Wildlife Service (KWS) and Kenya Forest Service (KFS) have in the past undertaken conservation efforts for the wetland. However, ongoing challenges related to encroachment and unsustainable resource use continue to undermine these efforts. More recently, the County Government has initiated steps towards the gazettement of the lake as a national reserve, a move that signals growing political support for its protection.

The gazettement of Lake Ol Bolossat as a protected wetland under the Environmental Management and Coordination Act (EMCA) in 2018, along with the development of an Integrated Management Plan (IMP), marked a major milestone. However, despite strong political goodwill, the implementation of this plan has faced significant hurdles, primarily due to inadequate financial resources. Moving forward, it is essential to empower local communities to participate in citizen-led conservation initiatives that align the health of the lake ecosystem with improved livelihoods. The proposed listing of the lake as a Ramsar site is a welcome development, as it would elevate the ecosystem's profile globally and potentially enhance benefit flows to the local community.

The document is organised into the following major sections:

- a) General background
- b) Description of the project area
- c) Description of approach and methodology for each thematic area
- d) Results, discussions and key recommendations for each thematic area
 - Plants
 - Fungi
 - Reptiles & Amphibians
 - Mammals
 - Invertebrates
 - Birds
 - Fish and Water Quality
 - Spatial Analysis
 - Socio-economic



CHAPTER 1 **BACKGROUND**

Wetlands in Kenya are fast disappearing and their conservation and total economic value remain unknown. Despite Kenya having a robust policy on wetlands, the sustainable management of wetlands has remained a challenge due to inadequate and scant biodiversity information. Lake Ol Bolossat is a critical biodiversity hotspot in Kenya, a designated Important Bird and Biodiversity Area (IBA) and gazetted as a Wetland Protected Area. Despite these designations, the lake remains under serious threat and receives insufficient attention in terms of management and protection, largely due to the lack of reliable and comprehensive biodiversity data.

The Government of Kenya listed the lake among the priority wetlands to be designated as Ramsar sites by 2024. However, lack of adequate and reliable biodiversity data is hindering the designation process, and affects the effective implementation and monitoring of the biodiversity conservation strategies and action plans. In this regard, the East African Wild Life Society (EAWLS) in partnership with University of Nairobi, Wangari Maathai Institute for Peace and Environmental Studies (UON-WMI) and Wildlife Research and Training Institute (WRTI) with funding from the JRS Biodiversity Foundation, implemented a three-year project from 2023 to 2026 in the Lake Ol Bolossat Ecosystem, dubbed ***“Unlocking Biodiversity Data to Facilitate Designation of Lake Ol Bolossat as the 7th Ramsar Site in Kenya”***.

The project aimed to generate reliable baseline biodiversity information to support the designation of Lake Ol Bolossat as a Ramsar Site. It also sought to strengthen the overall management of the lake by providing information to support the review of the Integrated Management Plan and the development of appropriate management strategies and actions. The project incorporated knowledge and skills transfer, indigenous knowledge, and open sharing and access to biodiversity data to strengthen stakeholder capacity and support more informed and effective management of the lake ecosystem.

Specifically, the project aimed to achieve the following objectives:

- Establish the ecological characteristics of Lake Ol Bolossat watershed;
- Catalyse citizen participation and build local capacity in biodiversity research and monitoring to support improved management of the Lake; and
- Influence policy, scientific, and inclusive decision-making for improved biodiversity conservation and sustainable management of the Lake ecosystem.

The background of the page is a photograph of a natural landscape. The upper portion shows a calm body of water, likely a lake, with a sky in shades of blue and purple. The lower portion shows a dense forest of tall, thin trees, possibly conifers, with a greenish-yellow hue. A black rectangular box is centered over the image, containing the chapter title.

CHAPTER 2

PROJECT SITE

2.1 Study Area

Lake Ol Bolossat (hereafter known as Project Area) is located in Nyandarua County of Central Kenya at a latitude of 0° 09' S and longitude 36° 26' E approximately 195 km North of Nairobi. It lies at an average altitude of 2340 m and sits in a valley between the northwestern slopes of Aberdare Mountain and Dundori Ridge. The lake covers a total area of 43.3 km² of which 39.3 km² is Grassland area while 4 km² is open water. It is a key biodiversity area and acts as a lifeline for people, livestock and wildlife in Nyandarua County and other counties.

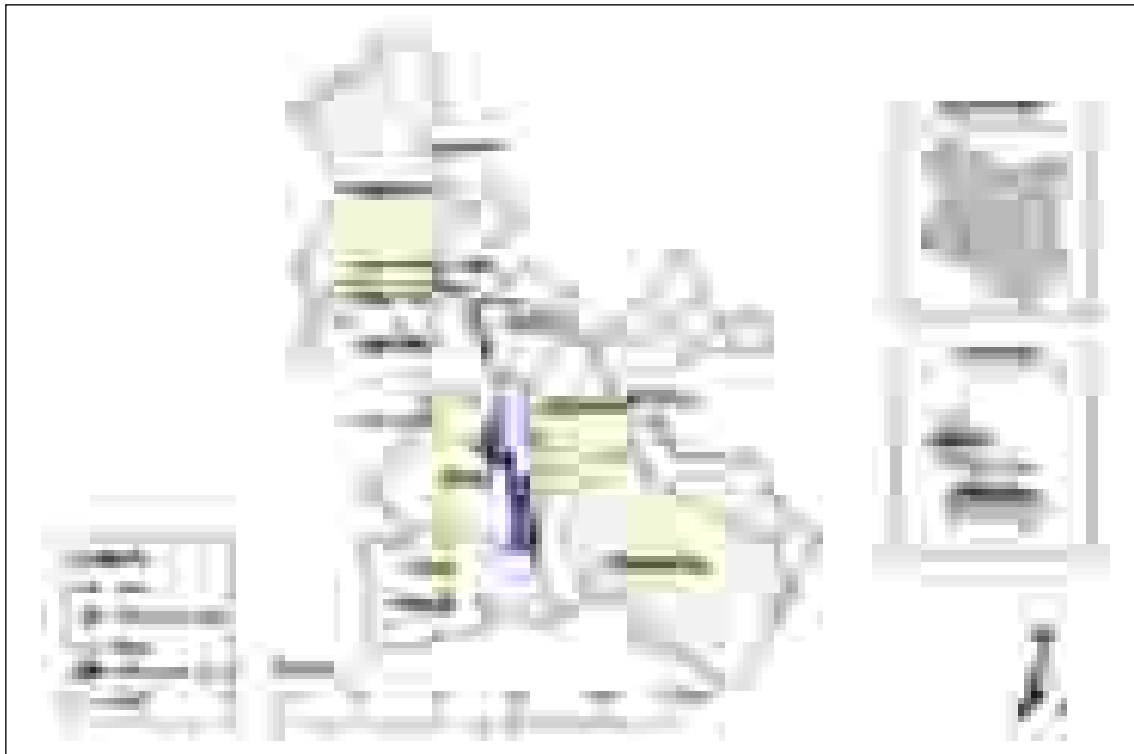


Figure 1: Location of project area and road network

2.1.1 Protection Status

L. Ol Bolossat was declared a protected wetland in 2018 under Environmental Management and Coordination Act (EMCA), a critical step towards enhancing its protection as a wetland of both national and international importance. It has an active Integrated Management Plan 2023-2033, a key requirement for both the gazettement process and effective long-term management of the lake. Sustainable conservation efforts require a collaborative management approach that recognizes and involves the local communities in all the management practices. Extra protection status includes Lake Ol Bolossat Catchment Protection Area Order, Legal Notice No. 116 of 2023. Currently, the Nyandarua County is in the process of having the lake gazetted as a national reserve, a move that will enhance its protection status.

2.1.2 Demography, Cultural, Ethnic and Social Groupings

The estimated population in Nyandarua County is 638,289 persons based on the 2019 national population census. This comprised 315,022 males and 323,247 females (KNBS, 2019). The county is serviced by several government hospitals; Nyahururu, Ngano, Ol Kalou -JM Kariuki Memorial County Referral Hospital, Engineer District Hospital. Mission hospital funded by church and Non-Governmental Organisation (NGO), Dispensary i.e. Mirangine Health Centre and a number of private hospitals.

The learning infrastructures are located within close proximity to the study area which surrounds Lake Ol Bolossat with an average range of 1.5 km. The furthest school is located about 7 km from the area. There are about 39 Early Childhood Development schools, 30 primary schools and 24 secondary schools with most being 2-4 km from the study area. The average expenditure on literacy level is approximately Ksh 67,000 per annum from the socio-economic survey.

2.1.3 Topography

Lake Ol Bolossat lies in a wedge-shaped (fault) valley known as '*Ongata Pusi*' located in Ewaso Ng'iro drainage basin. Ewaso Ng'iro drainage basin rises to 2600 m Above Sea Level (ASL) in the south and falls to below 1000 m ASL in the north. The lake is one of a series of rift valley benches aligned in a north-south direction at a higher elevation than the other Rift Valley Lakes (2,340 m ASL). On the eastern side, the lake borders the steep Satima escarpment (2,550 m). The faulting activity in the area resulted in a complex drainage system that separates major drainage basins – the southern tip of the Lake is 6 km from River Malewa upstream that drains to Lake Naivasha in the Rift Valley. Lake Ol Bolossat is an internal drainage basin whose swamps have a high salt content possible due to high evaporation rate and partly due to the nature of sediments that constitute the area (Krhoda, 1992). The riparian grasslands offer year-round livestock grazing land for surrounding communities.

2.1.4 Hydrological Dynamics

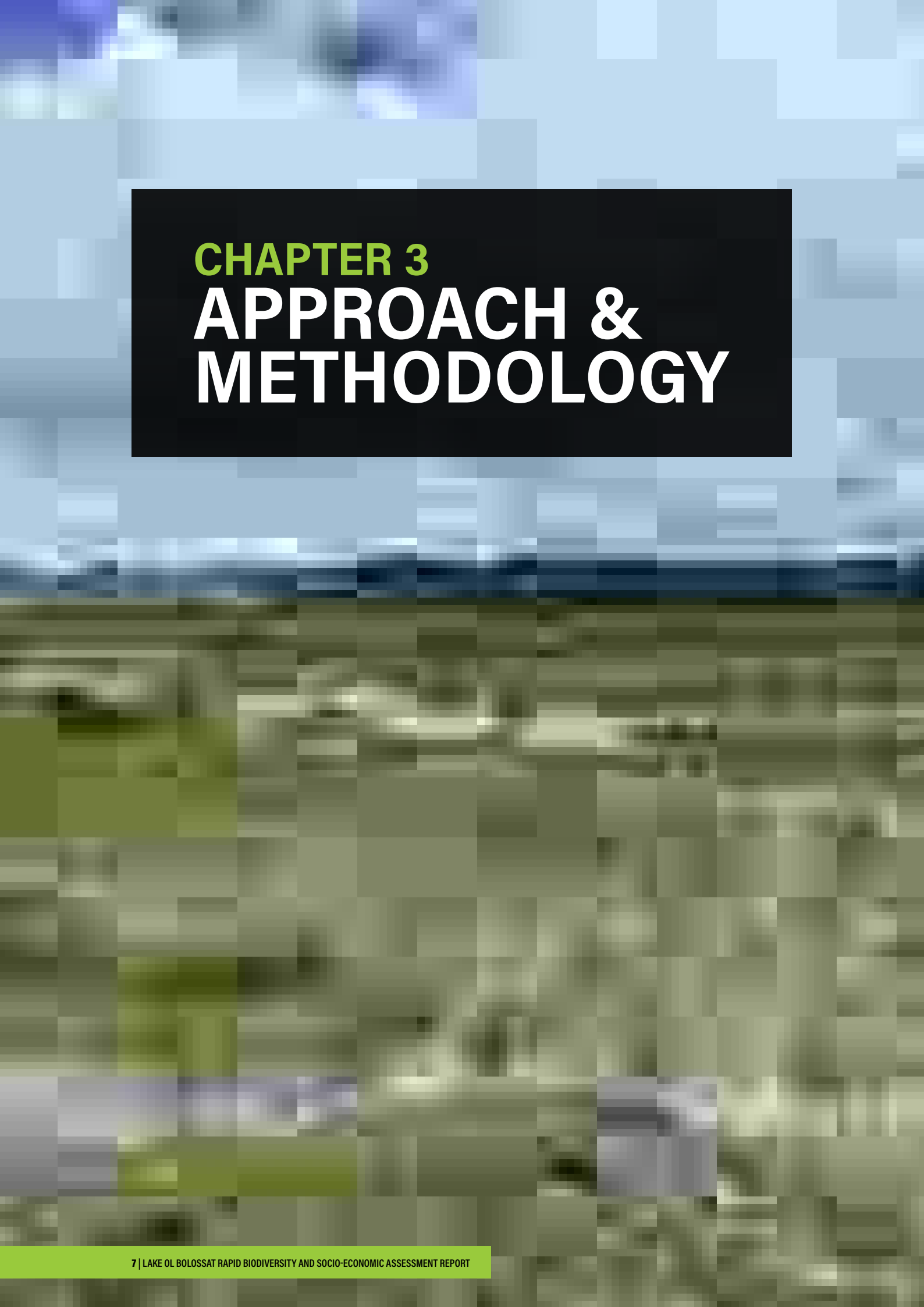
The hydrology of Lake Ol Bolossat is influenced by the effects of long-term and seasonal variations in weather and water inflow from the surrounding highlands. The lake water level is highest during the rains, especially in July/August. The mean water depth is 1.0 m varying from 0.73 m in the south, through 1.20 m in the central part to 1.83 m in the northern part. Lake Ol Bolossat however, has open water fluctuations in dry years with open water appearing as a series of pools separated by emergent macrophytes. The system loses water through the continuous flow of Ewaso Narok River and evapotranspiration. Evapotranspiration from the abundant swamp vegetation also contributes to this seasonality.

The depth of Lake Ol Bolossat averages at 0.75 m but ranges between 0.20 to 1.6 m deep. The eastern side of the lake is much shallower than the western side. The average depth of water in the shore is less than 0.30 m, while the open water is 1m but this ranges from 0.30 m to 1.60 m. Compared to the south and north, the southern part of the lake is relatively deeper.

2.1.5 Physical-chemical Conditions

According to Thenya *et al.*, (2011), the ecosystem pH ranges between 6.7 to 8.3 with an average pH of 7.68 on the eastern side with slightly higher values near Nyahururu falls and Manguo pools. The values decline towards the southern direction as water levels reduce and the ecosystem is characterised by marshy land.





CHAPTER 3

APPROACH & METHODOLOGY

3.1 Plants

Data was collected from the six sites corresponding to the administrative wards (Table 1). In each block, plants were sampled along a transect measuring about 100 m as well as opportunistic collections. All plants encountered were recorded, and the geolocation of each collection site was noted using a cellphone GPS, taken at the centre of each site.

Plants encountered were identified in the field however for species that were difficult to identify on site, fertile herbarium vouchers specimens were collected using standard methods (Bridson & Forman, 1992). Collected voucher specimens were then dried, processed, identified and preserved at the East African Herbarium. Specimens were identified using keys found in botanical monographs and various volumes of the Flora of Tropical East Africa, Kenya Trees Shrubs and Lianas (Beentje, 1994) and the Upland Kenya Wild Flowers (Agnew, 2013). Basic training in plant collection and identification was given to members of the local community accompanying and guiding the research team in the field (Plate 1).

Table 1: Plant sampling sites

Date	Ward/Locality	Latitude	Longitude	Elevation (m)
16-11-2023	Shamatta	-0.17748232	36.45965	2321
17-11-2023	Rurii	-0.18614963	36.44477	2326
18-11-2023	Central Ward -Iria-ini	-0.13450766	36.44629	2323
19-11-2023	Weru - Karandi Sub Loc.	-0.14215482	36.4277	2324
20-11-2023	Gatimu	-0.02036096	36.39723	2323
21-11-2023	Kiriita - Manguo	-0.02367842	36.39898	2320
21-11-2023	Kiriita- Hippo Point	-0.038531	36.376206	2320
21-11-2023	Kiriita - Chaparungu; Kanguyo springs	-0.04044009	36.43014	2347



Plate 1: Collecting *Salix mucronata* at the Hippo point

3.2 Fungi

3.2.1 Desktop Analysis

Before onset of the field surveys, a literature review was undertaken to assess fungal diversity already documented in the Lake Ol Bolossat ecosystem. The aim was to develop a comprehensive list of fungi known in the area. This was achieved through detailed search of research articles using Google Scholar and other internet sources such as research gate. Both published and un-published sources including research articles, books, technical reports and thesis related to the Aberdares Ranges were reviewed. The literature search focused on materials published up to 9th November 2023.

Search terms included wetland specific keywords such as forest, Aberdares, riparian and Central Kenya. Fungal-related keywords included fungi, macro-fungi (mushrooms), arbuscular mycorrhiza fungi (AMF), *ectomycorrhiza*, *Fusarium* and *Trichoderma*. The search yielded over 400 articles, but only three articles were relevant to the study sites, reflecting lack of studies on fungi in the study area.

3.2.2 Field Survey

Fungi Experimental Design

In this study, 6 sampling blocks, each 10 km apart, were identified, with three located in the East and three in the West (Figure 2, Table 2). In each block, two transects of 1 km in length were established, spaced, 3 to 5 km. The first plot was installed near the lake shore-side of the wetland area and the last plot was installed at settled areas with the cultivated land. Along each transect four plots (designated H1, H2, H3 and H4) each measuring 50 m x 50 m, and spaced 250 m apart, were demarcated for sampling of macrofungi. The H1 plot was located at the lowest water point and was partially submerged in lake water. The remaining three plots were positioned along the wetland slope, increasing in elevation. H2 was situated in natural grassland, approximately 250 m from the lakeshore (Table 1). H3 and H4 were located in farmland either in cultivated fields (maize crop) or within plantations of *Eucalyptus polybractea*, *Eucalyptus saligna*, or *Acacia mearnsii*. Additionally the two remaining natural forest ecosystems were sampled to serve as baseline data for comparison. The experiment had a total of 54 plots (6 blocks, 2 transects and 4 plots as well as 6 plots from two remnant forested ecosystems)

Collection and morphological characterization of macro-fungi species

In each plot, encountered macro fungi were photographed *in situ* and key characteristics such as phenology, odour, habitat, colour, nature of substrate and associated plant species were recorded. Numbers of fruiting bodies encountered in each sampling plot were also recorded. Few representative fruit bodies with all diagnostic features of each collection were transported to Mycology laboratory for herbarium collection and microscopic analysis whenever necessary. In the laboratory, the collected macro-fungi identification was based on macro-micromorphological features by comparison using coloured field guide books, monographs of colored mushrooms such as (Largent & Their 1984, Largent 1986, Kirk *et al.* 2001, Harkonen *et al.*, 1995, 2003, Mueller *et al.*, 2004, Lincoff, 2005) and

internet facility. Some of the mushrooms after freshly observation were oven dried (40°C) overnight and deposited at the mycological herbarium of the National Museums of Kenya.



Figure 2: Lake Ol Bolossat sampling area along admin and geographic features

Table 2: Fungi sampling blocks, transects and plots in Lake Ol Bolossat Ecosystem

Block	Local name	Transects	Number of Plots
Block 1	Shamata Ward	T1	4
		T2	4
Block 2	Rurii Ward	T1	4
		T2	4
Block 3	Central Ward	T1	4
		T2	4
Block 4	Weru Ward	T1	4
		T2	4
Block 5	Gatimu Ward	T1	4
		T2	4
Block 6	Kiriita Ward	T1	4
		T2	4
Forest Remnants	Chaparungu	T1	3
	Gatimu Ward	T2	3
Total number of plots sampled			54

3.2.3 Data Analysis

Species density, richness and diversity were assessed for the entire ecosystem and for each land use. Shannon-Wiener diversity index (Nolan & Callahan 2006) was used as it does not disproportionately favor either rare or common species but instead weights all species according to their frequency in the sample. Paleontological Statistics (PAST) Software was used for diversity analysis data (Hammer *et al.*, 2001). Analysis of variance (ANOVA) was performed for density, species richness and diversity index to find significant effect across land use on macro-fungi using SPSS Version 18 (SPSS 2009). Turkey's test was applied for comparison of means when appropriate.

3.3 Reptiles and Amphibians

Data was collected using two main approaches: desk based review and field assessment.

Desktop analysis:

This analysis included reviewing literature from research publications, reports from past and ongoing projects, media reports, data on administrative boundaries relevant to Lake Ol Bolossat and its surrounding areas. The Herpetology Collection of the National Museums of Kenya, checklists and field guides were used to compile data for reptiles and amphibians. Additional data were sourced from previous studies and databases such as the Global Biodiversity Information Facility (GBIF).

Field Assessment: Ground-truthing and biodiversity data collection

Ground-truthing was conducted to obtain actual information on the status of biodiversity in selected sampling points in Lake Ol Bolossat. Tools used in the ground-truthing included a GPS (eTrex 20 Garmin) for recording geolocation data, cameras for photographic documentation and notebooks for recording pertinent information. Local administrators and community members facilitated the teams to access the sampling locations. GPS coordinates for each Time-Limited Search (TLS) and species encounter site, were logged using the GPS device. Ground-truthing also contributed to defining the biogeographical distribution boundaries of recorded species.

3.3.1 Species Sampling

i) Timed-Limited Searches (TLS)

In each sampling point, Time-Limited Searches (TLS) by two observers lasting 30 minutes each equivalent to one man-hour effort was used (Karns, 1986; Heyer *et al.*, 1994; Sutherland, 1996). The searches were carried out within each sampling point without setting boundaries. Searches were done in all possible reptile and amphibian micro-habitats such as tree barks, under stones, decomposing logs, tree stumps, holes, shrubs, bushes and digging within loose soils. All the different species and number of reptiles and amphibians found were recorded. The TLS were carried out during the day and at night.

ii) Visual Encounter Surveys (VES)

Additionally, VES was used to supplement TLS data. This is a non-standardized method used only for qualitative and semi-quantitative data mainly for presence or absence of species (Rödel & Ernst, 2004; Veith *et.al.*, 2004). Due to its flexibility and being opportunistic, it is mostly recommended for supplementing species inventories. Opportunistic records e.g. observations by other researchers of different taxa contributed to collection or observation of herpetofauna.

iii) Night Sampling

At night, a combination of VES and Auditory Encounter Surveys (AES) was employed. It involved using a strong spotlight to search and spot species as the 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 could not be immediately identified, were recorded with a digital voice recorder for later comparison with amphibian calls database. This method recorded only amphibians during this survey. At night, a maximum of an hour was used to sample a site and all species recorded in every 30 minutes were recorded as a complete Time Limited Search.

iv) Interviews

Interviews were 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 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) Species Identification and Voucher Specimen

Identification of the species was made using published taxonomic keys (Spawls *et al.*, 2018; Channing and Howell, 2006) and taxonomy for amphibians was done according to Frost *et al.*, 2007. Where necessary, voucher specimens were euthanized and fixed in 10% formalin. All the materials collected were deposited at the herpetology collection of the National Museums of Kenya, Nairobi.

3.3.2 Statistical Tests and Analysis

Species richness and diversity was estimated from the TLS data using Estimates 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 of TLS. A species and specimen sampling effort index were calculated as a ratio of number of species/specimen and number of TLS in each sampling site. This shows an indication of the species diversity and specimen density in each sampling site.



Plate 2: a-Heath/Moor habitat, b-reptiles and amphibians specimen preparation
Top left to right to bottom: Dried bogs provided microhabitats for amphibians and reptiles; a local assistant helping to dig out amphibians from a burrow hole; Howard Atubwa, Research Assistant, preparing voucher specimens and preserved specimens in a preservation box.

3.4 Mammals

3.4.1 Sampling

The site was divided into 6 sampling sites in the Shamata, Rurii, Central, Weru, Gatimu and Kiriita wards. Surveys were conducted in all directions from a central starting point within each site to ensure comprehensive spatial coverage.

Two line transects were established per site, one positioned near terrestrial/farmed lands and the other one along the aquatic shoreline. The two line transects were used to maximize the detection of mammal species across different habitat types. The survey was conducted at the onset of the wet season, following an extended dry period. The heath around the lake provided suitable habitat for various small mammals, including the climbing mouse (*Dendromus* spp). The geographic coordinates for each sampling site are presented in Table 3.

Table 3: Mammals sampled per ward and their coordinates

Date	Ward/Locality	Latitude	Longitude	Elevation (m)
16-11-2023	Shamatta	-0.255311	36.467801	2324
17-11-2023	Rurii	-0.18609588	36.4444600	2328
18-11-2023	Central	-0.13563499	36.44701833	2324
19-11-2023	Weru	-0.1553975	36.4326692	2324
20-11-2023	Gatimu	-0.012921642	36.39842747	2322
21-11-2023	Kiriita	-0.02388082	36.39852223	2321

3.4.2 Desktop Analysis

This included research of previous related research/published material in the area. The materials used included search from past and ongoing projects, field guidebooks, media reports, publications and National Museums of Kenya database. The data was put together to form a base for work done at Lake Ol Bolossat.

3.4.3 Field Sampling

Indirect Sampling

The study used indirect field techniques, which included the identification and recording of mammalian signs such as footprints, scrapes, scratches, shelters, burrowings, scats and bones. These techniques are widely recognized for detecting cryptic or nocturnal species that may not be visually observed. In contrast, direct observation methods involve visual sightings of mammals in the field. However, for the purpose of this study, only indirect sampling methods were used. (Wemmer *et al.*, 1996; Rudran *et al.*, 1996).

Transect walks were conducted by walking slowly along pre-identified line transects, with observers scanning both along and adjacent to the transect lines for any evidence of mammal presence. The recording time for each transect was 1km per hour with a pause after 100 m to listen for calls or any movement on trees, grassland or the bushes. This method was done on transects located along the

shoreline and near farmland, as well as in adjacent areas since mammals often transverse between multiple habitat types due to their mobility.



Plate 3: Heath/Moor habitat where climbing mouse was found to live under



Mole rat burrowings

Footprint of animal near the lake shoreline



Remnants of hippopotamus skin

Dendromus seen after turning over heath heaps

Plate 4: Different images encountered along different transects during the survey

3.5 Invertebrates

Both standardized and non-standardized methods of data collection were employed for invertebrate sampling. Standardized methods are important for long term monitoring while non-standardized methods contribute to the development of comprehensive checklists. The following methods were applied:

3.5.1 Species Sampling

i. Pan Trapping

Fifteen pan traps (colored yellow, blue and white) were set in clusters of three among flowering plants. This method targets flower visiting insects, which are often pollinators, including bees, wasps, true flies (Diptera) and butterflies. Traps were half-filled with water, and a few drops of odourless liquid detergent were added to reduce the surface tension, ensuring insects sink upon contact. Pan traps were set early in the morning and retrieved in the afternoon. Collected specimens were preserved in 80% ethanol for later identification.

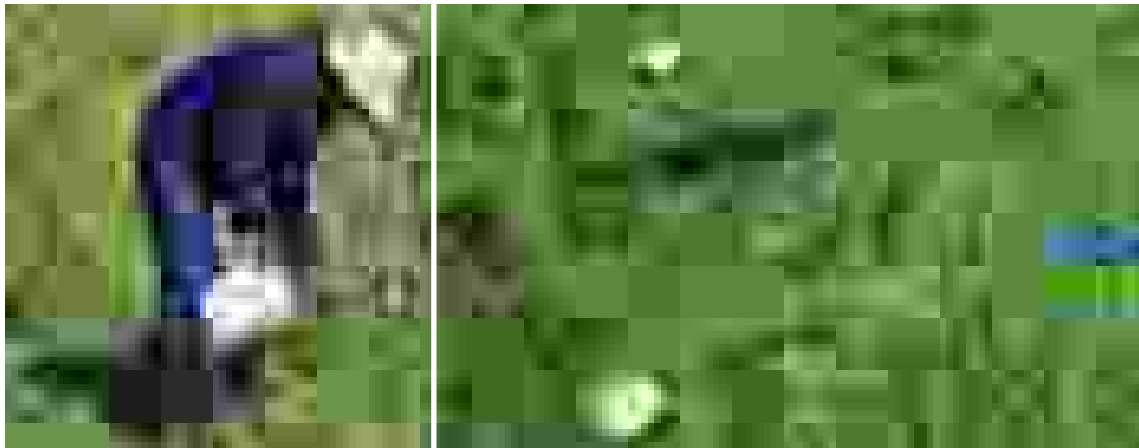


Plate 5: Setting of pan traps in Central Ward, Lake Ol Bolossat, November, 2023

ii. Aquatic Sampling

Aquatic invertebrates were collected using a 30 x 30 cm aquatic net from accessible points along the shoreline and from inflowing streams originating in the escarpment (Plate 6). Samples were transferred to a sorting tray, where representative specimens were selected using forceps and droppers, and preserved in vials containing 80% ethanol.



Plate 6: Taking an aquatic sample from the lake (left), from rock seepage (middle) and sorting an aquatic sample (right)

iii. Active Searches

In addition to trapping, active searching was conducted to collect invertebrates not targeted by traps. This included manually turning over stones and logs to hand pick specimens and the use of sweep nets to capture flying or resting individuals (Plate 7). Sweep netting was carried out randomly across habitats to maximize species representation. Specimens were preserved in 80% ethanol while delicate taxa such as dragonflies and butterflies were transported in open ended glassine envelopes to maintain wing integrity.

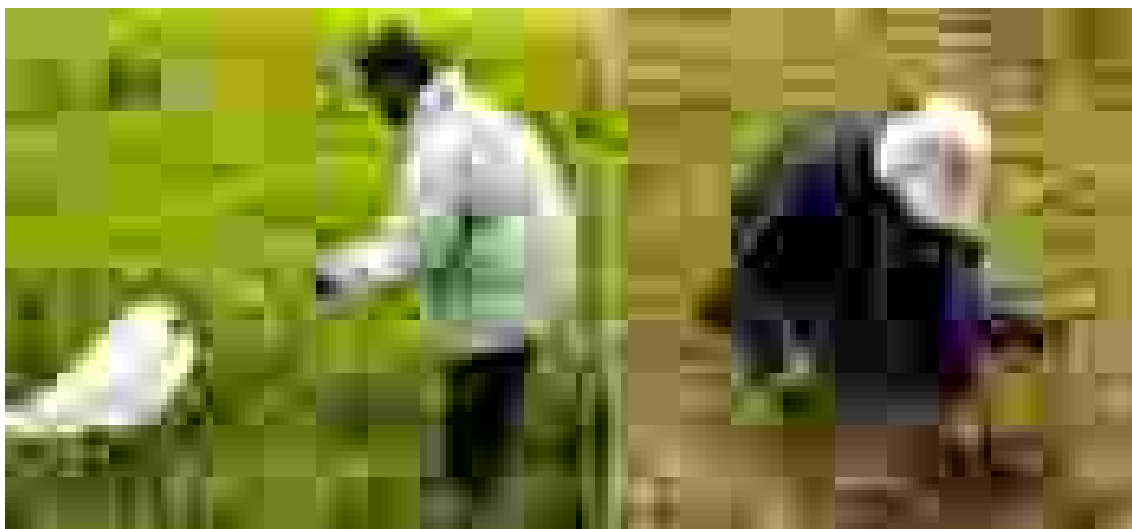


Plate 7: A community member using a sweep net (left) and hand picking of dung beetles from cow dung (right)

3.5.2 Specimen Preparation and Identification

Ethanol-preserved specimens were sorted, and mounted on stainless steel entomological pins, then dried in ovens for several days. Identification was conducted using dichotomous keys and by comparison with reference collection at the National Museums of Kenya.

3.6 Birds

3.6.1 Study Design

Avian field survey was carried out over a nine-day period from 14th to 22nd November 2023 at Lake Ol Bolossat ecosystem. This ecosystem includes mainly wetland together with an associated riverine habitat, grassland adjacent to the lake and bushed-grassland interspersed with secondary forest. All these habitats are surrounded by farmlands that are likely to influence bird community structure. Lake Ol Bolossat is an elongated wetland stretching from north to south; the southern part around Shamata area is drier while the northern side towards the Thompson's fall area is wetter. Human influences on the lake include overgrazing, bird nest destruction by grazing cattle, bird eggs collection by children, over-extraction of papyrus reeds on the shore of the wetland, deliberate and accidental wild fires and land grabbing. Following a reconnaissance survey on the first day of the survey, sampling points for point counts and timed species counts were established in two main habitat types including grassland adjacent to the lake,

bushed-grassland with secondary forest and riverine area, proportional to the size of each of these habitat types.

3.6.2 Sampling

Two systematic methods were used to sample and census birds: Timed Species Counts (TSCs) and Point Counts (PCs). These methods aimed to build a comprehensive bird species list across habitat types, and to establish baseline abundances for long-term monitoring. This baseline data can be used in the future to detect changes in avifaunal composition over time and to compare whether significant shifts or differences occur.

i. Timed Species Counts (TSCs)

TSCs are used to rapidly generate species lists and to estimate the relative abundance of bird species (Davies, 2002). We used a modified version of TSC method, where observers noted whether birds were:

- Above or below 3 m from the ground (to account for detectability issues, especially for understory species),
- Within or beyond 25 m from the observer's route or position (to reduce bias from noisy or conspicuous species, which may otherwise inflate abundance estimates) (Bennun & Waiyaki, 1993).

The TSC data was used to calculate the TSC index. TSCs were broadly spread across all major habitat types in proportion to their size, to ensure representation of the available microhabitats: Grasslands adjacent to the lake, and the bushed-grasslands with secondary forest. Fifteen TSCs were conducted, each lasting 40-minutes. Each pair of TSCs was separated by a minimum distance of 100 meters to avoid double-counting and spatial autocorrelation.

ii. Point Counts (PCs)

While not as comprehensive as TSCs in building species lists, point counts are ideal for monitoring bird populations and correlating avian data with habitat variables (Davies, 2002). For this study, PCs were placed systematically along transects within each major habitat type.

A total of 50-point count stations were established across the study area, with each point separated by between 200-250 meters. This spacing ensured independence between sampling points and minimized disturbance overlap.

iii. Supplementary Observations

Opportunistic bird sightings made outside the formal survey methods were also recorded and used to complement the species checklist.

3.6.3 Data Analysis

i. Species Accumulation Curves Modelling

To estimate species richness and assess sampling sufficiency, we fitted an asymptotic species accumulation model to the observed data, using nonlinear

regression techniques (Gaidet *et al.*, 2005). Specifically we adopted the exponential equation of the linear dependence model (Soberón & Llorente 1993). This model is practical for relatively less diverse assemblages of well known taxonomic groups, such as mammals, birds and certain tropical insect taxa (Moreno & Halffter 2000; Soberón & Llorente 1993; Willott 2001). The model expresses the expected number of species $S(p)$ as a function of sampling effort, where p represents the number of sampling units (in this case, days):

$$S(p) = \frac{a}{b} [1 - \exp(-b \cdot p)]$$

Where

- $S(p)$ is the predicted number of species after p sampling days,
- a represents the increase rate at the beginning of the sampling period
- a/b is the asymptote (Gaidet *et al.*, 2005; Soberón & Llorente 1993).
- $\exp$ denotes the exponential function.

We had two models based on two values of a :

- the mean increase rate of species over the initial 5 days including the 1st day (i.e., days 1-5),
- the rate of increase over the initial 5 days, but excluding the 1st day (i.e., days 2-6).

ii. Timed Species Counts (TSCs) Data Analysis

Because the modified method was used, the *TSC index* was calculated based on only the records within 25 m. For each TSC, each species within these limits was assigned an index ranging from 0 to 4, depending on whether it was recorded during the first 10 minutes (= 4), second ten minutes (= 3), down to 0 for a species not recorded during that count. An average score was then calculated over all (number of TSCs in each habitat type) counts total, from which we computed a mean score for each habitat type, and a grand mean score for the Lake ecosystem.

iii. Point Counts (PCs) Data Analysis

We assessed species relative abundance and distribution using the *PC occurrence index*, which is the proportion of counts where a species was recorded. We used the total number of individuals counted to provide an index of relative abundance.

3.6.4 Diversity Metrics

i. Shannon-Wiener Index

We computed a Shannon diversity index for each habitat type as:

$$H' = - \sum_{i=1}^S p_i \ln(p_i)$$

where

H' is the Shannon–Wiener diversity index

S is the total number of species in the community (species richness)

p_i is the proportion of individuals found in the i th species and

$\ln$ is the natural logarithm.

Evenness

We calculated evenness as the ratio of each Shannon-Wiener diversity value to the maximum possible diversity per habitat type:

$$E = \frac{H'}{H_{max}} = \frac{H'}{\ln S}$$

where

E is Evenness (constrained between 0 and 1)

H' is Shannon–Wiener diversity index

S is the total number of species in a sample.

ii. Jaccard's Index of similarity:

Jaccard's index was used to compare species similarity (beta diversity) between habitat types in the study site. The index provides a percentage of faunal similarity and is computed as:

$$J = \frac{j}{r} * 100$$

where

J is Jaccard's Index (%)

j is the number of species found in both of two samples and

r is the total number of species in both samples.

Forest dependency

Bird species were classified either as forest-specialist (FF), forest generalist (F), forest visitors (f) or non-forest (non-f) species (Bennun *et al.*, 1996). The FF and F are dependent on forests, while f and non-f are not. The distribution of these categories were allocated in each of the two habitat types in the study.

Data was analysed using the STATISTICA program (StatSoft 2001), Microsoft Excel and R statistical software.

3.7 Fish and Water Quality

3.7.1 Water Sampling

In situ physico-chemical parameters of surface water using a handheld multi-parameter probe meter (Hanna model HI98194) (Plate 8), following UNEP & WHO (1996) guidelines were measured. The parameters measured included:

- pH,
- Total dissolved solids (TDS),
- Surface water temperature,
- Salinity and
- Electrical conductivity

To minimize site disturbance effects, all measurements were taken prior to any physical disturbance at the sampling sites. In addition, duplicate 500 ml water samples were collected at each site in clean, sterile containers for laboratory

analysis of phosphate and nitrate concentrations, key indicators of freshwater nutrient status. The water samples were preserved in a cooler box with ice immediately after collection to prevent degradation of chemical constituents and transported to the University of Nairobi laboratory for analysis.



Plate 8: In situ measurement of physical chemical parameters of water

3.7.2 Fish Sampling

Fish sampling was carried out in the main lake and closely associated wetlands and streams. The study area was divided into six sections corresponding to county ward boundaries for systematic coverage. Sampling methodologies were selected based on habitat type and known habitat preferences of fish species.

i. Hand seining

In shallow open waters, a 3 m long seine net with 2 wooden buttons was employed. Two people operated the net by dragging it across the shallow water (Plate 9).



Plate 9: Fishing using a hand seine

ii. Electrofishing:

In rivers and canals, electrofishing was employed. This method uses a combination of backpack electrofishing machine and a seine net. Two people block one side of the stream with the net while another shocks the water immobilising the fish that are collected with the seine net.

iii. Gill Netting:

In deeper open waters, monofilament gill nets (mesh size 10 mm; 30 m long × 1.5 m wide) were used. The nets were tied end to end and left at each site for a period of two hours and checked every 30 minutes to avoid overfishing. The fish samples were removed from the net and kept temporarily in a bucket of water mixed with a killing agent waiting processing.

Interaction with local fishermen and community members was used as a supplementary method to gather indigenous knowledge on fish species occurrence in both lake and riverine habitats. The captured species were identified to species level, counted and recorded in the field notebook. The fish samples photographs were taken immediately after capture to document natural coloration following ichthyological standards. Fish were then immersed into a well labelled container with 10% formalin for initial fixation and transported to Ichthyology Section of National Museums of Kenya for taxonomic verification using standard keys and reference collections, then preserved in 70% ethanol as voucher specimens (Coad, 1995). Where fish of the same species were caught, some were returned into the water.

3.7.3 Quality Assurance and Quality Control

a. Water Sampling Quality Assurance and Quality Control

Water samples were collected in duplicates at each sampling site to ensure consistency and reproducibility of results. The multiparameter probe meter (Hanna model HI98194) was calibrated daily using certified standard solutions before field measurements were taken. Water samples were collected before any disturbance at the site to avoid contamination. Samples were immediately stored in ice cooled containers and transported to the laboratory for analysis within recommended holding times. Laboratory procedures included the use of blanks, duplicates, and known standards to verify the accuracy and precision of phosphate and nitrate measurements. A chain of custody form accompanied all samples from the field to the laboratory to maintain sample integrity.

b. Fish Sampling Quality Assurance and Quality Control

All fish sampling including electrofishing activities were conducted under relevant research permits and ethical approval from the appropriate regulatory authorities. Sampling gear including nets and electrofishing equipment was cleaned and inspected before and after use to prevent cross contamination between sites. Fish species were identified in the field by trained personnel and photographs of live specimens were taken immediately after capture to preserve natural coloration following standard ichthyological practices. Where fish were

not required as voucher specimens, handling time was minimized and fish were released alive back into their habitats to adhere to animal welfare standards. Specimen identifications were further verified at the Ichthyology Section of the National Museums of Kenya using taxonomic keys and comparison with reference collections. Field data sheets were checked for completeness and accuracy daily. Voucher specimens were fixed in ten percent formalin and later preserved in seventy percent ethanol to ensure long term preservation and reference.

3.8 Spatial Analysis

3.8.1 Field Validation and Habitat Characterization

Sampling sites were selected based on predictor variables and further adjusted through field validation. Ground truthing was conducted to verify land use and land cover classes, analyze species richness, characterize habitats, and record environmental degradation and associated drivers within each hotspot category. Habitat characterization was performed using transect walks, during which photographic evidence was collected to document site conditions.

3.8.2 Spatial Data and Sources

Spatial data consisted of selected features that interact in space directly and indirectly with habitat and species (Table 4, Figure 3). These include the biophysical and socio-economic factors that have positive or negative influences on the status of the water towers. Justification is however provided for each factor (variable) used in the analysis.

3.8.3 Geoprocessing

Geoprocessing technique was applied to prepare spatial layers for biodiversity hotspot analysis. Intersection analysis was used to identify locations where multiple environmental factors co-occur. Proximity analysis was performed to assess the distance of sampling points to key geographic features, providing insight into potential spatial relationships.

3.8.4 Hotspot Analysis

Biodiversity hotspots were defined as areas exhibiting disproportionately high species richness coupled with significant potential conservation threats. To generate the hotspot map, several predictor variables were integrated with the response variable (species richness) through statistical analysis and geoprocessing techniques. This approach allowed the customization of hotspot parameters at a local scale, providing a robust tool for conservation prioritization.

In this analysis, biodiversity hotspots were modeled as the outcome of a regression between species richness and the mean spatial weighting index of selected predictor variables, including vegetation cover, proximity to roads and urban centers, slope angle, drainage density, and spring distribution density. Geoprocessing techniques were used to create an attribute matrix, and predictor variables were normalized to a common scale ranging from 0 to 1 to enable integration.

Hotspot areas were classified into three major classes, Very Hot, Moderately Hot, and Less Hot, using an Equal Interval classification method with limited manual adjustments in ArcGIS. Variables were categorized into indices based on their relative contribution to biodiversity patterns, as detailed in the accompanying Table 5. Areas classified as Very Hot were identified as priority zones with the highest biodiversity concentrations, while Less Hot areas reflected relatively lower biodiversity values.

Table 4: List of predictor variables with measurable variables for use in modelling suitable habitats

Predictor Variable	Measurable Variable	Justification
Drainage system	Distance in meters from the drainage channel	The riverine and/or riparians are habitat for animal species and a reserve for diverse plant species. It is also serve local socio-economic importance.
Wetlands	Size of the feature and distance from the edge (shore)	This is a habitat and dry season refugia for wild animals and livestock
Springs	Spring density and distance from springs	These are sources of water for both wild animals and domestic use. Animals occur around these springs or they visit the resource from drinking.
Slope angle	Gradient in angle	Areas with high slope angles are vulnerable to soil erosion. These areas, in some places, vegetation area reserved hence contributing to vegetation covers in an area.
Surface reflectance	A scale index ranging from 0 - 1	Reflectance of a surface indicates the condition of a particular land cover feature. The higher the reflectance from a particular feature the poor the status.
Road network	Distance from road and road density	People normally settle in areas near the road for accessibility. These areas consist of settlements and farmlands. Areas with high road density are also affected by the development. They certainly have poor vegetation covers.
Urban or Town centers	Distance from the town	Areas around towns are under pressure for biological resources such as construction timber, and fuelwood.
Land cover	Type with weighted scale	The type of land cover potentially indicate the kind of habitat and species occurring in the area,

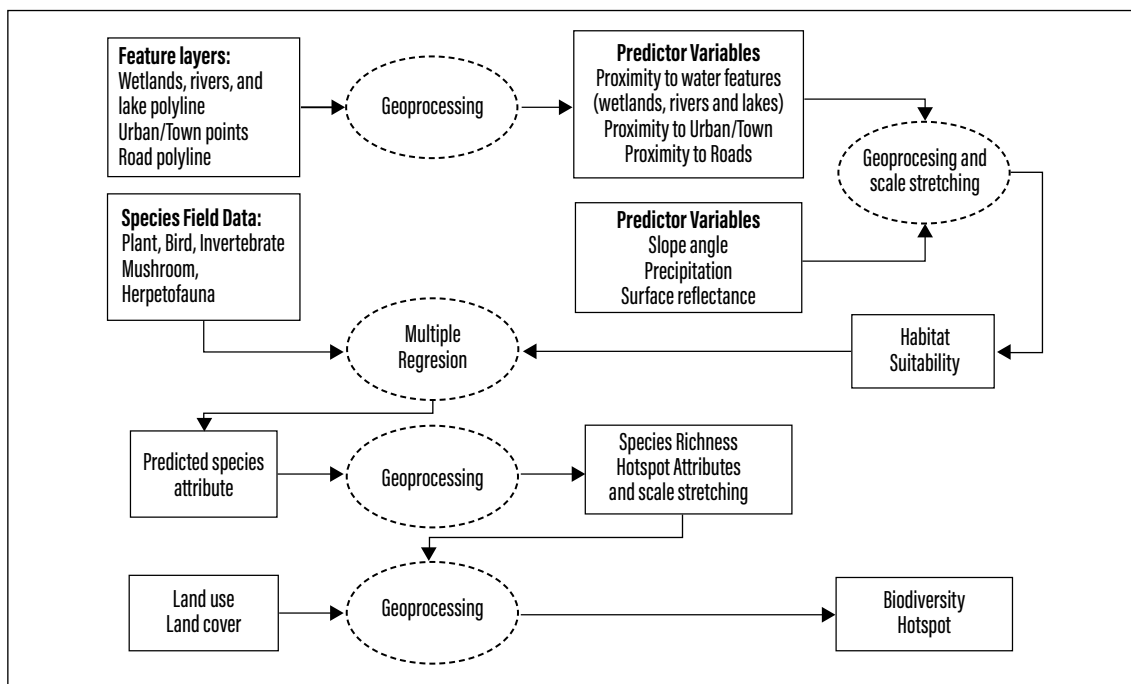


Figure 3: The workflow and processes for generating of biodiversity hotspots

Table 5: Spatial predictor variable with the description of categorical scale of hotness for biodiversity conservation

No.	Predictor Variable	Less Hot	Moderately Hot	Very Hot
1.	Species	Less rich in species	Has moderate richness	Very rich in species
2.	Slope	Low slope angle, Vulnerable to Encroachment, Less species richness	Moderately steep	High slope angle, Vulnerable to Degradation, High species Hotspot
3.	Vegetation cover	Low vegetation Index, Less species richness	Moderate vegetation index	High Index, High species richness
4.	Spring Density	No or Low counts of springs, Less species richness	Moderate counts of springs	More counts of spring, High species richness
5.	Drainage System	No or low Drainage Density, areas far from road Less species richness	Moderate density of drainage	High Drainage Density, areas near drainage system, High species richness
6.	Road	More road network density, nearness to the road, Presence of Invasive Species, Less species richness	Moderate density of road network	No or less road density, High species richness

3.8.5 Biodiversity Data and Spatial Integration

Secondary biodiversity data were acquired from both online and desktop databases. The primary data collection for various taxa employed GPS enabled devices to facilitate integration with spatial datasets. Specifically, the mobile application kMACHO was adopted for geo-referencing data collection and to support production of biodiversity hotspot maps.

i. Satellite Data

The land cover analysis was carried out using available satellite imagery. Landsat images sourced from the United States Geological Survey (USGS), were used for this purpose. Landsat data were considered due to their extended availability, long historical record (from 1972 to present), moderate spatial resolution (30 meters), and a temporal resolution of 16 days, making them ideal for long-term land cover analysis.

Data were obtained from the following Landsat missions: Landsat MSS, Landsat TM and Landsat OLI. Images were selected based on the appropriate rows and paths that covered the study area. Analysis intervals of five or ten years were applied, enabling detailed observation of land use and land cover change trends over time.

ii. Image Processing

Image processing and analysis was performed using ENVI 5.3 software. As the USGS-sourced images are already geometrically rectified, no further orthorectification was required. Multiple spectral bands were stacked into composite layers to enhance analytical detail, and mosaicking was performed to merge scenes covering the entire study areas.

iii. Image Classification

Image classification used automatic categorization of multispectral satellite image pixels into predefined land cover classes. This process allowed the identification of homogenous pixel groups representing specific landscape features. Each pixel was assigned to a particular land use or land cover type as described in Table 6 below:

Table 6: Land Use and Land Cover types

Land Use Land Cover Type	Description
Grassland-Tussocks	Areas (irregular shape) with terrestrial tall grasses
Grassland	Areas (irregular shape) with short grasses
Farmland/Ranch	Large farms (regular shaped) consisting of short and tall grasses
Farmland/Cropped	Seasonal, Fallow areas with grasses and Existing Crops
Built-up Area	Residential, Roads, Airstrips and other artificial structure
Wetland Sedges	Areas with aquatic macrophytes especially in the Apoceae Order
Water Area	Areas covered with surface water
Eucalyptus Plantation	Woodlot consisting of Eucalyptus tree species

iv. Unsupervised Classification

Unsupervised classification was used to group pixels into natural clusters based on spectral similarities across multiple bands, without predefined class labels. The ISODATA algorithm was utilized to assign pixels to the most probable cluster based on spectral similarity to the presumed mean. These preliminary classes were later labeled based on ground verification. The results of the unsupervised guided the field-based ground truthing exercise.

v. Ground-Truthing

Ground truthing was performed to validate satellite-derived land cover classes and enhance classification accuracy. Data were collected along transects traversing the study sites, recording land use and land cover information at systematically selected points. For each point, the following were documented: the geographical coordinates, textual description and photographs. Data collection was facilitated using the mobile-based, geo-referenced data management system kMACHO. The ground truthing data were then used to refine and improve the initial land cover classification results.

vi. Habitat Fragmentation Analysis

After classification, habitat fragmentation analysis was undertaken. Gaps between polygons for each land cover class were estimated for each successive time interval to assess trends in habitat fragmentation or consolidation of each habitat class.

vii. Land Cover Change Analysis

The classified images for different time intervals were converted into vector layers (shapefiles) to support land cover change detection. Land cover change analysis employed a thematic change matrix, which detailed transitions between different land use and land cover types across time periods. The matrix enabled the quantification and interpretation of landscape dynamics.

viii. Map Production

The final outputs were exported to ArcGIS software for map production. Various spatial features were overlaid onto the classified images to enhance the interpretability of the derived maps. These maps included key features related to factors of environmental degradation and were instrumental in identifying biodiversity hotspot areas.

3.9 Socio - Economic

3.9.1 Strategic Approach

To ensure that the process was participatory, widely known and accepted, consultations were held with local administration, including both County Government officials and local chiefs, as well as local organisations involved in Lake's conservation. This was achieved through courtesy calls to the respective offices of both National and County governments. A letter of introduction was provided by EAWLS to facilitate stakeholder engagement during the socio-

economic survey. These engagements allowed for effective planning of the socio-economic data collection. Prior to fieldwork, informed verbal consent was sought from participants, aligning with ethical standards for community-based research.

Selection of Enumerators

Using EAWLS field contacts, local enumerators were recruited from administrative wards around Lake Ol Bolossat, specifically from Shamata, Central, Kiriita, Igwamiti, Gatimu, Weru and Rurii wards. Recruitment considered the education level of candidates, with preference given to those with university or college education and familiarity with local contexts. Enumerators underwent a two-day training focused on data collection approaches, ethical considerations, use of the mobile-based tool (kMACHO), and a thorough review of the questionnaire to ensure consistency and quality of data collection.

3.9.2 Questionnaire Household Survey

The household survey was conducted using a structured questionnaire deployed through the mobile based kMACHO platform which enabled real-time monitoring of collected data by the lead scientist. The questionnaire covered key themes including household demographics, livelihoods, land tenure, land use changes, conservation perceptions, and socio-economic dynamics. Data was submitted daily allowing for continuous monitoring of quality and coverage, with adjustment made as necessary.

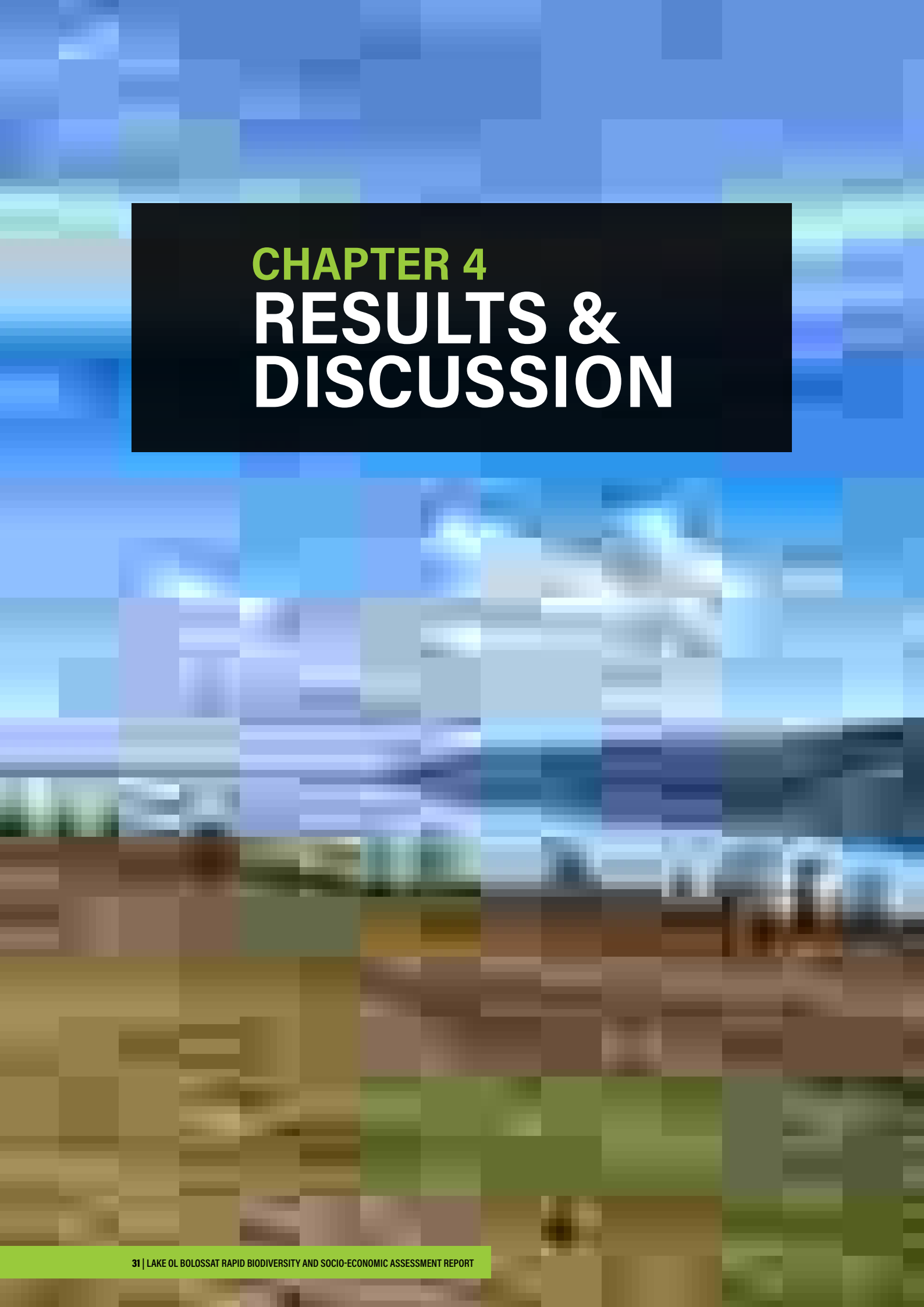
Two hundred and fifty five households were surveyed in Central Ward, Gatimu Ward, Kiriita Ward, Rurii Ward, Shamata Ward, and Weru Ward between 16th and 22nd November 2023. The sampling strategy involved surveying households within a maximum radius of 4 km from the lake boundary. In densely populated areas, every 5th household was selected, while in sparsely populated areas, every 3rd household was chosen. Starting points for surveys were randomized from a central point within villages to enhance representativeness. Quantitative data was analysed using STATA for descriptive statistics, while qualitative responses were analysed thematically using NVIVO.

3.9.3 Key Informant Interviews

To complement the household survey, key informant interviews were conducted with individuals directly involved in resource management and community leadership. These included County government officials, National administrators, heads of civil-society organisations, village elders, hoteliers, and senior community members, ensuring representation across all seven wards (Shamata, Central, Kiriita, Igwamiti, Gatimu, Weru and Rurii).

In total, 14 key informants interviews were purposively selected, considering diversity in stakeholder roles, age groups, and gender where possible. The qualitative data from these interviews was coded and analysed thematically using NVIVO.





CHAPTER 4

RESULTS & DISCUSSION

Biodiversity Thematic Areas

This chapter presents the findings from both the desktop review and fieldwork for each taxon, along with the results of the socio-economic survey. The results are organized by taxon, presented in the following order: plants, fungi, reptiles and amphibians, mammals, invertebrates, birds, spatial analysis, and the socio-economic survey. For each taxon, the total species richness is provided at the family, genus, and/or species level, and in certain instances, sub-species are included. A full species list for each taxon is presented in an appendix.

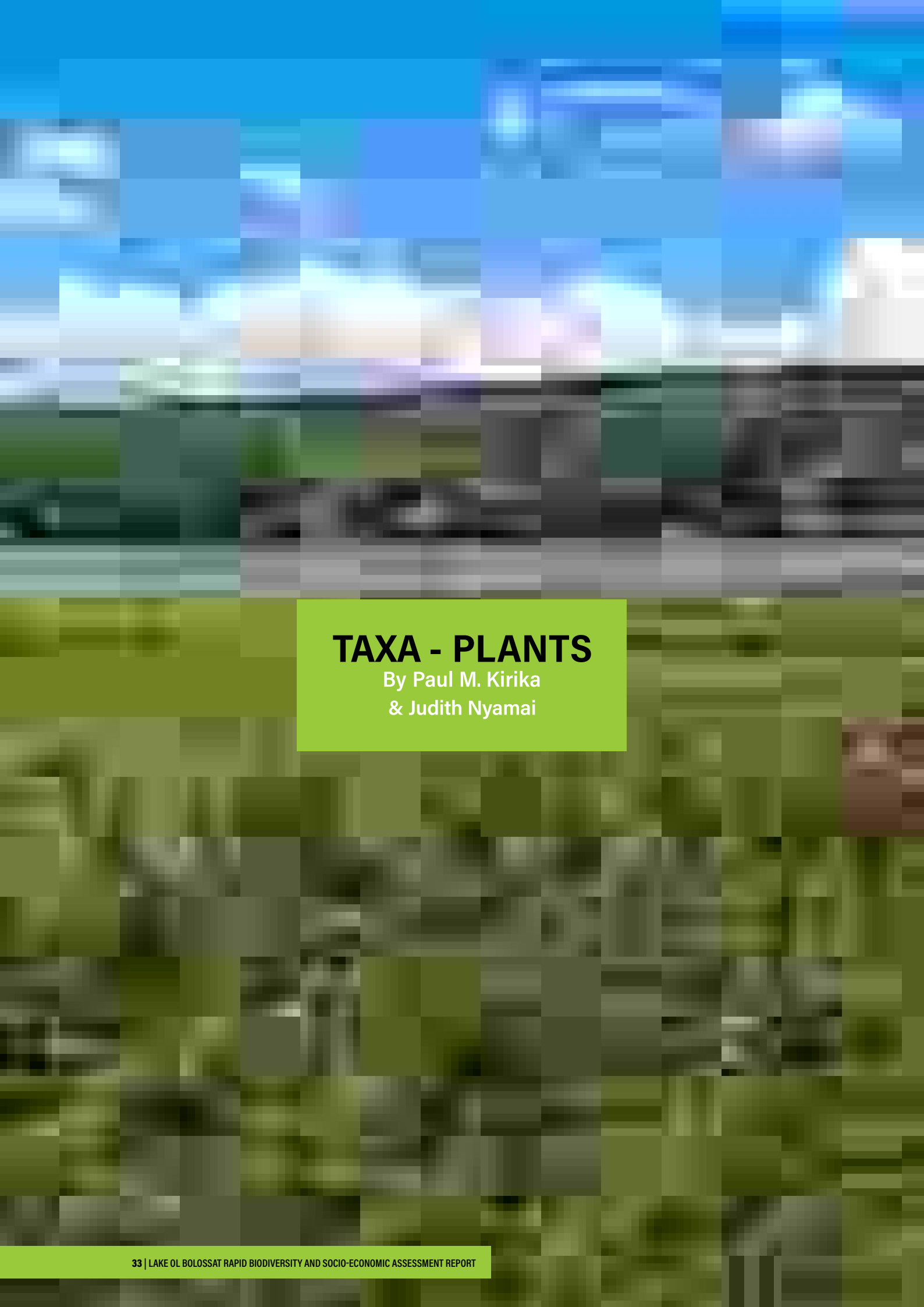
Species are evaluated in terms of their conservation importance using various criteria, including their status on the IUCN Red List of Threatened Species, CITES Appendices, endemism, national protection status, and, for birds, their dependency on forest habitats, migration status, and feeding guilds. Invasive species, such as *Cirsium vulgare* were identified, and their impacts on local biodiversity, including competition with native species and alteration of habitat structure, are discussed. Additionally, species of economic importance—such as those used in ethnomedicine, food sources, or ecotourism are highlighted, along with species that serve as biological indicators of environmental health.

Photographs, either taken in the field or sourced from other credible references, are presented to illustrate key species and their habitats. These images also serve to highlight field observations of human interference with natural systems, including soil erosion and unauthorized logging activities, which may affect species and habitats.

The findings are supported by visual representations such as tables, graphs, and pie charts. To validate land cover classifications and ensure accuracy in spatial analysis, classification accuracy assessments, including confusion matrices and Kappa coefficients, were calculated. These tests aid in quantifying the reliability of land cover maps used in the analysis. Where applicable, statistical tests such as ANOVA, were employed to help interpret and validate the results. The use of these tests aids in understanding the patterns and trends observed in the biodiversity data.

For each taxon, a detailed discussion is provided, accompanied by specific recommendations for conservation and management. The chapter concludes with a spatial analysis, which uses GIS tools such as ArcGIS, along with specialized plugins for biodiversity mapping, to interpret species observations and their distribution in the field. This analysis integrates species richness data with environmental and physical variables, such as slope, accessibility, vegetation index, spring density, and drainage. The spatial analysis facilitates the identification of critical areas for the protection and conservation of biodiversity within the water tower.

Sampling for taxa was conducted using standardized field methods, including transect and plot sampling, which ensured consistency and reproducibility in data collection. The sampling design aimed to capture the full diversity of species within each taxon, and the field survey methodology is detailed in the field section for clarity and transparency.



TAXA - PLANTS

By Paul M. Kirika
& Judith Nyamai

4.1 Taxa: Plants

4.1.1 Introduction

Plants are the primary producers, upon which all other living organisms on earth depend. Globally, there are an estimated 390,000 plant species documented to date, the majority of which are found in the tropics. Kenya harbours about 7,000 species of vascular plants, thereby having the second richest flora within the eastern Africa region after Tanzania (11,000), and ahead of Uganda (4,500) and Ethiopia (6,000) (Zhou *et al.*, 2017). This plant diversity comprises 1,720 genera and 240 families, the majority being legumes (708), grasses (576) and members of the daisy family (403). Previously, only about 370 species, classified into 255 genera belonging to 92 families (Terer *et al.*, 2019), were documented for the Lake Ol Bolossat ecosystem. However, the diversity is likely much higher than currently documented.

Biodiversity inventories provide precise data regarding the presence, diversity and abundance of species within a given geographic area. Analyses and dissemination of these data is crucial in helping develop sustainable species conservation strategies as underpinned by tenets of the Convention on Biological Diversity (CBD). Drawing sound conservation interventions should therefore be guided by the taxonomic and ecological knowledge generated through inventories in order to enhance effectiveness and minimise the risks to biodiversity and individual taxa.

Documentation of the components of biodiversity in Kenya is largely incomplete for most landscapes and ecosystems, including the Lake Ol Bolossat ecosystem. The purpose of this study was therefore to generate more biodiversity data to help in policy formulation and decision making regarding the conservation of this fragile ecosystem and to facilitate its designation as the 7th Ramsar site in Kenya.

4.1.2 Field Findings

A total of 300 herbarium voucher specimens were collected, processed, and preserved at the East African Herbarium.

About 147 species were newly recorded for the lake basin, adding up the total number of species to 518 (Appendix 1) up from 371 documented in the previous study (Terer *et al.*, 2019). These were classified into 329 genera and 99 families. The twelve most speciose families recorded in the ecosystem were; Asteraceae (88 species, 17%), Poaceae (52, 10%), Fabaceae (39, 8%), Cyperaceae (30, 6%), Lamiaceae (20, 4%), Amaranthaceae (14, 3%), Rubiaceae (14, 3%), Acanthaceae (12, 2%), Apiaceae (12, 2%) and Malvaceae and Solanaceae with 11 (2%) species each (Figure 4).

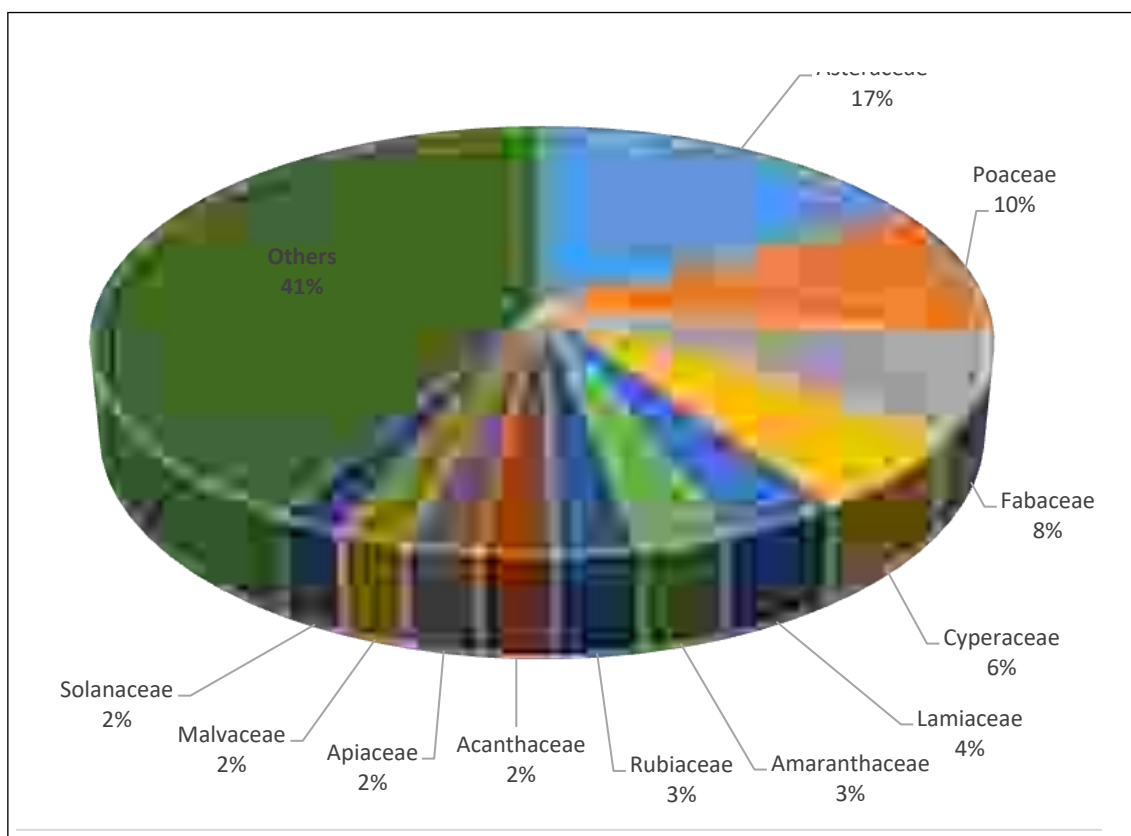


Figure 4: Distribution of plant species richness across major families recorded in the Lake Ol Bolossat ecosystem.

The twelve most speciose families, including Asteraceae, Poaceae, and Fabaceae, account for the majority of species diversity, highlighting patterns of family dominance within the ecosystem.

i. New Records of Plants to Kenya

Two plant species namely; *Calceolaria tripartita* and *Lactuca serriola* (Plate 10) were recorded for the first time in Kenya, while a second collection of *Oenothera tetraptera* was also made. Furthermore, the collection of *Calceolaria tripartita* may represent the first record for Africa according to Plants of the World Online (POWO, N.D). These findings expand the known floristic composition of Kenya and highlight the importance of continued botanical exploration and documentation.

- a. *Calceolaria tripartita* is an annual subshrub, native to Mexico, Panamá, Peru and Venezuela. It is known for its medicinal uses and primarily grows in the seasonally dry tropical biome.
- b. *Lactuca serriola* is an erect annual or biennial herb that can reach upto 2m in height, its native range extends from Europe to southwestern Siberia and China, and from North Africa to Somalia. It grows predominantly in temperate biomes.
- c. *Oenothera tetraptera* is a perennial plant whose native range extends from South Texas through northwestern Venezuela and Bolivia. It is primarily found in subtropical biomes and is noted for its medicinal properties.

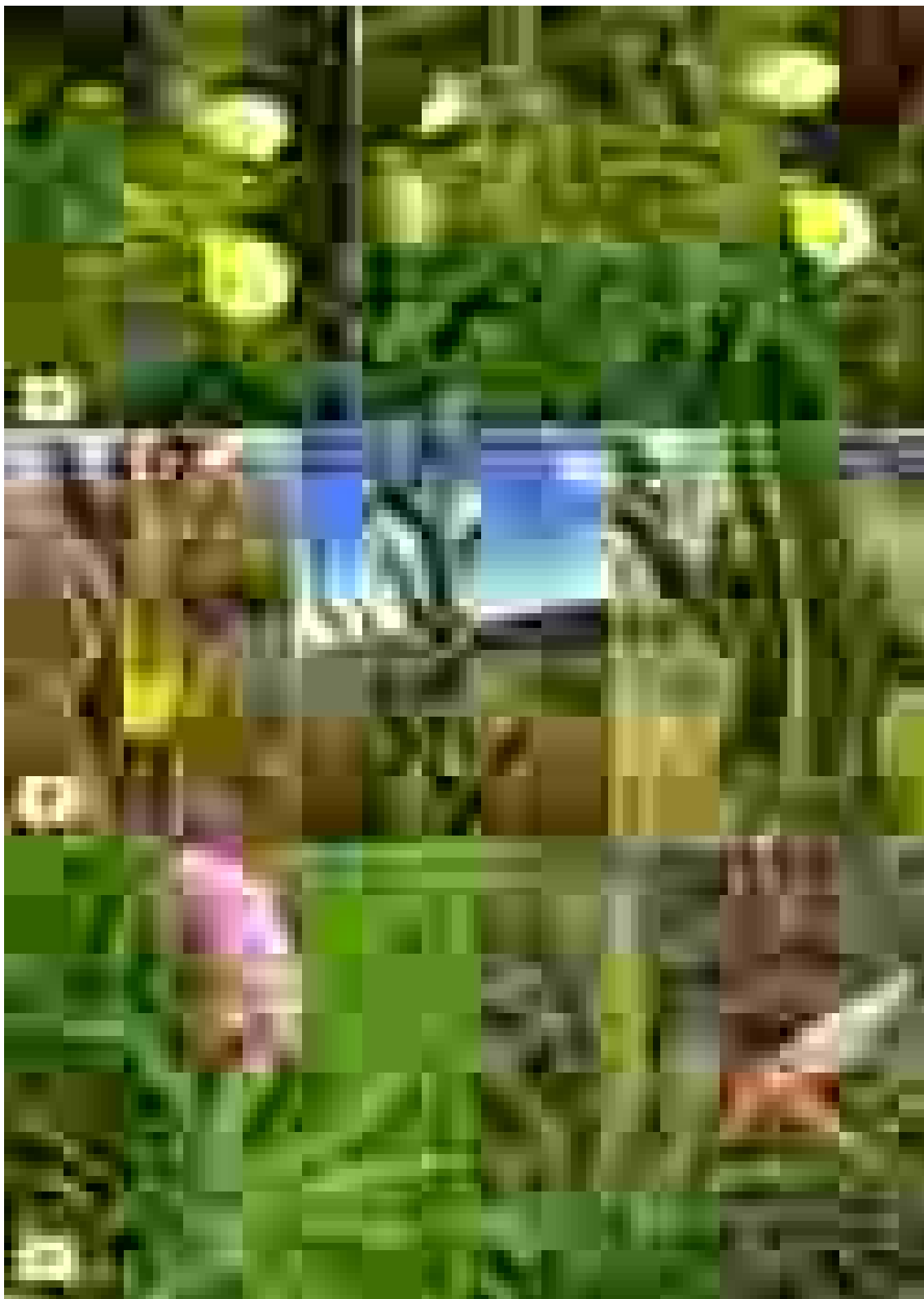


Plate 10: New records of plants for Kenya

A - Calceolaria tripartita B - Lactuca serriola C - Oenothera tetraptera

A total of 147 species were recorded for the Lake Ol Bolossat ecosystem for the first time. They comprised some indigenous and exotic species (Plate 11).

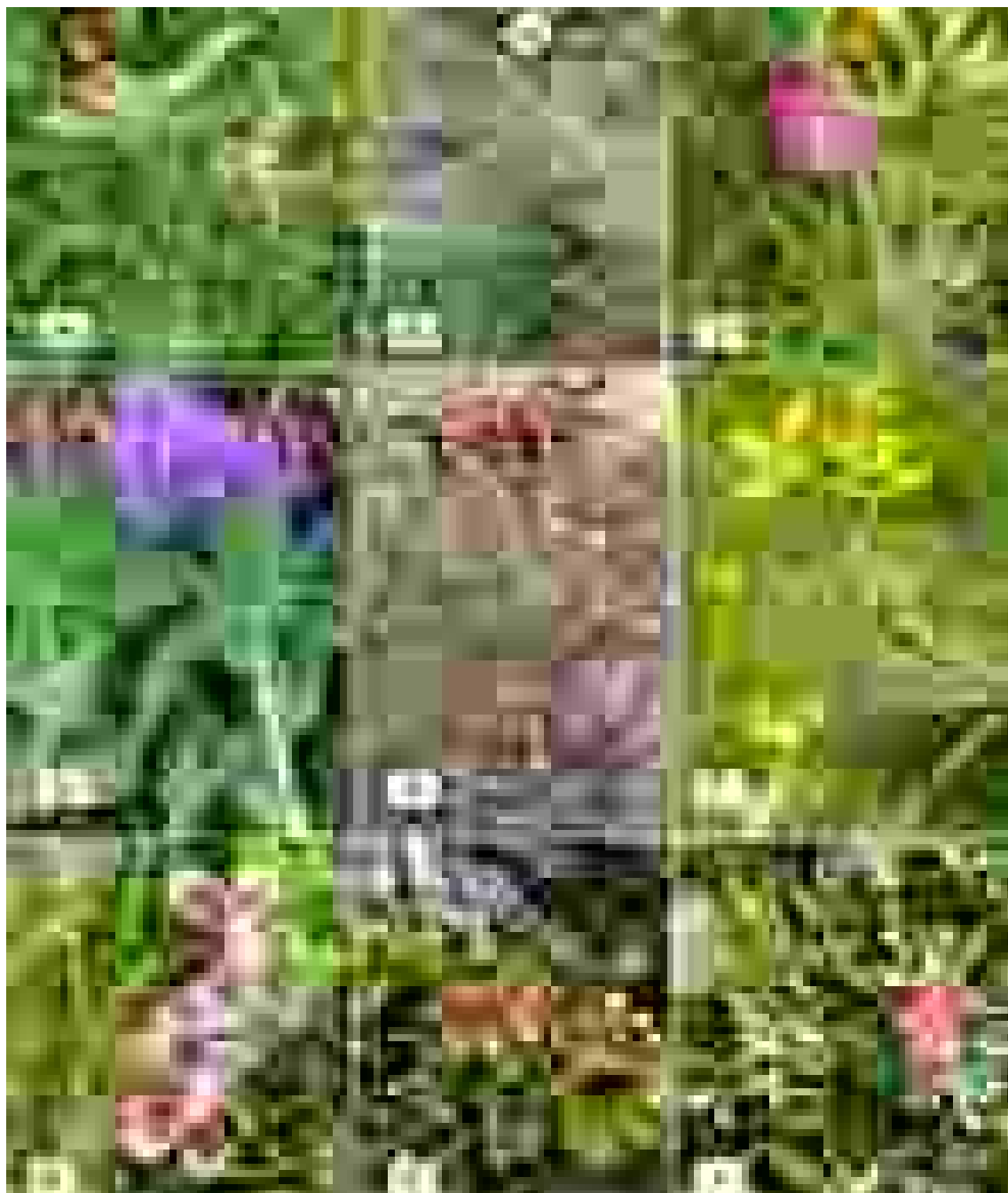


Plate 11: Some of the new plant records to the Lake ecosystem

A. *Centaurea melitensis* L.; B. *Echinops angustilobus*; C. *Epilobium hirsutum*; D. *Echium plantagineum*; E. *Bryophyllum pinnatum*; F. *Sisymbrium officinale*; G. *Silene gallica*; H. *Tara spinosa*; I. *Indigofera brevicalyx*

ii. Invasive weed species

Invasive species are among the five main threats to biodiversity, ranking second to habitat loss. They pose a serious threat to natural vegetation by outcompeting indigenous species thereby reducing their populations and ultimately altering ecological integrity of the ecosystem. In this study, about 65 species of weedy species were documented, of which 24 were identified as invasive alien species. Among these, the most aggressively invasive was *Cirsium vulgare* (common name: spear thistle) (Plate 12). *Cirsium vulgare* is a biennial herb that grows primarily in the temperate biome. Its native range extends from Europe to Siberia, the Arabian Peninsula, and northwestern Africa. This species was observed to have extensively colonized large areas of the lake ecosystem, particularly the wetter regions. Its dense, spiny growth forms impenetrable thickets that suppress native vegetation, alter soil seed banks, and reduce habitat suitability for grazing wildlife and livestock. If left unmanaged, *Cirsium vulgare* can significantly diminish the biodiversity and resilience of invaded ecosystems.

Table 7: Weedy Species recorded

Family	Botanical name	IAS
Agavaceae	<i>Agave sisalana</i> Perr. ex Engelm.	✓
Amaranthaceae	<i>Achyranthes aspera</i> L.	
Amaranthaceae	<i>Aerva lanata</i> (L.) Juss	
Amaranthaceae	<i>Amaranthus graecizans</i> L.	
Amaranthaceae	<i>Amaranthus hybridus</i> L.	
Apiaceae	<i>Cyclospermum leptophyllum</i> (Pers.) Sprague ex Britton & P.Wilson	
Asteraceae	<i>Ageratina adenophora</i> (Spreng.) R.M.King & H.Rob.	✓
Asteraceae	<i>Ageratum conyzoides</i> L.	✓
Asteraceae	<i>Bidens pilosa</i> L.	
Asteraceae	<i>Centaurea melitensis</i> L.	
Asteraceae	<i>Cirsium vulgare</i> (Savi) Ten.	✓
Asteraceae	<i>Conyza bonariensis</i> (L.) Cronquist	
Asteraceae	<i>Conyza steudellii</i> A.Rich.	
Asteraceae	<i>Conyza tigrensensis</i> Oliv. & Hiern	
Asteraceae	<i>Cotula anthemoides</i> Willd.	
Asteraceae	<i>Cotula australis</i> (Spreng.) Hook.f.	
Asteraceae	<i>Galinsoga parviflora</i> Cav.	
Asteraceae	<i>Pseudognaphalium luteo-album</i> (L.) Hilliard & B.L.Burt	
Asteraceae	<i>Schkuhria pinnata</i> (Lam.) Kuntze	
Asteraceae	<i>Senecio madagascariensis</i> Poir.	✓
Asteraceae	<i>Tagetes minuta</i> L.	
Asteraceae	<i>Taraxacum officinale</i> Weber ex F.H.Wigg.	
Boraginaceae	<i>Cynoglossum lanceolatum</i> Forsk.	
Boraginaceae	<i>Echium plantagineum</i> L.	✓
Bignoniaceae	<i>Jacaranda mimosifolia</i> D.Don	✓

Brassicaceae	<i>Lepidium bonariense</i> L.	
Brassicaceae	<i>Sisymbrium officinale</i> (L.) Scop.	
Caryophyllaceae	<i>Silene gallica</i> L.	
Chenopodiaceae	<i>Chenopodium album</i> L.	
Chenopodiaceae	<i>Chenopodium carinatum</i> R.E.Fr.	
Chenopodiaceae	<i>Chenopodium murale</i> L.	
Chenopodiaceae	<i>Chenopodium schraderianum</i> Schultes	
Commelinaceae	<i>Commelina africana</i> L.	
Convolvulaceae	<i>Dichondra repens</i> J.R.Forst. & G.Forst.	
Convolvulaceae	<i>Ipomoea cairica</i> (L.) Sweet	✓
Crassulaceae	<i>Kalanchoe delagoensis</i> Eckl. & Zeyh.	✓
Cyperaceae	<i>Cyperus cyperoides</i> (L.) Kuntze	
Cyperaceae	<i>Cyperus rigidifolius</i> Steud.	
Fabaceae	<i>Acacia melanoxylon</i> R.Br.	✓
Fabaceae	<i>Senna bicapsularis</i> (L.) Roxb.	✓
Fabaceae	<i>Senna didymobotrya</i> (Fresen.) H.S.Irwin & Barneby	✓
Fabaceae	<i>Trifolium rueppellianum</i> Fresen.	
Lamiaceae	<i>Leonotis nepetifolia</i> (L.) R.Br.	
Lamiaceae	<i>Leucas deflexa</i> Hook.f.	
Malvaceae	<i>Malva verticellata</i> L.	
Oleaceae	<i>Fraxinus pennsylvanica</i> Marshall	✓
Oxalidaceae	<i>Oxalis corniculata</i> L.	
Passifloraceae	<i>Passiflora edulis</i> Sims	✓
Pinaceae	<i>Pinus patula</i> Schiede ex Schltdl. & Cham.	✓
Plantaginaceae	<i>Plantago lanceolata</i> L.	
Plantaginaceae	<i>Plantago major</i> L.	
Poaceae	<i>Eleusine indica</i> (Kenn.-O'Byrne) S.M.Phillips subsp. africana (Kenn.-O'Byrne) S.M.Phillips	
Polygonaceae	<i>Polygonum aviculare</i> L.	
Portulacaceae	<i>Portulaca quadrifida</i> L.	
Proteaceae	<i>Grevillea robusta</i> A.Cunn. ex R.Br.	✓
Rosaceae	<i>Rubus niveus</i> Thunb.	✓
Salicaceae	<i>Dovyalis caffra</i> (Hook.f. & Harv.) Warb.	✓
Salviniaceae	<i>Salvinia molesta</i> D.S.Mitch.	✓
Solanaceae	<i>Cestrum aurantiacum</i> Lindl.	✓
Solanaceae	<i>Datura stramonium</i> L.	✓
Solanaceae	<i>Nicandra physaloides</i> Gaertn.	
Solanaceae	<i>Physalis peruviana</i> L.	✓
Solanaceae	<i>Solanum campylacanthum</i> Hochst. ex A. Rich.	✓
Solanaceae	<i>Solanum nigrum</i> L.	
Urticaceae	<i>Urtica massaica</i> Mildbr.	

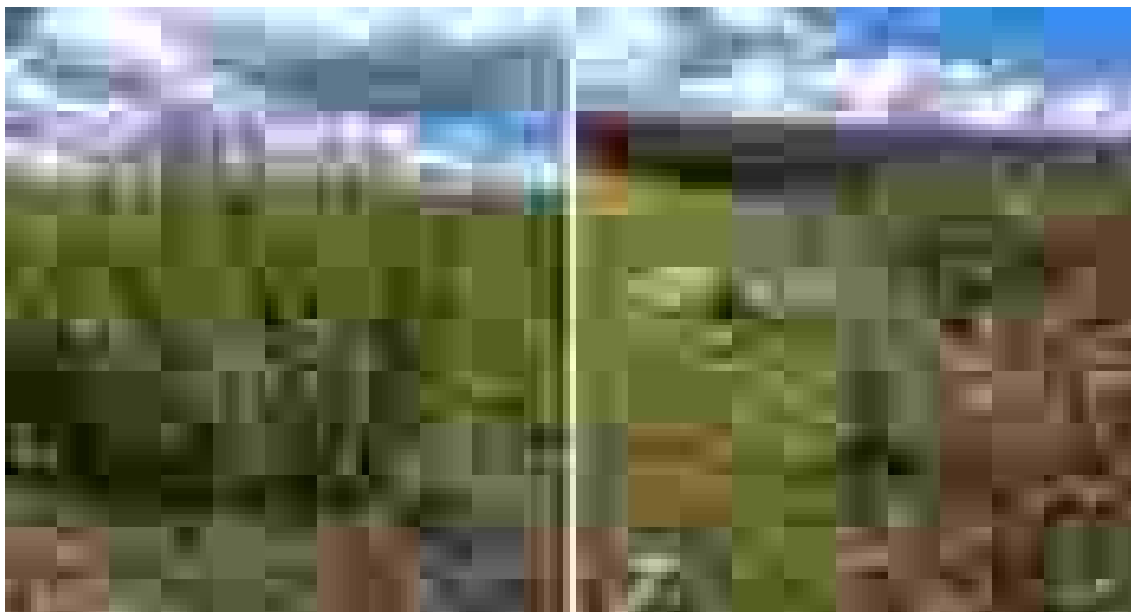


Plate 12: *Cirsium vulgare* (spear thistle)

iii. Species of Conservation Concern

One Kenyan endemic species, *Kenyacanthus ndorensis* (Plate 13), was recorded in Weru Ward, Karandi Sub-location. Additionally, species of conservation concern previously recorded in the ecosystem include *Prunus africana*, classified as Vulnerable on the IUCN Red List, and *Senecio pseudosubsessilis* listed as Endangered. Two infraspecific taxa endemic to the Eastern Africa region, *Dicliptera maculata* subsp. *usambarica* and *Impatiens meruensis* subsp. *cruciata*, were also recorded.



Plate 13: *Kenyacanthus ndorensis*

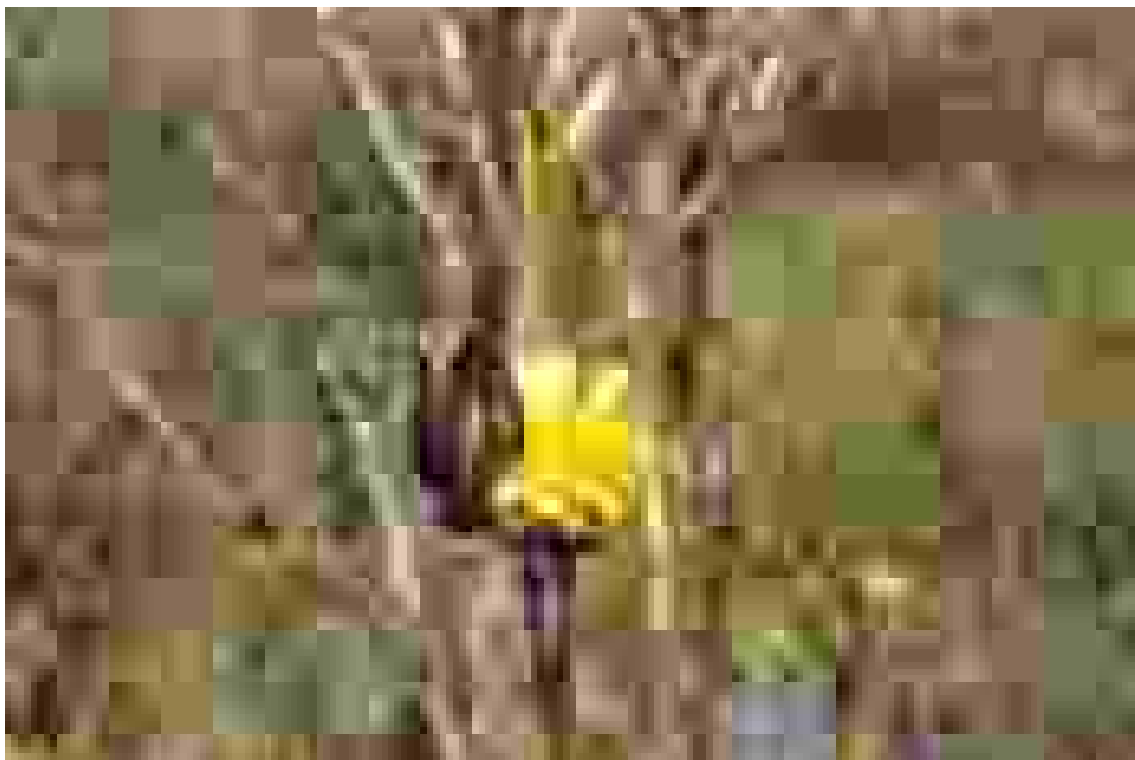
4.1.3 Conclusions and Recommendations

The Lake Ol Bolossat ecosystem is increasingly threatened by a range of anthropogenic pressures, notably population growth and the corresponding demand for agricultural land, and settlement expansion. These have led to illegal encroachment, overgrazing, and excessive water abstraction. Consequently, there is escalating degradation of the natural habitats, reduced water retention capacity, soil erosion, the spread of invasive species and pollution. These stressors are compounded by a rise in human-wildlife conflict.

Despite these challenges the Lake Ol Bolossat ecosystem and Satima Escarpment offer scenic landscapes with high potential to support sustainable livelihoods, such as ecotourism, high-altitude sports training, and recreational activities.

Recommendations

- Raise community awareness on the presence and ecological impact of invasive alien species and promote management strategies.
- Support local communities in developing alternative livelihoods such as ecotourism, high-altitude sports training, and nature-based enterprises.
- Delineate and protect ecosystem boundaries to prevent illegal encroachment and land conversion.
- Regulate livestock grazing to prevent overstocking beyond the ecosystem's carrying capacity and reduce competition with wildlife.
- Control water abstraction to maintain natural hydrological flow regimes and secure lake recharge.
- Prevent pollution by sensitizing communities against improper disposal of domestic waste and the runoff of agricultural chemicals into the lake.



Lactuca serriola



TAXA - FUNGI

By Mary N. Muchane
& Kelvin M. Waithaka

4.2 Taxa: Fungi

4.2.1 Introduction

Fungi are critical functional components of forested and wetland ecosystems, playing essential roles in sustaining ecosystem processes and supporting biodiversity. Understanding fungal diversity is therefore important for the sustainable management and restoration of functional ecosystems.

Macro-fungi, or mushrooms, are fungi species that produce visible fruiting bodies and extensive, though invisible, below ground mycelial networks (Chang & Miles, 1992). Globally, an estimated 3.8 million fungal species with about 150,000 macro-fungi are distributed across diverse ecosystems (Hawksworth & Lücking, 2017).

In their natural habitats, macro-fungal communities perform key ecological roles, including:

- Regulating nutrient cycling through decomposition of dead plant and animal material
- Supplying nutrients to plants
- Serving as food sources for insects, small mammals, and soil microbes (Ambrosio *et al.*, 2015)
- Beyond ecological functions, macro-fungi also contribute significantly to local livelihoods through:
 - Food provision
 - Income generation
 - Production of dyes, pharmaceuticals, organic acids, hormones, animal feeds, and beverages (Boa, 2014)

Importantly, macro-fungi are highly sensitive to environmental changes such as shifts in temperature, humidity, soil quality, and vegetation composition (Tibuhwa *et al.*, 2011). Their presence and diversity can thus serve as early indicators of ecosystem degradation, with declines in fungal communities often preceding plant community degradation by 5–10 years (Arnolds, 1991; Jakucs, 1988).

Similarly, Arbuscular Mycorrhizal Fungi (AMF), a major component of the soil microbial community, form symbiotic associations with the roots of over 80% of all plant species (Smith & Read, 2007). These fungi enhance nutrient and water uptake, increase resistance to root diseases, improve soil structure, and play a central role in sustaining plant community stability (Koide, 1991; Augé, 2001; Hart & Klironomos, 2002; Wilson *et al.*, 2009). Like macro-fungi, AMF are also sensitive to soil and habitat degradation and can serve as indicators of ecological stress. Knowledge of AMF diversity and functionality is particularly valuable for informing ecological restoration strategies, especially those involving indigenous tree species (Muchane *et al.*, 2012).

In light of these ecological and functional roles, this study aimed to assess the diversity of fungi within the riparian zones surrounding Lake Ol Bolossat. The primary goal was to document fungal diversity and explore their potential contributions to environmental and ecosystem services. The findings are intended

to inform the development of conservation strategies and promote sustainable livelihoods in the Lake Ol Bolossat ecosystem.

4.2.2 Fungal Diversity in Lake Ol Bolossat Ecosystem

The November 2023 field survey of macro-fungi in the Lake Ol Bolossat ecosystem recorded 176 species distributed across 65 genera and 30 families, all within the division Basidiomycota. Of these, 175 species belonged to the class Agaricomycetes, and one species was assigned to the class Dacrymycetes. Functionally, the macro-fungal community was dominated by humicolous species—those inhabiting humus-rich soils—accounting for 72% of all species (Figure 5, Plate 14, Table 8). Lignicolous fungi (wood-inhabiting) represented 14%, while litter dwellers, mycorrhizal species, coprophilous fungi (dung decomposers), and termite-cultivated fungi comprised 7%, 6%, 4%, and 0.3%, respectively.

Within Agaricomycetes, the order Agaricales exhibited the greatest family richness, with 20 families represented. Both Polyporales and Boletales contributed two families each, while Auriculariales, Geastrales, Hymenochaetales, Phallales, and Russulales were each represented by a single family.

The most species-rich family was Agaricaceae, with 68 species, followed by Bolbitiaceae (12), Tricholomataceae (10), Mycenaceae and Strophariaceae (9 each), Omphalotaceae (7), Marasmiaceae and Psathyrellaceae (6 each), and Hydnangiaceae (5). All remaining families had fewer than five recorded species (Figure 6, Appendix 2).

The observed dominance of humicolous taxa highlights the significance of decomposer fungi in nutrient cycling within the Ol Bolossat forest, wetland mosaic, suggesting a robust detrital food web and well-developed litter layer.

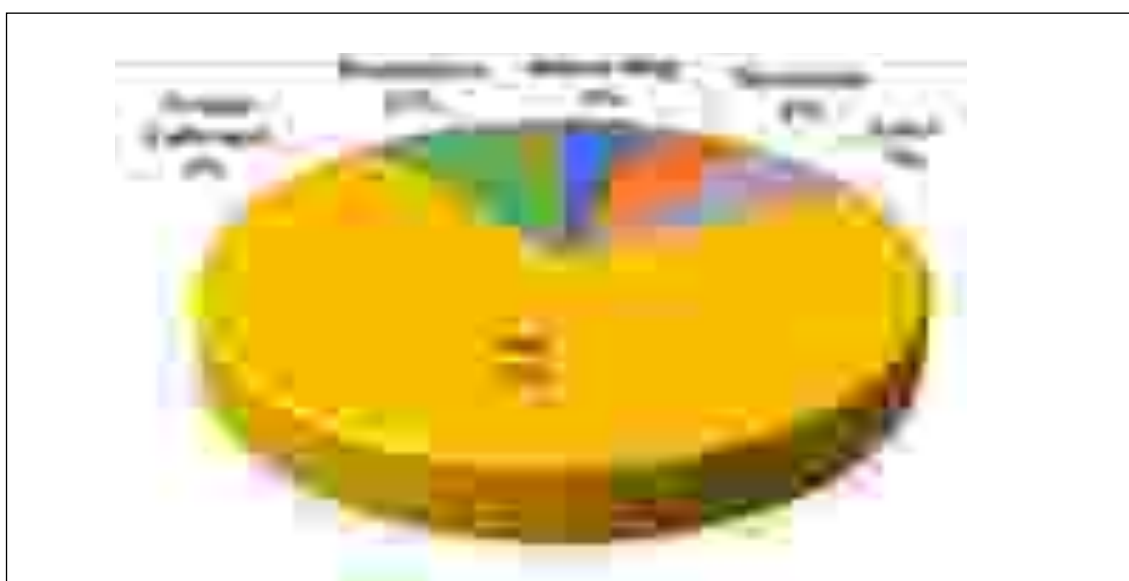


Figure 5: Quantitative distribution of macrofungi in the Lake Ol Bolossat based on substrate



Plate 14: Some macrofungi fruit bodies collected in Lake Ol Bolossat

Gymnopilus junonius (a), *Panaeolus antillarum* (b), *Stropharia* sp (c), *Calvatia cyathiformis* (d), *Pisolithus microcarpus* (e), *Clathrus columnatus* (f), *Lepsita nuda* (g), *Laccaria bicolor* (h), *Cyathus stercoreus* (i), *Favolaschia claudopus* (j) and *Stereum hirsutum* (k).

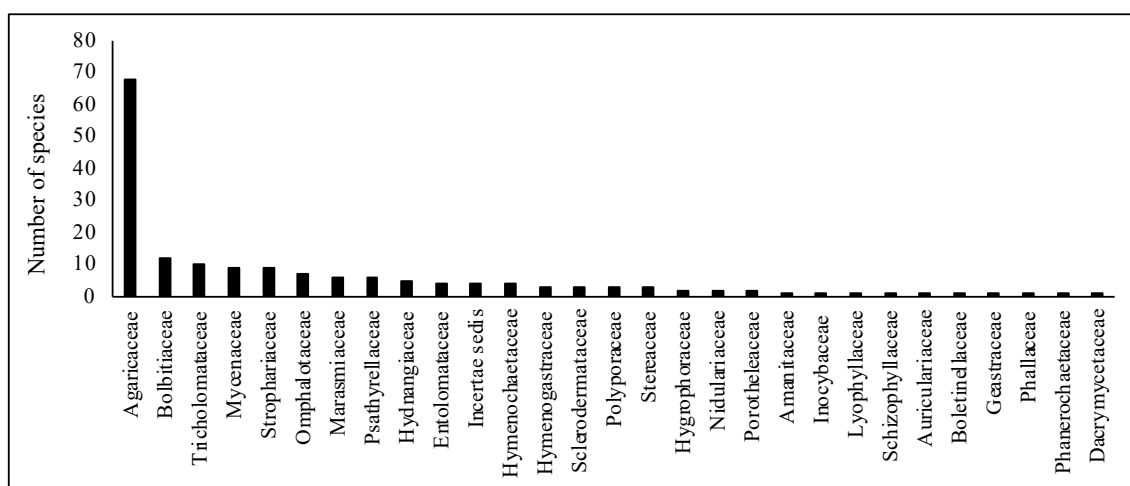


Figure 6: Quantitative distribution of macrofungi in the Lake Ol Bolossat ecosystem

4.2.3 Distribution of Macrofungi Diversity across Wards and Land Uses

We assessed macrofungi species distribution across the six wards and four common land uses. Overall, the ecosystem recorded a mean macrofungi species richness of 97.1 species and a mean density of 6.3 species per 50 × 50 m plot. Macrofungi species richness, density and diversity (based on Shannon's H and Simpson's 1-D indices) were relatively similar across the wards, although lower species numbers and densities were observed in Kiriita and Weru wards. In contrast, macrofungi richness, density, and diversity varied significantly among different land uses.

Natural forests supported the highest species richness and density, followed by natural grasslands and Eucalyptus plantations (Table 8). Although Eucalyptus plantations showed relatively high species density, they harbored fewer species overall compared to natural forests and grasslands. Farmlands and wetlands adjacent to the lake recorded the lowest species richness, density, and diversity.

Table 8: Macrofungi diversity in different wards and land uses in Lake Ol Bolossat

		Species	Diversity Indices			
		Richness	Density	Shannon (H)	Dominance (D)	Simpson (1-D)
		(2500 m ² plot area)				
Ward	Shamata	5.25	124.25	0.86	0.34	0.41
	Gatimu	5.25	119.63	0.80	0.37	0.38
	Central	6.63	108.38	1.14	0.34	0.53
	Rurii	7.50	88.25	1.02	0.55	0.45
	Weru	4.50	68.00	0.77	0.39	0.36
	Kiriita	3.13	68.00	0.70	0.36	0.39
	ANOVA	0.6 (0.69)	0.4 (0.88)	0.4 (0.84)	0.5 (0.74)	0.3 (0.89)
Land use	Forest	14.00a	104.83a	1.97a	0.24	0.77a
	Eucalyptus	6.50ab	198.42a	1.01a	0.51	0.50a
	Grassland	8.92a	115.00a	1.34a	0.42	0.58ab
	Farmland	4.08b	56.25b	0.68b	0.34	0.33bc
	Wetland	2.00b	14.67b	0.50b	0.30	0.28c
	ANOVA	6.6 (0.00)	6.8 (0.00)	6.6 (0.00)	1.4 (0.26)	6.5 (0.03)

Functional group distribution also varied by land use (Figure 7). Humicolous (humus-inhabiting) fungi dominated in grasslands, followed by natural forests and farmlands. Mycorrhizal species were recorded only in Eucalyptus plantations and farmlands, while no lignicolous (wood-decaying) fungi were documented in wetlands. Forests hosted the highest number of litter-dwelling fungi but lacked coprophilous (animal dung-inhabiting) fungi. Termite-cultivated fungi were recorded only in farmlands.

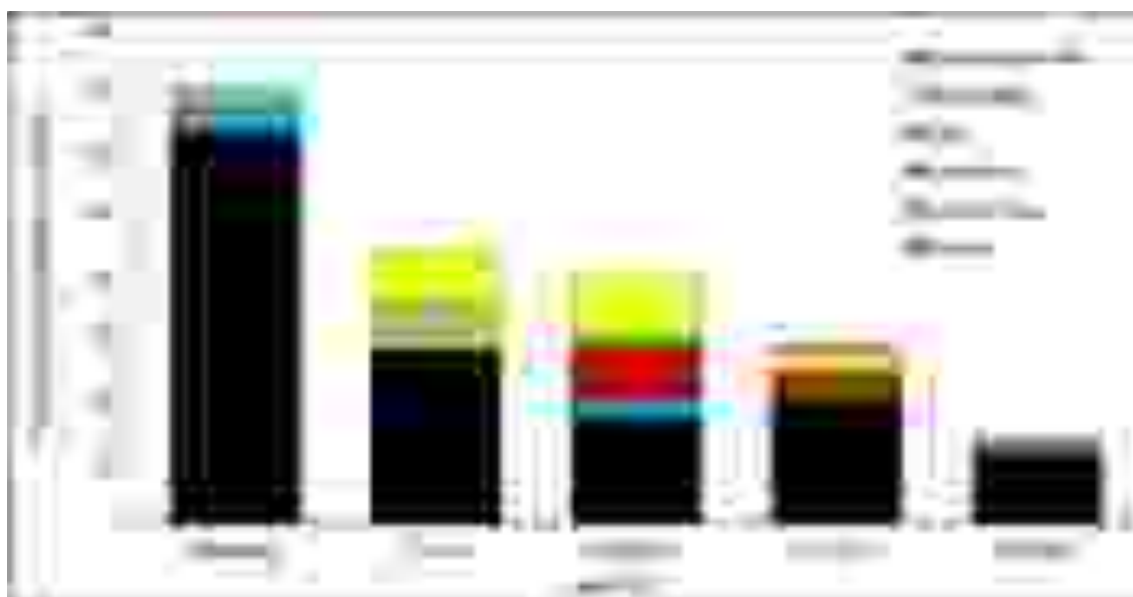


Figure 7: Quantitative distribution of macrofungi in land uses based on substrate

4 Arbuscular Mycorrhiza Fungi (AMF)

Based on spore morphology, a total of 42 AMF species belonging to five families and 13 genera were recorded (Figure 8, Plate 15, Table 9). Twenty AMF species were identified to species level, while 22 morphologically distinct but taxonomically unresolved morphotypes were also recognized. These unidentified species likely represent degraded or immature spores that could not be matched confidently to described taxa but were retained as separate morphotypes due to consistent morphological differences (Table 3).

The genus *Acaulospora* showed the highest spore abundance, accounting for 33% of the total spores, followed by *Scutellospora* and *Glomus*, each contributing 12%. Spore abundance among the remaining genera declined in the following order: *Diversispora* > *Funnelformis* > *Gigaspora* > *Claroideoglomus* > *Rhizophagus* > *Septoglomus* > *Centraspora* > *Dentiscutata* > *Racocetra* > *Sclerocystis* (Figure 8).

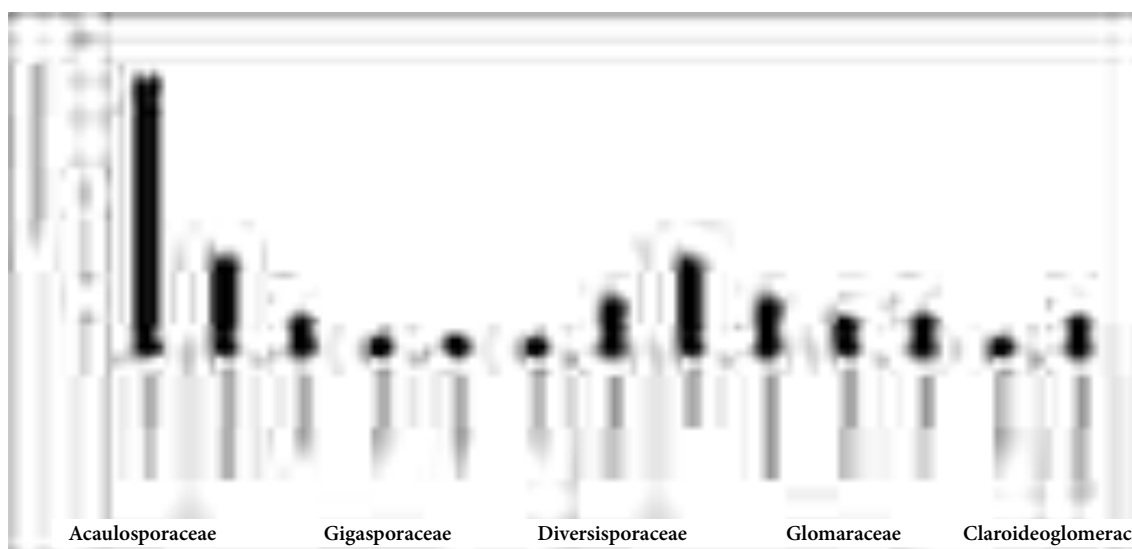


Figure 8: Distribution of Arbuscular mycorrhizal fungi genera in Lake Ol Bolossat Ecosystem



Plate 15: Selected Arbuscular mycorrhizal fungi (AMF) species documented in Lake Ol Bolossat Ecosystem.

Spores in a sample (a), *Acaulospora scrobiculata* (b), *Gigaspora decipiens* (c), *Claroideoglomus etunicatum* (d), *Acaulospora* sp (e), *Scutellospora calospora* (f), *Funnelformis geosporums* (g), *Acaulospra* sp (h) and *Acaulospora* sp (i).

Table 9: Arbuscular Mycorrhiza fungi in Lake Ol Bolossat

Family	Genus	Species	Shamata	Rurii	Central	Weru	Gatimu	Kiriita
			abundance in 50 g soil					
Acaulosporaceae	<i>Acaulospora</i>	<i>denticulata</i>	7.3	0.9	5.8	0.3	—	—
	<i>Acaulospora</i>	<i>excavata</i>	—	0.1	—	—	0.1	0.1
	<i>Acaulospora</i>	<i>herrerae</i>	0.9	0.3	0.1	—	—	—
	<i>Acaulospora</i>	<i>mellea</i>	0.8	0.3	0.4	0.1	—	0.1
	<i>Acaulospora</i>	<i>morrowiae</i>	1.3	0.6	0.4	0.4	0.5	0.1
	<i>Acaulospora</i>	<i>rhemii</i>	0.1	—	—	—	—	—
	<i>Acaulospora</i>	<i>scrobiculata</i>	—	0.1	0.1	—	—	—
	<i>Acaulospora</i>	<i>sp1 (Hyaline)</i>	0.1	—	—	—	—	—
	<i>Acaulospora</i>	<i>sp2 (Cream)</i>	16.9	25.9	8.0	18.0	35.6	16.8
	<i>Acaulospora</i>	<i>sp3 (Orange)</i>	3.3	1.5	2.6	—	—	—
	<i>Acaulospora</i>	<i>sp4 (Spined)</i>	1.0	0.6	0.5	—	0.4	0.1
	<i>Acaulospora</i>	<i>sp5 (Dark Brown)</i>	1.0	0.4	—	3.5	2.9	1.3
	<i>Acaulospora</i>	<i>sp6 (Cloudy)</i>	—	—	0.1	—	0.1	0.3
	<i>Acaulospora</i>	<i>sp7 (Yellow Orn)</i>	—	—	—	—	—	0.1
Diversisporaceae	<i>Diversispora</i>	<i>sp1 (Hyaline)</i>	—	0.4	0.1	—	0.3	—
	<i>Diversispora</i>	<i>sp2 (Hyaline Orn)</i>	—	—	7.5	—	—	—
	<i>Diversispora</i>	<i>spurca</i>	2.6	1.3	1.1	0.8	0.3	0.3
Gigasporaceae	<i>Centraspora</i>	<i>pellucida</i>	—	0.3	0.3	—	0.5	0.0
	<i>Dentiscutata</i>	<i>nigra</i>	—	—	—	—	0.1	0.1
	<i>Gigaspora</i>	<i>decepiens</i>	—	0.3	0.1	0.1	1.4	0.1
	<i>Gigaspora</i>	<i>margarita</i>	—	—	—	—	—	0.1
	<i>Racocetra</i>	<i>persica</i>	1.8	0.8	3.9	0.5	0.3	0.6
	<i>Scutellospora</i>	<i>calospora</i>	2.8	0.9	1.9	2.3	0.8	—
	<i>Scutellospora</i>	<i>scutata</i>	—	0.6	0.1	0.3	0.3	—
	<i>Scutellospora</i>	<i>sp1 (beaded)</i>	0.4	0.4	4.6	4.4	0.3	7.4
	<i>Scutellospora</i>	<i>sp2 (White)</i>	2.0	1.1	0.3	—	—	—
	<i>Scutellospora</i>	<i>sp3 (Hyaline)</i>	0.3	—	—	0.1	—	—
Claroideoglomeraceae	<i>Claroideoglossum</i>	<i>etunicatum</i>	1.9	4.1	5.5	0.8	3.6	5.5
	<i>Claroideoglossum</i>	<i>luteum</i>	—	—	0.1	—	—	—
Glomeraceae	<i>Funneliformis</i>	<i>geosporum</i>	6.3	3.4	1.6	2.5	0.1	0.9
	<i>Funneliformis</i>	<i>sp1</i>	—	0.1	—	—	—	—
	<i>Funneliformis</i>	<i>sp2 (Cream-brown)</i>	1.9	2.3	1.4	1.4	—	0.4
	<i>Glomus</i>	<i>hoi (spotted)</i>	1.8	0.8	0.5	0.6	0.3	1.1
	<i>Glomus</i>	<i>sp1 (Dark brown)</i>	0.3	—	0.1	0.1	—	—
	<i>Glomus</i>	<i>sp2 (Hyaline)</i>	5.6	7.0	6.1	0.4	0.9	0.1
	<i>Glomus</i>	<i>sp3</i>	0.1	0.3	0.3	0.1	0.1	0.4
	<i>Glomus</i>	<i>tetrastratosum</i>	—	—	0.3	0.1	0.3	0.1
	<i>Rhizophagus</i>	<i>sp1 (Dark brown)</i>	2.6	0.4	3.9	5.5	4.1	4.4
	<i>Rhizophagus</i>	<i>sp3 (Hyaline)</i>	2.1	2.6	0.4	—	1.3	0.5
	<i>Sclerocystis</i>	<i>sp1</i>	0.1	0.1	—	—	0.1	—
	<i>Septoglossum</i>	<i>sp1</i>	0.1	—	—	—	—	—
	<i>Septoglossum</i>	<i>sp2 (Hyaline)</i>	2.9	0.4	4.5	1.6	0.3	0.5

4.2.4 Distribution of AMF across Different Wards and Land Uses

We examined the distribution of arbuscular mycorrhizal fungi (AMF) across six wards surrounding Lake Ol Bolossat and across five dominant land-use types practiced by the local community. Species richness and abundance per 50 g of soil were comparable across the six wards, with the highest mean species richness observed in Rurii (11.3 species), Central (11.0), and Shamata (10.5). However, differences among wards were not statistically significant (ANOVA, $p = 0.16$ for richness, $p = 0.83$ for abundance).

Diversity indices, on the other hand, revealed more nuanced variation. Shamata and Central recorded the highest Shannon diversity ($H = 1.8$) and Simpson's index values ($1-D = 0.8$), indicating greater species evenness. In contrast, Kiriita exhibited the lowest diversity ($H = 1.2$, $1-D = 0.5$) and the highest dominance index ($D = 0.5$), suggesting its community was more skewed toward a few dominant species. Differences in diversity were statistically significant across wards (ANOVA, $p = 0.04$ for D , H , and $1-D$), with post-hoc comparisons indicating that Shamata and Central were significantly more diverse than Kiriita and Gatimu.

Across land-use types, AMF richness and abundance showed no statistically significant variation (ANOVA, $p > 0.3$ for all variables). However, natural forests recorded the lowest AMF richness (6.0 species) and abundance (15.3 spores), possibly due to limited disturbance and lower host density. Interestingly, although not statistically significant, the forest had the highest Simpson's index ($1-D = 0.8$), indicating a relatively even AMF community structure. Overall, while land use appeared to have minimal effect on AMF richness and diversity, spatial variation across wards revealed significant differences in community structure. These findings suggest that localised environmental or edaphic factors at the ward level may influence AMF diversity more than broad land-use categories.

Table 10: AMF diversity in different wards and land uses in Lake Ol Bolossat

		Species Richness	Abundance	Diversity Indices Dominance (D) Shannon (H) Simpson (1-D) 50 g soil		
Ward	Shamata	10.5	679	0.2c	1.8a	0.8a
	Rurii	11.3	579	0.3bc	1.6a	0.7ac
	Central	11.0	62.5	0.2c	1.8a	0.8a
	Weru	7.8	43.8	0.3bc	1.5b	0.7ac
	Gatimu	7.6	54.6	0.4ab	1.3bc	0.6b
	Kiriita	7.3	42.0	0.5a	1.2c	0.5c
	ANOVA	1.8 (0.16)	0.4 (0.83)	2.6 (0.04)	2.5 (0.04)	2.5 (0.04)
Land Use	Wetland	9.4	59.0	0.3	1.6	0.7
	Grassland	9.6	51.3	0.3	1.6	0.7
	Eucalyptus	8.2	53.4	0.3	1.5	0.7
	Farmland	9.8	55.3	0.4	1.5	0.6
	Forest	6.0	15.3	0.2	1.6	0.8
	ANOVA	1.1 (0.36)	1.2 (0.31)	0.4 (0.81)	0.1 (0.98)	0.4 (0.80)

4.2.5 Status of Fungi in Lake Ol Bolossat

A comprehensive review of the literature identified 96 fungal species previously recorded in the Lake Ol Bolossat ecosystem. These species spanned 74 genera, 54 families, and six taxonomic divisions: Ascomycota, Basidiomycota, Glomeromycota, Chytridiomycota, Zygomycota, and an unclassified group (*incertae sedis*). The data were compiled from three primary studies (Appendix 3).

In contrast, the present field survey recorded 218 fungal species, distributed across 78 genera, 35 families, and two divisions, Basidiomycota and Glomeromycota. Combined, the total known fungal richness in the Lake Ol Bolossat ecosystem now stands at 278 species across 121 genera and 63 families.

The fungal community was overwhelmingly dominated by the division Basidiomycota, comprising 211 species from 46 families and 89 genera (Figure 6; Appendix 2). The family Agaricaceae was the most species-rich, contributing 64 species, followed by Bolbitiaceae and Tricholomataceae, each with 10 species. All other families had nine or fewer species.

Within the division Glomeromycota, the highest species representation was observed in the family Acaulosporaceae (16 species), followed by Gigasporaceae (13) and Glomeraceae (12). Other families contributed fewer than five species each (Figure 9a).

The division Ascomycota accounted for 10 species, belonging to five families and nine genera. Among these, Xylariaceae was the most represented family (4 species), followed by Onygenaceae and Saccharomycetaceae, with two species each. The division Chytridiomycota included five families—Halomycetaceae, Spizellomycetaceae, Lobulomycetaceae, Powellomycetaceae, and Rhizophlyctidaceae each, represented by no more than two species. The division Zygomycota was represented by two families: Endogonaceae and Mortierellaceae. One family, Olpidiaceae, could not be assigned to any recognized division and is therefore considered *incertae sedis*.

a



b



Figure 9: Status of fungi in Lake Ol Bolossat Ecosystems.

Notably, the survey recorded 141 macrofungi and 25 AMF species as first records for this ecosystem. Among these is the rare *Myriostoma cf. coliforme* (Plate 16), a member of the family Geastraceae, which is currently listed as Critically Endangered in Britain.



Plate 16: First record of *Myriostoma cf. coliforme* in Lake Ol Bolossat, Kenya

Myriostoma cf. coliforme, collected in rich leaf-litter-rich soil in mixed Chaparungu woodland, a natural forest remnant in Lake Ol Bolossat. The species is currently red-listed as endangered in Britain.

4.2.6 Discussion

Fungal communities are key drivers of ecosystem processes, indicators of ecosystem health, and play critical roles in carbon cycling, decomposition, plant growth facilitation, and the regulation of microbial interactions. This study assessed the current status of fungal diversity within the Lake Ol Bolossat ecosystem, a critical yet understudied wetland in Central Kenya.

Although Lake Ol Bolossat is an important wetland in Central Kenya, supporting the livelihoods of over two million people and hosting several endangered species, data on its fungal diversity remains scarce. To date, only three studies have been conducted on fungal diversity in this ecosystem (Terer *et al.*, 2019; Muchane *et al.*, 2021; Kiama, 2022). One study (Kiama, 2022) focused on fungal propagules isolated from lake sediments, which likely represent both indigenous fungal communities and those introduced via erosion. The other two studies, conducted during the dry season, documented limited macro- and microfungal diversity (Terer *et al.*, 2019; Muchane *et al.*, 2021).

Fungal Richness Revealed through Field Survey and Literature Review

Our combined field survey and literature review revealed substantial fungal diversity in the Lake Ol Bolossat ecosystem. Literature review identified 96 fungal species across 74 genera, 54 families, and six divisions (Ascomycota, Basidiomycota, Glomeromycota, Chytridiomycota, Zygomycota, and incertae sedis). In contrast, the field survey documented 218 species in 78 genera, 35 families, and two divisions (Basidiomycota and Glomeromycota).

Our field survey recorded a significant increase in macrofungi species compared to earlier studies, which had identified fewer than 50 macrofungi species and fewer than 20 AMF species (Muchane *et al.*, 2021). This increase is largely attributed to the timing of sampling, which coincided with the rainy season, an optimal period for the fruiting of humicolous (humus-dwelling) macrofungi (Packham *et al.*, 2002). However, this timing likely excluded mid- and late-season fruiting species.

The fungal community was dominated by humicolous species, with members of the families Agaricaceae and Bolbitiaceae being the most represented. Genera such as *Agaricus*, *Chlorophyllum*, *Lepiota*, *Macrolepiota*, and *puffballs* (*Lycoperdon*, *Bovista*, and *Clavatia*) were common, primarily occurring in humus-rich forest soils, grasslands, and exotic tree plantations. Notably, *Lepiota* species were largely restricted to natural forests, emphasizing the importance of habitat heterogeneity for sustaining fungal diversity. Richness of Agaricales and dominance of Agaricaceae is ecologically typical in moist, humus-rich tropical or sub-montane forest ecosystems. This dominance pattern mirrors findings from other East African highland ecosystems, where Agaricales typically flourish in moist, shaded microhabitats with abundant leaf litter. Presence of humicolous species in wetland ecosystem plays vital role in nutrient cycling, supporting plant growth and maintaining water quality.

Unexpected Patterns in Fungal Functional Groups

Contrary to expectations and previous findings (Muchane *et al.*, 2021), relatively few wood-rotting fungi (e.g., from the Polyporaceae and Stereaceae families) was observed. This discrepancy may stem from seasonal variation: wood-rot fungi are more prevalent during drier periods, while humicolous fungi, being ephemeral with life spans under 20 days, thrive in wetter conditions.

Surprisingly, only one species of termite-cultivated fungus (*Termitomyces*) was documented in farmland, whereas earlier studies reported several species with high densities in both farmland and grasslands. This could be due to insufficient rainfall at the time of sampling as many *Termitomyces* species require at least 12 mm of rainfall per season for fruiting. These findings highlight the need for long-term, seasonally continuous monitoring to capture temporal variation in fungal communities.

Ectomycorrhizal (ECM) fungi were more abundant than anticipated, particularly in Eucalyptus and *Acacia mearnsii* plantations. *Laccaria* was the dominant genus, followed by *Tricholoma*, *Inocybe*, *Scleroderma*, and *Pisolithus*. These fungi likely benefit from the stable litter and root environments in these plantations.

High Diversity of Arbuscular Mycorrhizal Fungi (AMF)

The study recorded high AMF diversity, 42 species, across various habitats and land uses. The AMF community was dominated by members of the Acaulosporaceae family, consistent with earlier studies in Kenyan ecosystems (Mathimaran *et al.*, 2007; Muchane *et al.*, 2012). Their dominance may be linked to acidic soils with low organic matter, as previously reported pH values of 5.5 to 5.8 are known to promote their sporulation.

Interestingly, Gigasporaceae spores were more abundant in undisturbed grasslands and Eucalyptus stands compared to farmlands, indicating that minimal soil disturbance supports these taxa, in line with findings by Jansa *et al.*, (2002).

Notable Findings and Conservation Implications

Our study adds 141 previously undocumented macrofungi and about 25 AMF species to the known fungal inventory of Lake Ol Bolossat. Of particular note is the documentation of a rare *Myriostoma cf. coliforme* (family Geastraceae) specimen collected in mixed Chaparungu woodland. This species, listed as critically endangered in Britain, has not been previously recorded in Kenya. Its discovery underscores the potential loss of undocumented fungal diversity due to ongoing habitat degradation.

Natural forests and grasslands supported the highest macrofungi species richness and diversity, likely due to favorable microclimatic conditions (e.g., humidity, temperature), low human disturbance, and abundant organic substrates. Although these remnants are degraded, evidenced by logging for charcoal and firewood, they still harbor significant fungal biodiversity and merit urgent conservation.

Species density was highest in Eucalyptus plantations, possibly due to the dominance of *Laccaria* spp., indicating that even exotic plantations can temporarily support diverse fungal communities depending on the season (Muchane *et al.*, 2021). However, conversion of natural riparian areas to Eucalyptus or agricultural land results in a loss of 28–37% of macrofungi species and associated ecosystem services.

In contrast to macrofungi, AMF species richness did not vary significantly across land use types, possibly due to the timing of sampling. AMF spore production typically increases under dry conditions at the end of the rainy season. Further seasonal monitoring is needed to validate these patterns.

Anthropogenic Impacts on Fungal Diversity

Both macrofungi and AMF diversity were notably lower in areas near urban centers such as Kiriita and Gatimu (Nyandarua County), compared to more remote sites like Shamata, Rurii, and Central. Anthropogenic pressures, including infrastructure development, urbanization, quarrying, and pollution, likely contribute to habitat degradation and reduced fungal diversity. Additional threats include agricultural encroachment and land subdivision into small plots. Given the sensitivity of fungi to such anthropogenic pressures, these results highlight the need for eco-friendly measures to protect the remaining fungal diversity.

4.2.7 Conclusion and Recommendations

This study reveals that the Lake Ol Bolossat ecosystem supports a highly diverse fungal community, including many species previously undocumented in the region and potentially new to Kenya. Our survey recorded a fourfold increase in fungal diversity compared to previous studies, underscoring the importance of seasonal timing and comprehensive sampling in fungal biodiversity assessments.

Despite significant ecological degradation of Lake Ol Bolossat, the remaining natural forests and grasslands continue to harbor high fungal species richness and diversity. These habitats, particularly rich in members of the Agaricaceae and Bolbitiaceae families, offer critical ecological refuges and may serve as important baselines for re-establishing the original macro- and micro-fungal communities of the region.



TAXA - AMPHIBIANS & REPTILES

By Vincent Muchai
& Howard Atubwa

4.3 Taxa: Reptiles and Amphibians

4.3.1 Introduction

Flora and fauna occupy diverse habitats across the world, with distribution largely influenced by their physiological requirements. Some species inhabit aquatic ecosystems, such as oceans and freshwater systems, while others are found in drylands (e.g., deserts, forests, and highlands) or cold and icy regions. Amphibians and reptiles (collectively referred to as herpetofauna) are especially sensitive to environmental temperatures due to their ectothermic nature, relying on external sources of heat to regulate body temperature. Consequently, their distribution is strongly shaped by ecological factors such as climate, vegetation cover, elevation, human activities, and land management practices (Ndiritu *et al.*, 2021; Ngwava *et al.*, 2021; Eustace *et al.*, 2021; Malonza *et al.*, 2018). In Kenya, highland and montane ecosystems typically support fewer herpetofaunal assemblages compared to the warmer lowlands (Malonza, 2015; Ngwava *et al.*, 2021; Malonza *et al.*, 2011). This variation is attributed to the thermal and habitat preferences of many herpetofaunal species.

Amphibians and reptiles serve as effective bioindicators of ecosystem health, largely due to their biology and behavioral ecology. Their limited mobility, habitat specificity, and reproductive cycles make them highly sensitive to environmental changes. Notably, many amphibians exhibit a biphasic lifestyle, with aquatic larval stages and terrestrial adult stages. This dual dependence on aquatic and terrestrial habitats makes them particularly responsive to changes in water flow and habitat quality, often in ways distinct from fully aquatic organisms such as fish (Eskew *et al.*, 2012). Kenya is home to approximately 408 herpetofauna species. This diversity includes 120 amphibians, 140 lizards, 140 snakes, 5 marine turtles, 4 tortoises, 6 terrapins, and 1 crocodile (Malonza & Bwong, 2023; Herpetology Collection Database, 2023). These species inhabit a wide range of ecosystems—from mountaintops to coastal marine habitats.

Among Kenya's freshwater systems, Lake Ol Bolossat stands out as the only lake in Central Kenya. Lakes play a critical role in supporting herpetofauna by offering breeding grounds, feeding sites, and refuge habitats. These ecosystems form vital nodes in the food web for amphibians, reptiles, and other organisms. However, increasing anthropogenic pressures threaten the ecological integrity of Kenya's lakes. These threats include extraction for domestic and irrigation purposes, agricultural encroachment, siltation, and pollution. Specifically, lake systems face degradation from human waste, chemical contamination from pesticides and herbicides, and nutrient overload from fertilizer-laden runoff. These cumulative pressures jeopardize herpetofaunal populations and the broader ecological communities they support.

4.3.2 Study Site

The study area was divided into six sampling sites based on administrative wards. These were Shamata, Rurii, Central, Weru, Gatimu, and Kiriita. Surveys were conducted in the surroundings of each site, with sampling done in all directions from a central starting point. The study took place at the onset of the wet season,

following a prolonged dry spell. During the survey, water levels in the lake were rising, although aquatic vegetation—particularly species such as water lilies that are crucial for amphibian breeding and feeding—was sparse. The grass tussocks surrounding the lake had been heavily grazed during the dry season and were in the early stages of regrowth at the time of data collection.

The following is a brief description of the study sites based on conditions during the survey period. This description is specific to habitat characteristics relevant to herpetofaunal ecology. For a detailed account of plant species composition, refer to the accompanying Plant report (Chapter 4.1).

Rurii and Weru

These two sites are presented together due to their similar ecological characteristics, with only minor differences. Both locations featured grass tussocks on higher ground and emergent aquatic vegetation—such as regenerating grasses and creeping water plants—at lower elevations near the lake. Water levels on this side of the lake were higher compared to the Shamata, Gatimu, and Central sites (see Plate 17). Amphibians were encountered in a variety of microhabitats including small holes, water channels, beneath stones on fences, and among plants at the lake's edge. Reptiles were found on anthills, within dried bogs, along fences, and in burrows. Notably, two specimens of the Kenyan Skaapsteker (*Psammophylax multisquamis*) were discovered trapped in an abandoned well in Weru with no apparent means of escape. Their exit was facilitated by placing branches and vegetation into the well to create escape routes.

Shamata

This site was characterized predominantly by expansive grasslands interspersed with invasive plant species reaching heights of up to 2 meters. Surface water was mostly confined to narrow channels, small streams, puddles, and isolated wells, with the main lake water restricted to the central basin area. Agricultural activity, including wheat cultivation and eucalyptus plantations, was observed near the lake margins. Herpetofauna in Shamata were observed in reeds, water channels, burrows, and under overturned soil clumps. Unlike other sites, emergent aquatic vegetation was largely absent, with only grass found within the shallow water areas.

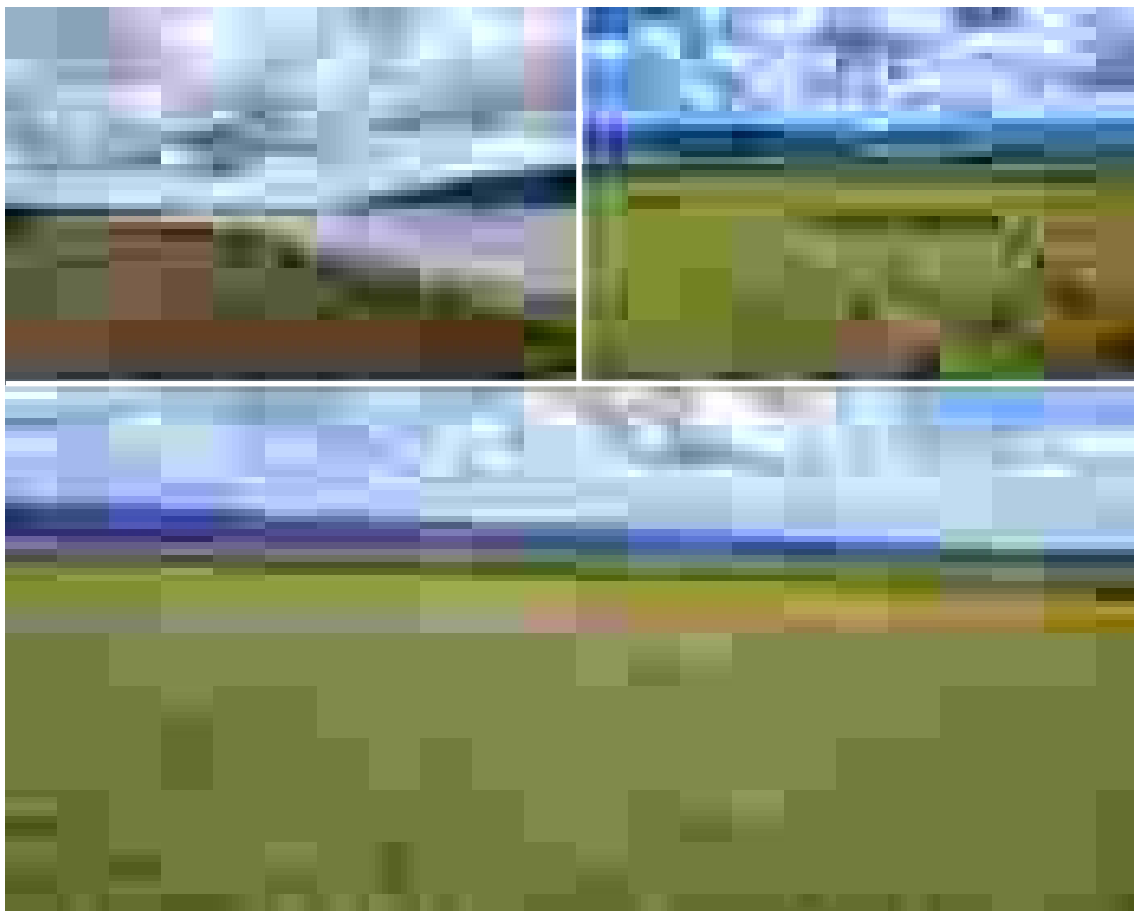


Plate 17: Areas formerly occupied the Lake left to right to bottom: Low water Levels at 'Ground zero' and grasses in the front and invasive weeds in the background.

Kiriita

This area contained deeper water bodies compared to other sites, although these were largely restricted to the center of the lake. The surrounding area includes residential estates, with houses constructed in close proximity to the lake edge. A water abstraction point supplying county residents was also present. The Manguo section of the lake, located toward one end, hosted ideal habitats for amphibians and reptiles, owing to the presence of reeds, aquatic vegetation, and bushy cover. Herpetofauna were observed utilizing a variety of microhabitats, including young white eucalyptus trees, bottle brush (*Callistemon* spp.) trees, reeds, aquatic plants, puddles, and the lake banks.

Central

This area was dominated by grasses, with water restricted to narrow, stream-like channels. Parasitic plants (refer to chapter 4.1 and 4.2) were observed growing extensively across the landscape, although aquatic plants and grasses were generally sparse. White eucalyptus trees were planted across most land parcels surrounding the site. White eucalyptus trees decompose much more slowly than other vegetation, affecting amphibians—especially in the tadpole stage as they reduce the amount of dissolved oxygen. Eucalyptus is also not a preferred plant for reed frogs to perch on or lay eggs, likely due to the toxic oils they release, their poor structure as hiding spots, and their impact on water chemistry. These factors

collectively make eucalyptus-dominated habitats less suitable for amphibian life. Eucalyptus also creates a uniform distribution of which attracts fewer species of insects thereby not a preferred vegetation type. Herpetofauna were recorded in a range of microhabitats including water channels, grassy patches, soil holes, overturned boulders, under dried floating bogs, and on fence poles.

Gatimu

Much of the original lake basin at this site had been subdivided and converted to agricultural use. Wheat farming is the primary agricultural activity in the region—and the leading driver of pesticide use. This poses a significant threat to reptiles and amphibians, whose habitats and survival are increasingly compromised by chemical exposure and habitat degradation. The area was generally wet even after a prolonged dry period, with only a few spots lacking surface water. Amphibians and reptiles were observed in trees, within water bodies, and on soil boulders that had been overturned during cultivation. Deeper water was limited to a few localized sampling points.

4.3.3 Species Diversity and Abundance

A total of 52 time-limited searches (TLS) were conducted across the sites, with six of these conducted at night. Shamata and Kiriita each had 10 TLS, including two night searches per site. Rurii and Weru each had nine TLS, with one conducted at night in each location. Central and Gatimu had eight TLS each, none conducted at night due to safety concerns, particularly the presence of hippopotamuses and limited suitable night-time sampling habitats (Table 10 and 12).

Selected species of amphibians and reptiles encountered during surveys are illustrated in Plate 18 and 19. In total, 17 species were documented during the survey: nine amphibians and eight reptiles. Of these, 14 species (nine amphibians and five reptiles) were identified using the TLS method. An additional four reptile species were identified exclusively through interviews with local residents. The visual encounter survey method yielded records of 11 species—six amphibians and five reptiles (Table 12).

Species were most easily located in Shamata and Weru, while Central was the most difficult site for herpetofauna detection. The highest number of individuals was recorded in Shamata and Kiriita, with Central yielding the fewest observations (Table 11 and 12). Notably, *Hyperolius glandicolor* (Peter's reed frog) exhibited unusual habitat use, with individuals observed perching on eucalyptus, pine, and bottle brush trees (Plate 18), suggesting adaptive shifts in habitat utilization possibly driven by land cover change. In rare or degraded habitats where native vegetation is scarce, reed frogs may be observed near eucalyptus trees. However, this occurrence reflects a lack of suitable alternatives rather than a true habitat preference.

Table 11: Species yielded from different sampling methods in all the sites

Species	Common name	Rurii	Central	Weru	Gatimu	Kiriita	Shamata
<i>Agama lionotus</i>	Red-headed rock agama	-	-	VES	-	-	-
<i>Amietia nutti</i>	Nutt's river frog	-	-	-	-	TLS	-
<i>Boaedon fuliginosus</i>	Common house snake	VES	INT	-	-	-	INT
<i>Cacosternum kinangopensis</i>	Kinangop dainty frog	TLS; VES	-	TLS	TLS	-	-
<i>Hyperolius glandicolor</i>	Peter's reed frog	TLS; VES	-	TLS	TLS	VES; TLS	TLS
<i>Kassina senegalensis</i>	Bubbling kassina	TLS	-	TLS	-	-	TLS
<i>Lycophidion capense</i>	Cape wolf snake	-	INT	TLS	-	-	-
<i>Mertensophryne lonnbergi</i>	Lönberg's earless dwarf toad	-	-	-	-	-	TLS
<i>Philothamnus battersbyi</i>	Battersby's Green Snake	-	-	-	-	-	INT
<i>Phrynobatrachus kinangopensis</i>	Kinangop puddle frog	-	-	-	-	TLS; VES	TLS
<i>Ptychadena mahnerti</i>	Mahnert's ridged frog	TLS; VES	TLS	TLS	TLS	-	-
<i>Psammophylax multisquamis</i>	Kenyan striped skaapstekater	TLS; VES	INT	TLS; VES	VES	-	INT
<i>Sclerophrys kerinyagae</i>	Kirinyaga toad	TLS	TLS	TLS	TLS	-	TLS; VES
<i>Trachylepis striata</i>	Striped kink	-	TLS	TLS	-	TLS; VES	-
<i>Trachylepis varia</i>	Variable skink	TLS	-	-	-	-	-
<i>Trioceros hoehneli</i>	Von Höhnel's chameleon	-	-	-	VES	TLS; VES	-
<i>Xenopus borealis</i>	Northern clawed frog	-	VES	-	TLS	TLS; VES	T-LS

INT=Interview, TLS=Time Limited Searches and VES =Visual Encounter Survey

Two species were recorded for the first time in this study area: *Amietia nutti* (Nutt's river frog) and *Psammophylax multisquamis* (Kenyan striped skaapstekater). Although these species are known from the general region, this study provides the first confirmed records from the specific survey sites. The discovery of new species records in a given area plays a vital role in strengthening local biodiversity inventories and guiding effective conservation planning. Such findings contribute to a more accurate understanding of species richness and ecosystem composition, which is essential for identifying biodiversity hotspots and areas of endemism. New records can reveal the presence of rare, threatened, or previously unrecorded species, prompting targeted conservation actions and habitat protection. This information also supports informed land use decisions by ensuring that development projects consider sensitive ecological areas. Additionally, tracking new species occurrences enhances our understanding of ecosystem health, species distribution shifts, and ecological interactions, especially in the face of climate change and habitat degradation. Beyond science, these discoveries can foster community engagement, inspire citizen science initiatives, and promote collaboration among researchers, conservationists, and policy makers—ultimately contributing to more sustainable environmental stewardship.

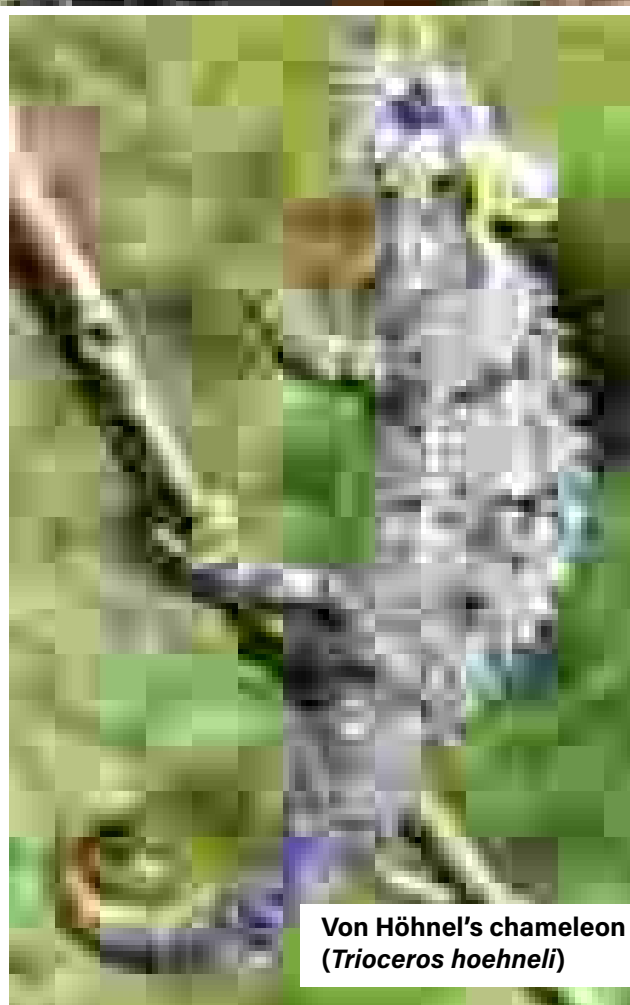


Plate 18: Reptiles recorded during the study.



Plate 19: Frogs recorded during the study left to right to bottom

Bubbling kassina (*Kassina senegalensis*), Kinangop puddle frog (*Phrynobatrachus kinangopensis*), Nutti's river frog (*Amietia nutti*), two colour morphs of common reed frog (*Hyperolius glandicolor*) and Kinangop dainty frog (*Cacosternum kinangopensis*).

Table 12: Species diversity, abundances, and sampling efforts recorded through Time-Limited Searches (TLS) across the six study sites

Type	Number of TLS	Species name	Common name	Shamata	Rurii	Central	Weru	Gatimu	Kiriita
Amphibian		<i>Cacosternum kinangopensis</i>	Kinangop dainty frog	10	9	8	9	8	10
Amphibian		<i>Ptychadena mahnerti</i>	Mahnert's ridged frog	107	41	0	40	19	91
Amphibian		<i>Mertensophryne lonnbergi</i>	Lönberg's earless dwarf toad	165	41	82	39	93	107
Amphibian		<i>Sclerophrys kerinyagae</i>	Kirinyaga toad	1	0	0	0	0	0
Amphibian		<i>Kassina senegalensis</i>	Bubbling kassina	5	2	5	2	1	0
Amphibian		<i>Phrynobatrachus kinangopensis</i>	Kinangop puddle frog	7	27	0	26	0	0
Reptile		<i>Trachylepis striata</i>	Striped kink	21	0	0	0	0	2
Amphibian		<i>Xenopus borealis</i>	Northern clawed frog	1	0	12	1	0	3
Amphibian		<i>Hyperolius glandicolor</i>	Bubbling kassina	1	0	0	0	2	0
Reptile		<i>Trachylepis varia</i>	Variable skink	60	80	0	83	2	140
Reptile		<i>Lycophidion capense</i>	Cape wolf snake	0	3	0	0	0	0
Reptile		<i>Psammophylax multisquamis</i>	Kenyan striped skaapskater	0	0	0	1	0	0
Amphibian		<i>Amietia nutti</i>	Nutt's river frog	0	0	0	2	0	0
Reptile		<i>Trioceros hoehnelti</i>	Von Höhnelt's chameleon	0	0	0	0	0	1
		Species diversity		0	0	0	0	0	1
		Species abundance		9	6	3	8	5	7
		Species sampling effort index		368	194	99	194	117	345
		Specimen sampling effort index		0.90	0.67	0.38	0.89	0.63	0.70
				368	32.3	1238	2157	13	34.5

Species Accumulation Over Time

More species were recorded as more time was spent sampling using the Time-Limited Searches method. However, the species accumulation curves did not plateau, as shown in Figure 10, indicating that additional species could likely be found with extended sampling effort. Data presented in Appendix 4 further supports this, showing that not all species historically known from the area were encountered during the survey.

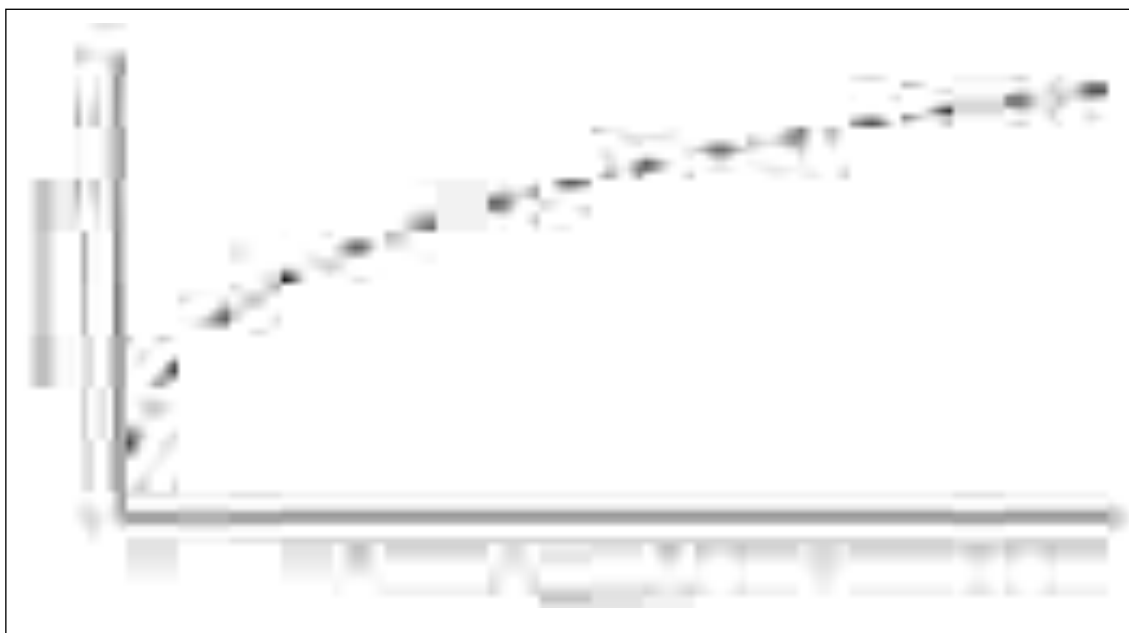


Figure 10: Species accumulation curves for the Time Limited Searches in Lake Ol Bolossat

4.3.4 Species of Conservation Concern

Based on data compiled from published literature, species checklists, and conservation databases, eight species of conservation concern were identified in the area (Table 13). These include both amphibians and reptiles of national and global conservation interest:

***i. Agama caudospinosa* (Spiny-tailed rock agama)**

A diurnal rock agama endemic to Central Kenya, typically found on rock slabs and in crevices, living in colonies led by a dominant male. Although it was not recorded during this survey, its habitat preferences suggest it may occur in rocky areas like Central and Shamata. It is classified as Least Concern (IUCN).

***ii. Bitis worthingtoni* (Kenyan horned viper)**

This species is endemic to the Rift Valley and surrounding areas, including Ol Kalou, making its presence likely in habitats near the lake, such as Manguo (Kiriita), Weru, and Gatimu. Although not recorded during the survey, its known range and habitat preferences suggest potential occurrence. It is listed as Vulnerable (IUCN) and in Appendix II of CITES. Although this species was specifically targeted during sampling, it was not encountered in the study area. Its absence could be attributed to several factors, including seasonal variation in

activity, low population density, habitat degradation, or limitations in the sampling methods used.

iii. *Cacosternum kinangopensis* (Kinangop dainty frog)

A montane grassland species endemic to Central Kenya and the Rift Valley. Categorized as Least Concern (IUCN), it was recorded at all sites except Central Ward.

iv. *Hyperolius montanus* (Kenyan montane reed frog)

Endemic to high-altitude grasslands and moorlands of Central Kenya and the Rift Valley. Although not recorded during the survey, it may occur in Manguo (Kiriita), Weru, and Gatimu. It is categorized as Least Concern (IUCN).

v. *Mertensophryne lonnbergi* (Lönberg's earless dwarf toad)

A toad endemic to the Central Kenya Highlands, especially the Aberdares. It is categorized as Vulnerable (IUCN) and was recorded only in Shamata. This toad lacks a call, which may contribute to detection difficulty using acoustic methods.

vi. *Phrynobatrachus keniensis* (Kenyan puddle frog)

An endemic frog of Central Kenya and Rift Valley highlands, typically found in puddles, shallow streams, and wells. Although it was not recorded during this survey, suitable habitat exists in all the sites. It is categorized as Least Concern (IUCN).

vii. *Phrynobatrachus kinangopensis* (Kinangop puddle frog)

Endemic to montane grasslands of Central Kenya, this species was recorded in Kiriita and Shamata. It is categorized as Least Concern (IUCN).

viii. *Ptychadena mahnerti* (Mahnert's ridged frog)

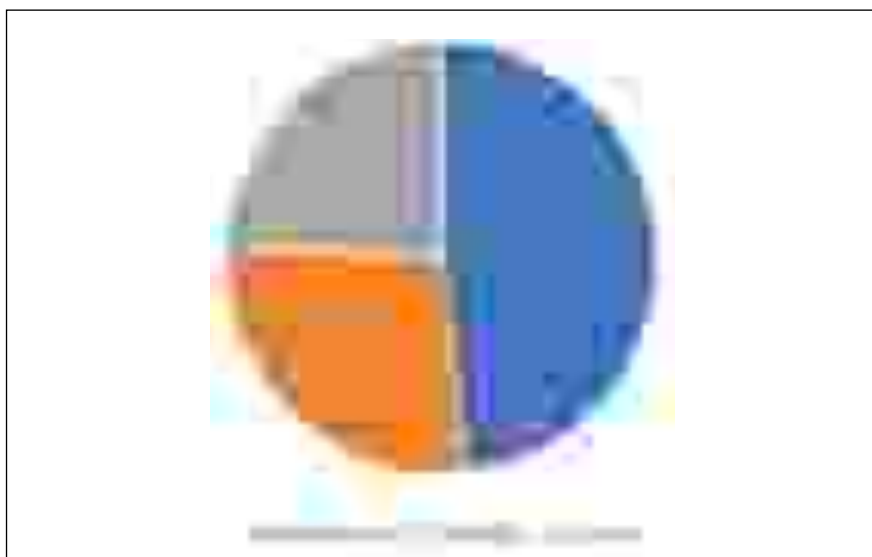
A Kenyan endemic found in moist savannahs and grasslands above 2000 m a.s.l., this species resembles *Ptychadena nilotica* (Nile ridged frog) but is smaller in size. It was found at all sampling points and is listed as Least Concern (IUCN). *Ptychadena mahnerti* is generally smaller in size, with smoother skin and less pronounced dorsal ridges compared to *P. nilotica*, which tends to be larger and more robust with clearly defined dorsal ridges and granular skin texture. The limb patterning in *P. nilotica* features bold dark crossbars, while *P. mahnerti* exhibits fainter markings. In terms of distribution, *P. mahnerti* is typically found in highland or montane regions, such as the central Kenyan highlands, often inhabiting grasslands and forest edges. In contrast, *P. nilotica* is more widespread in lowland areas, especially around wetlands and floodplains associated with the Nile Basin, and is more closely associated with aquatic environments.

Table 13: Summary of herpetofauna species of conservation Concern in Lake Ol Bolossat

Species name	Common name	Type	Conservation status
<i>Agama caudospinosa</i>	Spiny-tailed rock agama	Lizard	Kenyan Endemic; Least concern
<i>Bitis worthingtoni</i>	Kenyan horned viper	Snake	Kenyan Endemic; Vulnerable
<i>Cacosternum kinangopensis</i>	Kinangop dainty frog	Frog	Kenyan Endemic; Least concern
<i>Hyperolius montanus</i>	Kenyan montane reed frog	Frog	Kenyan Endemic; Least concern
<i>Mertensophryne lonnbergi</i>	Lönberg's earless dwarf toad	Frog	Kenyan Endemic; Vulnerable
<i>Phrynobatrachus keniensis</i>	Kenyan puddle frog	Frog	Kenyan Endemic; Least concern
<i>Phrynobatrachus kinangopensis</i>	Kinangop puddle frog	Frog	Kenyan Endemic; Vulnerable
<i>Ptychadena mahnerti</i>	Mahnert's ridged frog	Frog	Kenyan Endemic; Least concern

4.3.5 Species Checklist of Lake Ol Bolossat

Data collected from various books, checklists, databases, and during the field study indicate that a total of 29 species can be found in the area (Appendix 5). Of these, 17 species were confirmed during the sampling period, representing less than 60% of the expected species. Among these 17, four species were of conservation concern (Table 13 and Appendix 4). Frogs (amphibians) made up more than half of the recorded species, while lizards were the least represented group (Figure 11).

**Figure 11: Pie chart of the herpetofauna types recorded during the study period**

Voucher specimens were collected, curated, and deposited at the National Museums of Kenya. Specimens were curated following internationally accepted museum standards and in accordance with the legally recognized mandate of the National Museums of Kenya. Appendix 5 includes the unique museum specimen numbers assigned to the recorded specimens. A total of 31 specimens, 5 reptiles and 26 amphibians, were catalogued and referenced in the National Museums of Kenya's collection and database.

4.3.6 Threats to the Lake Ol Bolossat Herpetofauna Diversity

Grazing: This was very common in the area, to the point where grazing even occurred inside the lake. This practice destroys amphibian and reptile habitats, such as grasses and reeds (preferred by reed frogs), and the animals trample on herpetofauna eggs, particularly frog eggs, which are laid in water and vegetation.

Water abstraction: Streams that feed the lake are abstracted upstream to supply water to local communities, especially in Shamata and Central wards, where numerous unregulated water collection points exist. This reduces inflow into the lake, thereby lowering water levels. In Kiriita Ward, the County Government operates a large water abstraction point. While water provision is necessary, the lack of regulation and coordination could result in minimal or no water reaching the lake (Quote NEMA & Nyandarua County Government. (2020), Legal Notice No. 178 of 2018 & 42 of 2025).

Farming: Farming is widespread around the lake, with food crops such as wheat and maize being grown. Additionally, eucalyptus trees (e.g., *Eucalyptus globulus*, *E. camaldulensis*) are planted extensively for commercial purposes. Eucalyptus leaves decompose slowly and release allelopathic compounds that can alter soil chemistry and suppress native plant growth. Additionally, eucalyptus plantations reduce habitat quality for wetland-dependent species, disrupt hydrological balance, and lower overall biodiversity. These trees dry out wetlands and marshes, undermining the ecological function of the lake. Some eucalyptus species produce toxins that can negatively affect amphibians at both tadpole and adult stages. During land preparation, soil tilling accelerates evaporation by exposing the ground. While large boulders offer some refuge to amphibians and reptiles, the overall effect of farming is habitat and microhabitat degradation. To protect the ecological integrity of the lake, a buffer zone should be established around its perimeter where only indigenous tree species are planted. These native trees support local biodiversity, stabilize soils, and help maintain the natural hydrological balance. Once this protective buffer is in place and functional, the planting of exotic tree species—such as eucalyptus—can be considered at a safe distance beyond the buffer, ensuring they do not negatively impact the wetland ecosystem.

Pollution: through pesticides and human waste: As part of agricultural activity, inorganic fertilizers and pesticides are used. These substances negatively impact amphibians, particularly in their egg and tadpole stages. Amphibians have permeable skin, sometimes used for respiration, which readily absorbs chemicals and can lead to poisoning and death. The water at Thompson Falls was observed to smell of sewage, suggesting possible contamination or mixing of sewage and freshwater. A detailed water analysis report is in chapter 4.7.

Human settlement: In areas like Kiriita near Manguo, human settlement extends to the lake's edge. This reduces the lake's spatial extent and contributes to pollution from raw sewage and other toxins, as many estates lack proper waste disposal systems. Plastics, diapers, and polythene are often disposed of directly into the lake, further polluting it.



Plate 20: Farming and agro-chemical in the study area

Examples of threats to Lake Ol Bolossat's herpetofauna and habitat. From top left to bottom right: (1) wheat farming occurring adjacent to the lake margin, (2) pesticides commonly used in wheat cultivation, and (3) plantation of Eucalyptus species near the lake, with farming activities encroaching into the natural forest. These practices contribute to habitat degradation, pollution, and hydrological changes affecting amphibians and reptiles.

4.3.7 Discussion

Weather significantly influences herpetofaunal diversity and abundance. Amphibians are most active and breed prolifically during the rainy season, making them easier to detect. In contrast, reptiles are more commonly observed in sunny conditions as they bask to regulate their body temperature. This reflects the ectothermic nature of both groups, whose activity is closely tied to ambient temperatures (Malonza & Bwong, 2023; Channing & Howell, 2006; Duellman & Trueb, 1986).

The study was conducted at the onset of the rainy season following a prolonged drought that had desiccated Lake Ol bolossat, leaving some sections entirely dry. This event severely reduced suitable habitats and microhabitats, concentrating herpetofaunal activity in limited moist and vegetated zones. Amphibians were particularly affected due to their reliance on aquatic vegetation and moisture for breeding (Duellman & Trueb, 1986; Malonza & Bwong, 2023). Inadequate moisture can delay or prevent breeding, increase competition for limited breeding sites, and expose eggs and larvae to desiccation. As rainfall resumed and water levels rose, breeding habitats began to reform, though amphibian reproduction remained largely restricted to isolated wet areas, reducing overall species richness.

Most species showed a degree of habitat plasticity, likely in response to the limited availability of preferred environments. For example, Bubbling Kassina (*Kassina senegalensis*) was frequently found sheltering in ground holes rather than in its typical habitat of emergent aquatic grasses. This behavior likely reflects a drought-survival strategy, as individuals seek out moist microhabitats to avoid desiccation and maintain hydration (Wells, 2007; Duellman & Trueb, 1994). Such behavioral flexibility is critical for survival in harsh, changing environments.

Habitat-specialist species recorded during the survey included the Kenyan striped skaapskater (*Psammophylax multisquamis*), restricted to grasslands, and aquatic specialists such as the Northern clawed frog (*Xenopus borealis*) and Nutt's river frog (*Amietia nutti*). Notably, Peter's reed frog (*Hyperolius glandicolor*), which typically relies on floating aquatic vegetation like water lilies for perching and breeding, was observed using exotic tree species such as eucalyptus, pine, and bottle brush. This shift in behavior likely reflects habitat degradation and the loss of preferred vegetation due to drought. Although this adaptive strategy may offer short-term survival, it also suggests ecological stress and a decline in habitat quality (Wells, 2007; Harper *et al.*, 2010).

Sampling occurred at the peak of the rainy season, favoring the detection of amphibians over reptiles. Amphibians congregate in aquatic habitats during this period to breed, leading to higher observed numbers. However, amphibian distribution was not uniform across the study area. Some zones, with more permanent water bodies and aquatic vegetation like water lilies, supported greater amphibian abundance and diversity, while drier areas had fewer records.

The study recorded less than 60% of the known species from the area, and the species accumulation curve did not plateau, indicating that additional species would likely be detected with extended sampling. The timing of the study during the wet season inherently favored amphibian detection. Future surveys conducted during the dry season may yield a more comprehensive inventory by capturing reptile species and amphibians using different ecological strategies.

4.3.8 Conclusions and Recommendations

This study highlights the significant influence of seasonal weather patterns on the diversity, distribution, and behavior of amphibians and reptiles around

Lake Ol Bolossat. Amphibians were more abundant during the wet season due to increased water availability and aquatic vegetation essential for breeding. However, the preceding prolonged drought had restricted species to limited suitable habitats, prompting adaptive behaviors such as using exotic trees or terrestrial refuges, an indication of ecological stress. These shifts underline the importance of maintaining high-quality wetland habitats. Although a range of species was recorded, the species accumulation curve suggests under-sampling, indicating that more extensive, multi-seasonal surveys are needed. Conservation at Lake Ol Bolossat should focus on restoring native vegetation, managing water levels, and protecting critical breeding areas to support herpetofaunal resilience and biodiversity.

Recommendations

To obtain a more comprehensive understanding of herpetofauna diversity in the study area, a dry season survey is recommended. This will allow for better detection of reptiles, which are more visible during dry and sunny periods due to their reliance on external temperatures for thermoregulation.

Long-term monitoring of amphibian and reptile populations should be implemented to assess and quantify the effectiveness of any habitat restoration interventions. Because herpetofauna are highly sensitive to seasonal changes, monitoring should be designed with seasonality in mind to capture fluctuations in species abundance and distribution throughout the year. A list of selected herpetofauna species recommended for consistent sampling is provided in Table 14. An annual two season (dry and wet season study is necessary to capture and also compare species changes.

Table 14: List of herpetofauna species for monitoring

Species name	Common name	Type	Conservation status
<i>Phrynobatrachus kinangopensis</i>	Kinangop puddle frog	Amphibian	Terrestrial under stones holes and shallow water or puddles
<i>Cacosternum kinangopensis</i>	Kinangop dainty frog	Amphibian	Terrestrial under stones holes and shallow water or puddles
<i>Mertensophryne lonnbergi</i>	Lönberg's earless dwarf toad	Amphibian	Terrestrial on dry land or on dry banks
<i>Sclerophrys kerinyagae</i>	Kirinyaga toad	Amphibian	Terrestrial on dry land or on dry banks
<i>Amietia nutti</i>	Nutt's river frog	Amphibian	Fully aquatic but basks on river banks
<i>Psammophylax multisquamis</i>	Kenyan striped skaapsteker	Reptile	Grasses
<i>Trioceros hoehneli</i>	Von Höhnel's chameleon	Reptile	Arboreal on trees
<i>Trachylepis varia</i>	Variable skink	Reptile	On grasses
<i>Hyperolius glandicolor</i>	Peter's reed frog	Amphibians	Reed , banks or trees

It is critical that water abstraction from local sources be regulated to ensure sustained inflow to the lake system. Wells should be protected from destruction, and surrounding habitats, such as forest patches and shrublands, should be conserved, as they provide essential microhabitats and breeding grounds for herpetofauna. Combining all existing water projects around Lake Ol Bolossat into a single, well-coordinated mega project with robust monitoring systems would improve outcomes and simplify regulation. This integrated approach would enhance efficiency, ensure better resource use, and strengthen oversight compared to managing multiple fragmented initiatives. Achieving this will require concerted efforts, particularly from the Water Resources Authority (WRA), and the active empowerment and involvement of the local Water Resource Users Association (WRUA).

The landscape around the lake should be rehabilitated through reforestation efforts, using native species to complement well protection measures and improve overall habitat quality. A well-designed landscape restoration program should aim to replace exotic vegetation with native species. Native species (e.g. *Croton megalocarpus* (Croton), *Juniperus procera* (African pencil cedar), *Olea africana* (African wild olive) contribute to the formation of fast-decomposing ground litter, which creates suitable conditions for ground-dwelling amphibians and reptiles. In contrast, exotic species such as eucalyptus may inhibit undergrowth and reduce soil moisture retention.

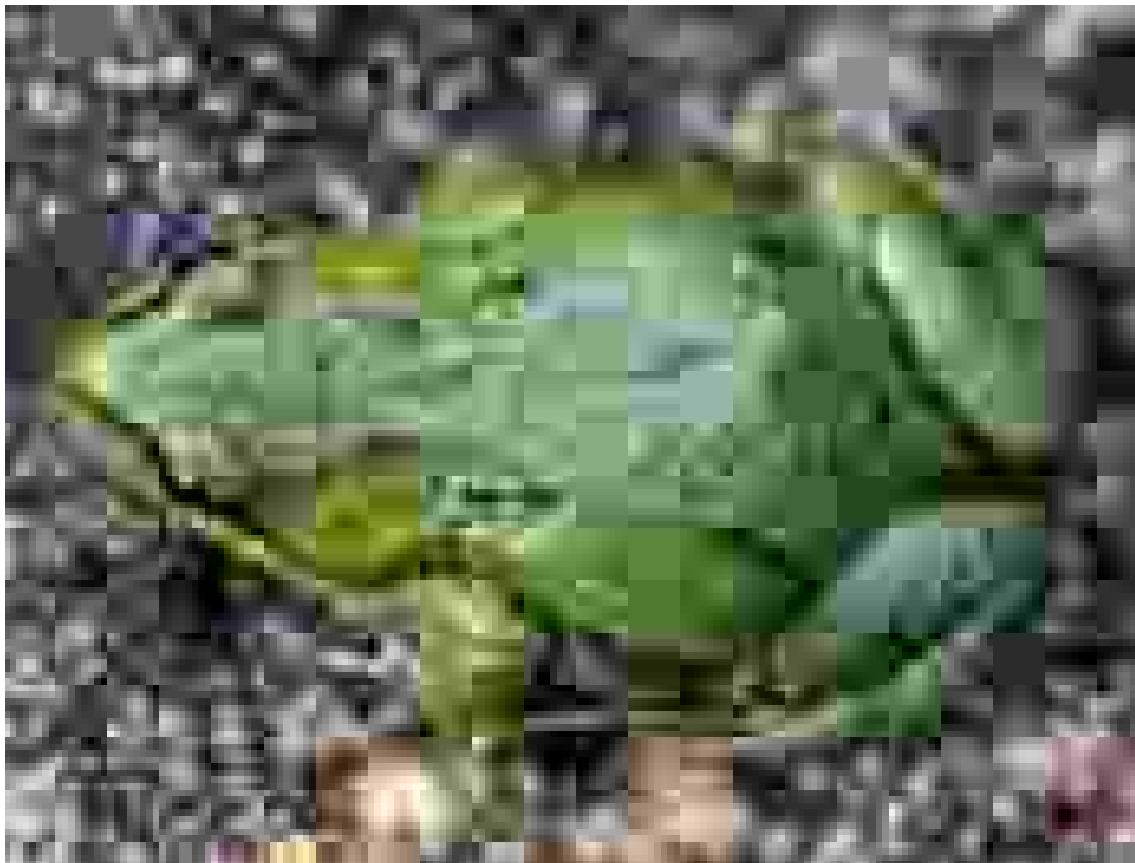


PHOTO BY DANIEL LIEPICK

Kinangop Dainty Frog



TAXA - MAMMALS

By Immaculate Muthoni
& Caro Nyongesa

4.4 Taxa: Mammals

4.4.1 Introduction

Mammals play critical ecological roles in many ecosystems and some are especially vulnerable to environmental changes (Ernest & Brown, 2001). As such, they serve as useful indicator species for predicting the impacts of human land use and climate change (Cameron & Scheel, 2001). In animal ecology, disturbance, whether caused by natural or anthropogenic factors, is defined as “a change in conditions which interferes with the normal functioning of a biological system” (Van Andel *et al.*, 1987). Human-induced habitat conflicts are of particular concern and may involve off-road driving (Boyle & Samson, 1985), refuse dumping and vegetation trampling (Schonewald-Cox & Buechner, 1992), frequent fires (Sauvajot, 1995), proliferation of trails (Bolger *et al.*, 1997), and other pressures related to recreational and social activities.

Ecosystem goods and services that sustain human life are, in essence, direct products of ecological functions. These primary ecological processes include soil formation and nutrient cycling (Peterson *et al.*, 1988), plant propagation through pollination and seed dispersal (Wilson, 1997), regulation of faunal communities (Kingdon *et al.*, 2013), and atmospheric regulation. Collectively, these functions underpin the provisioning of water, food, soil, medicine, and a livable climate—without which life on Earth would not be viable (CBD, 2010; Wilson, 1997; Elmqvist *et al.*, 2003).

Understanding mammal social systems and behavior is best achieved through observations of individuals in their natural habitats. While this is often feasible for large mammals, indirect methods are typically employed even for these species. Indirect monitoring, where population size, trends, or behavioral indicators are inferred from camera-trap images, scat counts, or track surveys, is well suited to situations where direct observations are impractical (Taberlet *et al.*, 1999; O’Connell *et al.*, 2011). Such approaches are particularly valuable for rare, shy, or elusive animals (Stanley & Royle, 2005; Kühl *et al.*, 2008; McFarlane *et al.*, 2020), and are also effective for multispecies and community-level monitoring efforts (Cromsigt *et al.*, 2009; Burgar *et al.*, 2019; Wittische *et al.*, 2020).

Despite comprising nearly half of all mammalian species (Wilson & Reeder, 1993), rodents remain understudied. Their small size, cryptic appearance, and nocturnal behavior have often limited behavioral studies to captivity (Bronson, 1979; Carter & Roberts, 1997), semi-natural settings (e.g., Lidicker, 1976; Gerlach & Bartmann, 2002), or indirect methods in nature such as live-trapping (Salvioni & Lidicker, 1995; Keesing, 1998; Getz *et al.*, 2000), radiotracking (Webster & Brooks, 1981; Wilkinson & Baker, 1988; Johannesen *et al.*, 1997), fluorescent pigment tracking (Ribble & Salvioni, 1990), and genetic analyses (Ribble, 1991). Direct behavioral observations of small mammals in the wild remain rare, though early studies such as Rathbun’s (1979) work on elephant shrews were foundational. Some progress has been made through direct studies of diurnal species (Jackson, 1999; Randall *et al.*, 2000; Tchabovsky *et al.*, 2001), larger nocturnal species (Sommer, 2000), and even a few small nocturnal species (Ågren *et al.*, 1989; Wynne-Edwards, 2003).

4.4.2 Mammal Community Diversity

A total of 29 individual mammals, representing 7 species from 5 different orders were recorded during the biodiversity survey (Figure 12). These species included the Hippopotamus (*Hippopotamus amphibius*), Montane African climbing mouse (*Dendromus insignis*), Cape Hare (*Lepus capensis*), Smoky white-toothed shrew (*Crocidura fumosa*), House mouse (*Mus musculus*), Spotted hyena (*Crocuta crocuta*) and Mole rat (*Tachyoryctes ibeanus*). Among these, *H. amphibius* was the most abundant, with a total count of 126 individuals observed in Lake Ol Bolossat . The remaining species were represented by fewer individuals: two *Lepus capensis*, one each of *C. fumosa* and *C. crocuta*, and three individuals each of *D. insignis*, *M. musculus*, and *T. ibeanus* (Table 15)



PHOTO BY JEFF DAVIS

Montane African climbing mouse

Table 15: Species diversity, abundances, and observations from the transects in the 6 six sampling sites

Species Scientific Name	Remarks	Locality/Ward	GPS Coordinates
<i>Species Scientific Name</i>	Hippo tracks observed	Shamata ward	0.255311,36.8091499
<i>Hippopotamus amphibius</i>	Hippo print	Shamata ward	12695663, 36.8091499
<i>Hippopotamus amphibius</i>	Collected	Shamata ward	0.17843021, 36.4561300
<i>Dendromus insignis</i>	Collected	Shamata ward	0.1824010, 36.4573454
<i>Crocidura fumosa</i>	Hippo mandible	Shamata ward	1.2695663, 36.8091499
<i>Hippopotamus amphibius</i>	Collected	Shamata ward	0.17424978, 36.45636273
<i>Dendromus insignis</i>	Collected	Rurii ward	0.1824288, 36.443864
<i>Mus musculus</i>	Hippo Skin	Rurii ward	1.295663, 36.8091499
<i>Hippopotamus amphibius</i>	Observed	Rurii ward	1.2695663, 36.8091499
<i>Lepus capensis</i>	Hippo Assorted	Rurii ward	1.2695663, 36.8091499
<i>Hippopotamus amphibius</i>	bones	Rurii ward	0.18609588, 36.4444600
<i>Mus musculus</i>	Collected	Rurii ward	0.19040810, 36.44514245
<i>Mus musculus</i>	Collected	Central ward	0.11918600, 36.44202833
<i>Dendromus insignis</i>	Collected	Central ward	0.113563499, 36.44701833
<i>Hippopotamus amphibius</i>	Hippo print	Central ward	0.13283820, 36.446773
<i>Lepus capensis</i>	Observed	Central ward	0.13216190, 36.4474861
<i>Hippopotamus amphibius</i>	Hippo Skull	Central ward	11.991539, 36.44304310
<i>Crocuta</i>	Hyena scats	Central ward	0.13398011, 36.441693819
<i>Hippopotamus amphibius</i>	Hippo mandible	Gatimu Ward	0.0129213642,36.39842747
<i>Hippopotamus amphibius</i>	Hippo print	Gatimu Ward	0.02433134, 36.39721326
<i>Hippopotamus amphibius</i>	Hippo print approx. 100	Gatimu Ward	0.022118845,36.40482434
<i>Hippopotamus amphibius</i>	Hippo print	Gatimu Ward	0.123736, 36.2424432
<i>Hippopotamus amphibius</i>	Hippo scat	Gatimu Ward	0.123736, 36.2424432
<i>Hippopotamus amphibius</i>	Hippo pool	Gatimu Ward	0.0167838257,36.40372395
<i>Hippopotamus amphibius</i>	Hippo scat	Gatimu Ward	0.01787817, 36.40168719
<i>Hippopotamus amphibius</i>	Hippo print (track)	Gatimu Ward	0.01991177, 36.40670232
<i>Hippopotamus amphibius</i>	Hippo track	Kiriita Ward	0.02388082, 36.39852223
<i>Tachyoryctes ibeanus</i>	Burrowings	Kiriita escarpment	0.04159555, 36.43111962
<i>Tachyoryctes ibeanus</i>	Burrowings	Kiriita Forest area	0.04240034, 36.43147835
<i>Tachyoryctes ibeanus</i>	Burrowings	Kiriita Forest area	0.04289056, 36.43133998

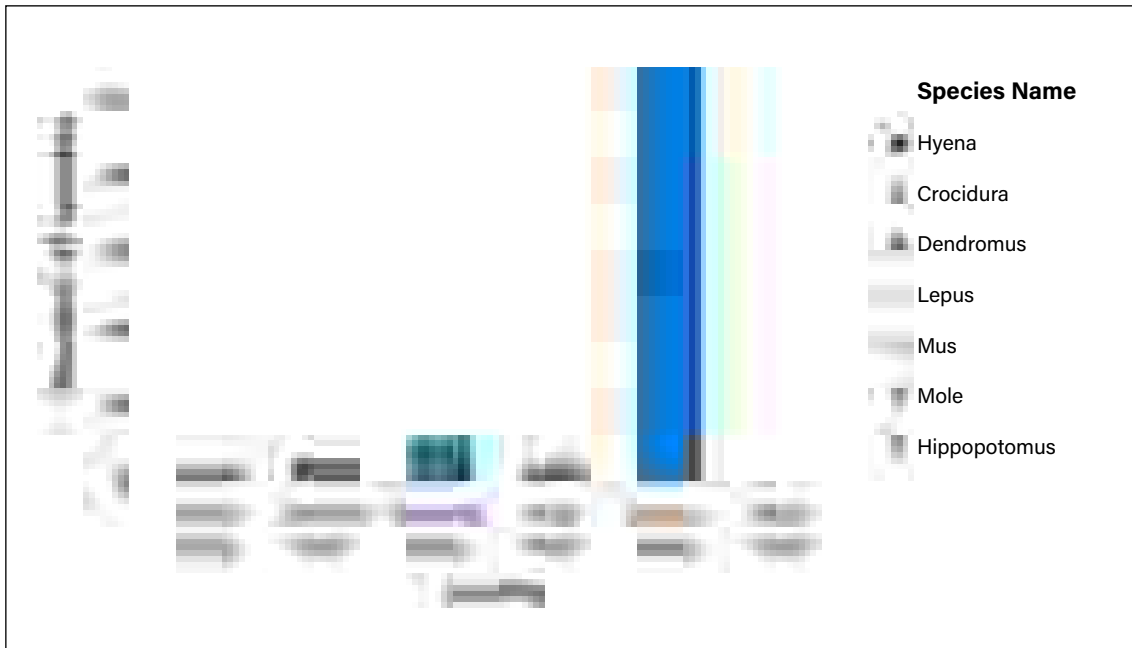


Figure 12: Number of mammal species from each of the sampled sites in the six wards

4.4.3 Discussion

A minimum level of ecological knowledge required for effective mammal management includes identifying species present, understanding their distribution, and estimating their relative abundance across habitat types (Sheng *et al.*, 2010).

A previous study by Terer *et al.*, (2019), based on community interviews, reported the presence of the spotted hyena, serval cat, and a “rare antelope” during the dry season. In the current survey, spotted hyena (*Crocuta crocuta*) scat was found along the lake shoreline in Central Ward, confirming its presence. However, the serval cat and the antelope were not directly observed.

The hippopotamus (*Hippopotamus amphibius*) remains the most dominant mammal species in Lake Ol Bolossat and should be prioritized for conservation. Comparison with prior data from the project’s inception report showed several species previously recorded were not observed in this study. Notably, species such as marsh mongoose (*Atilax paludinosus*), striped grass mouse (*Lemniscomys striatus*), brush-furred mouse (*Lophuromys spp.*), coypu (*Myocastor coypus*), southern tree hyrax (*Dendrohyrax arboreus*), Afroalpine vlei rat (*Otomys typus*), and Angoni vlei rat (*Otomys angoniensis*) were absent in this survey. However, new records included the mole rat (*Tachyoryctes ibeanus*), house mouse (*Mus musculus*), montane climbing mouse (*Dendromus insignis*), white-toothed shrew (*Crocidura fumosa*), and spotted hyena.

Hippopotamus sightings were consistently dominant across all surveys, while the Cape hare (*Lepus capensis*) was recorded in each field visit. The low species count, especially of small mammals compared to the 14 species documented in the National Museums of Kenya (NMK) database, is likely due to the brief sampling period and potential seasonal migrations. A longer-term, seasonally

stratified survey is necessary to fully assess the area's mammalian diversity and ecological dynamics.

Mus musculus exhibits a flexible social system typically composed of a dominant male, multiple females, and their litters, along with subordinate individuals of both sexes (DeLong, 1967; Lidicker, 1976; Bronson, 1979; Berry, 1981; Singleton, 1983; Gray *et al.*, 2000), contributing to rapid population growth under favorable conditions.

The montane African climbing mouse (*Dendromus insignis*) displays unique predator-avoidance strategies, including arboreal agility using its adapted hind limbs and climbing tail. Nocturnal and granivorous-insectivorous, its ecological role includes seed dispersal and pest regulation. The individuals recorded in this study were at approximately 2000 m altitude, though this species has been recorded up to 4240 m in other mountainous regions, primarily inhabiting heath and alpine zones.

Mole rats (*Tachyoryctes ibeanus*), due to their fossorial lifestyle, significantly contribute to soil aeration and turnover, influencing plant community dynamics and supporting avian and mammalian predators (Flynn, 1990). Their ability to degrade cellulose-rich plant matter enhances carbon sequestration and nutrient cycling in soils, making them critical players in ecosystem functioning.

4.4.4 Conclusions and Recommendations

Lake Ol Bolossat hosts a notable diversity of vertebrate species, particularly mammals, whose numbers could increase significantly with habitat protection and vegetation restoration. Our findings affirm the lake's ecological value, especially as a key habitat for the hippopotamus. Species such as *Dendromus insignis* also depend on specific habitat types like moorland and heath, which require urgent conservation efforts. The low detection of some previously reported species may be attributed to seasonal movements and limited survey duration.

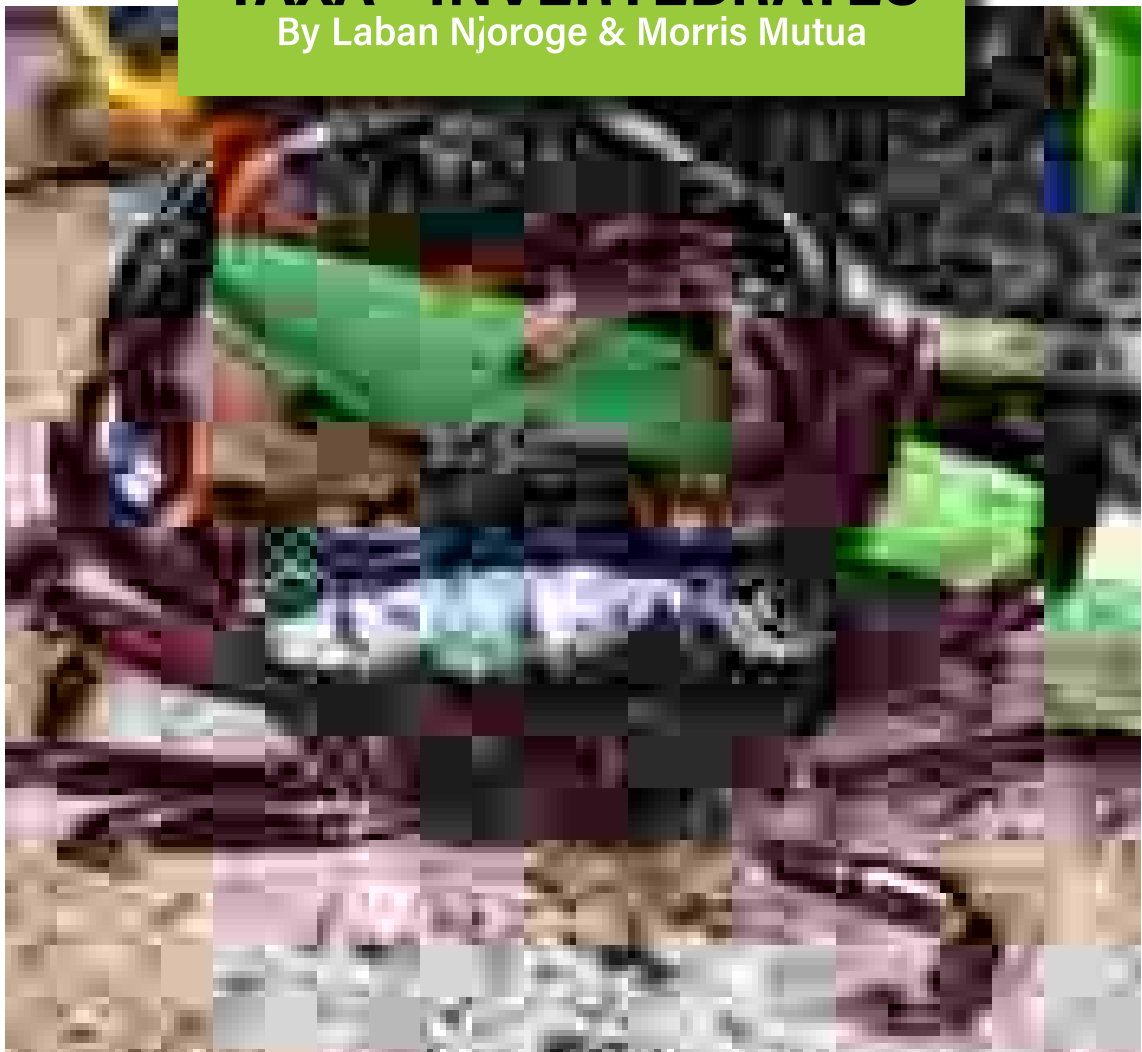
Recommendations

- Promote eco-tourism initiatives centered on flagship species such as the hippopotamus to support conservation and local livelihoods.
- Demarcate the lake boundaries clearly to prevent encroachment and protect critical wildlife habitats.
- Regulate livestock grazing around the lake to reduce resource competition between wildlife and domestic animals.
- Implement sustainable water use practices, especially for irrigation in upstream rivers feeding the lake, to maintain water levels and ecological health.
- Raise community awareness on the importance of the lake and its biodiversity to curb pollution and prevent solid waste dumping along the shoreline.



TAXA - INVERTEBRATES

By Laban Njoroge & Morris Mutua



4.5 Taxa: Invertebrates

4.5.1 Introduction

Invertebrates are vital components of ecosystems, where they perform essential functions and provide key ecosystem services such as pollination, nutrient cycling, and ecological monitoring (Prather *et al.*, 2013). They also play a crucial role in food webs, serving as primary food sources for higher trophic levels, including fish, birds, and even humans. Moreover, invertebrates are highly responsive to environmental changes, making them valuable indicators of ecosystem health and anthropogenic impact (Hodkinson & Jackson, 2005).

Different invertebrate groups respond to changes in different habitats. For instance, butterflies and ants have been shown to be reliable indicators of habitat alteration in terrestrial ecosystems such as forests (Kyerematen *et al.*, 2018). In aquatic systems, orders such as mayflies (*Ephemeroptera*), stoneflies (*Plecoptera*), caddisflies (*Trichoptera*), and dragonflies (*Odonata*) are well-recognized bioindicators of water quality and ecosystem integrity (Magoba & Samways, 2010).

Globally, invertebrates comprise the most species-rich group of organisms (Mora *et al.*, 2011). In Kenya, approximately 25,000 invertebrate species have been recorded, including about 900 butterfly species and 172 dragonfly species (MEWNR, 2015; Njoroge *et al.*, 2017). These species inhabit diverse biomes, including aquatic, forest, grassland, desert, and alpine tundra ecosystems. Despite their ecological significance, invertebrate studies at Lake Ol Bolossat have predominantly focused on aquatic taxa, leaving a notable data gap regarding terrestrial invertebrate diversity and distribution.

4.5.2 Invertebrate Assemblage and Diversity

This survey documented a total of 206 invertebrate species across 16 taxonomic orders. A detailed species checklist, including their distribution, is provided in Appendix 6. The collections were dominated by five orders: Coleoptera (beetles), Hymenoptera (bees, wasps, and ants), Hemiptera (true bugs), Diptera (true flies), and Orthoptera (grasshoppers and crickets), as illustrated in Figure 13. Several other orders were also represented, though most were limited to a single species each.

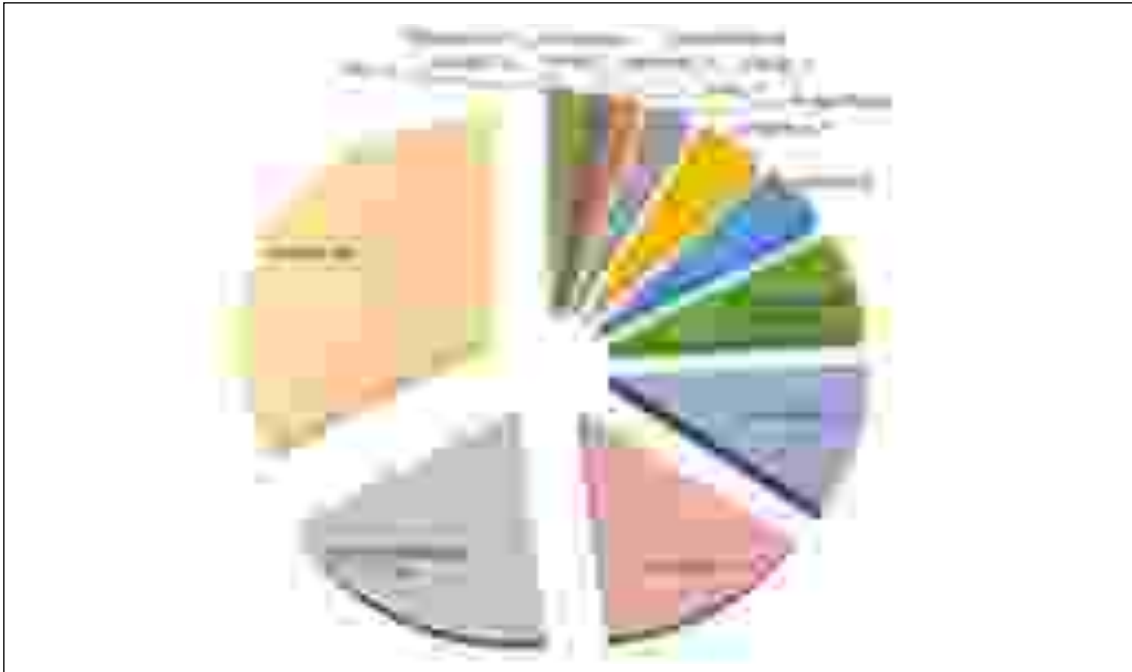


Figure 13: Composition of different invertebrate orders from Lake Ol Bolossat , November 2023

Such skewed taxonomic dominance is typical in habitats with limited structural or vegetative diversity, characteristics observed in some of the sampling sites around Lake Ol Bolossat. The relative abundances of the recorded orders are presented in Figure 14, offering insights into the community composition and potential indicator taxa for the area. *Africallagma elongatum* damselfly (left) and *Orthetrumn caffrum* serving as a bioindicator of freshwater quality due to its sensitivity to environmental changes (Plate 21). Backswimmers are ecologically important as major predators in aquatic ecosystems, helping to control populations of other invertebrates, and they also play a role in nutrient cycling and can be used as bioindicators of environmental health (Plate 22).

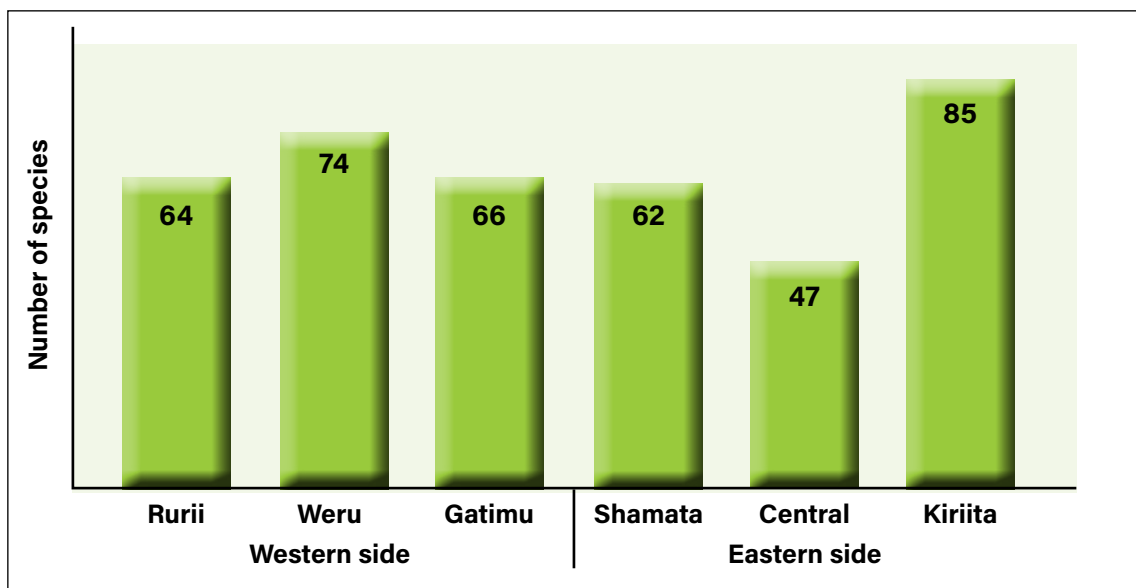


Figure 14: Number of species from each of the sampled sites in the six wards



Plate 21: *Africallagma elongatum* damselfly (left) and *Orthetrumn caffrum* dragonfly (right) observed at Lake Ol Bolossat

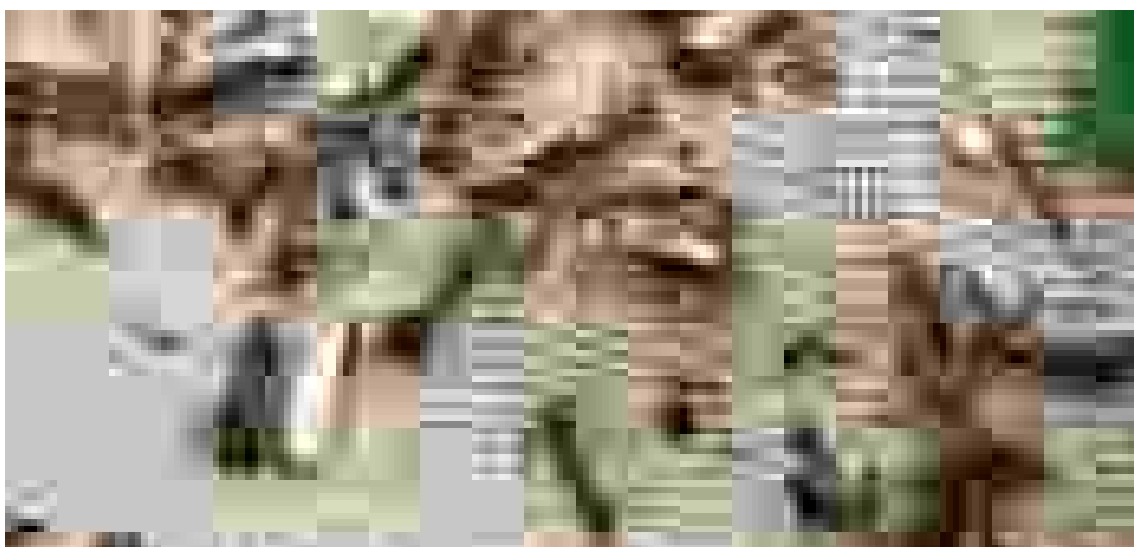


Plate 22: Backswimmers from a stream in Kanguyo Forest, Manguo area, Lake Ol Bolossat

4.5.3 Habitat Specific Species

Lake Ol Bolossat and its surrounding area support several habitat-specific invertebrate species. These include the Red-veined Darter (*Sympetrum fonscolombii*), a harvester ant (*Messor angularis*), a mosquito species (*Anopheles christyi*), and the butterfly *Actizera stellata* (Plate 23 & 24). The Red-veined Darter dragonfly is considered rare within East Africa, based on its limited known distribution. In Kenya, it has been primarily reported from the central highlands (Plate 23). According to Dijkstra (2023), *S. fonscolombii* is typically associated with standing water bodies that support aquatic vegetation within open landscapes, such as Lake Ol Bolossat. The population observed in this lake is the largest ever recorded by the authors, highlighting the lake's importance as a breeding habitat for the species. Numerous nymphal stages and newly emerged adults were documented across multiple wards, confirming successful breeding within the lake.



Plate 23: An adult male Red-veined darter (left) and its distribution in Eastern Africa (right)



Plate 24: A newly emerged Red-veined darter male (left) and a nymph (right) from Weru Ward, Lake Ol Bolossat

Harvester ants (*Messor angularis*, family Formicidae) are known for collecting and storing grass seeds in underground granaries (Plate 25). Their nests are often found in grasslands, particularly in areas with sparse vegetation or loose stones. Active colonies were documented near the lake, especially in Weru Ward. Notably, adult *S. fonscolombii* dragonflies were frequently observed resting near these ant nests, suggesting a potential form of commensalism.

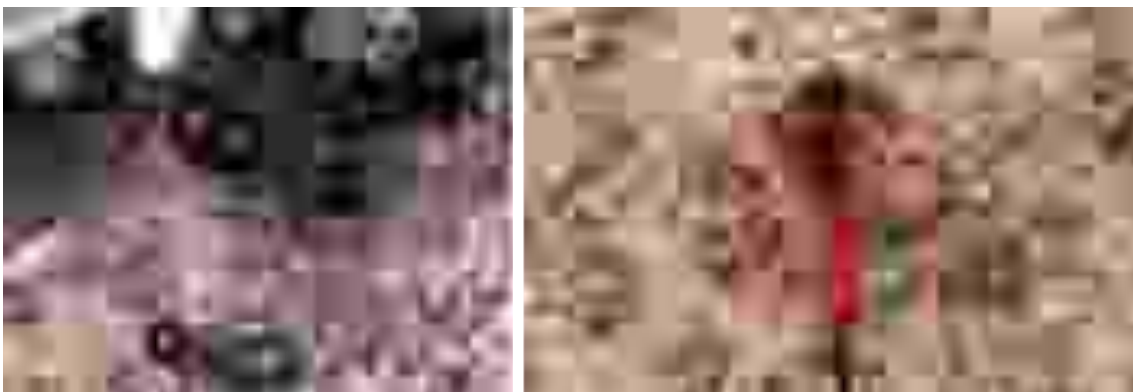


Plate 25: A Harvester ant nest in Weru Ward (left) and a Red-veined darter dragonfly resting in a cleared area (right)

Anopheles christyi, a mosquito species restricted to cold environments, was also recorded (Plate 26). This species has previously been reported from high-altitude areas such as Kikuyu, Limuru, the Aberdares, Timboroa, and Meru. *A. christyi* is genetically close to the malaria vector *Anopheles gambiae*, prompting its inclusion in a global genome sequencing effort (Neafsey *et al.*, 2014), with Kenyan specimens sourced from Meru. The species does not bite humans and is not a disease vector, instead feeding on sheep blood. The high population density observed at Lake Ol Bolossat could make the site important for future research on cold-adapted mosquito species.

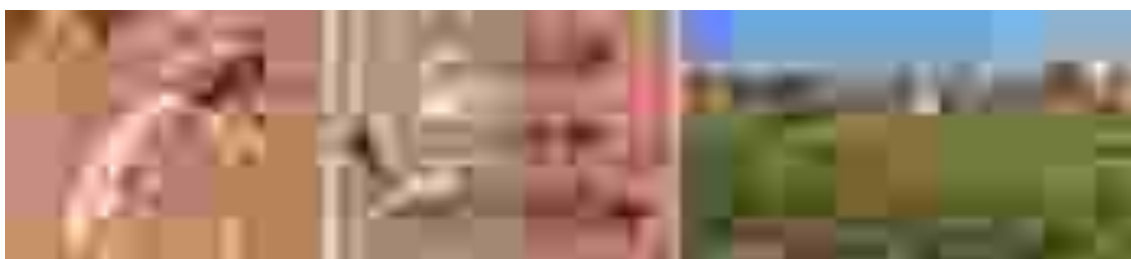


Plate 26: *Anopheles christyi* adults (left), larval stages (middle) and a flock of sheep (right)

The lake's open grasslands also support two small butterflies in the family Lycaenidae: *Actizera stellata* (Red-clover Blue) and *Zizula hylax* (Tiny Grass Blue). These species were particularly abundant around flowering grasses and herbs such as *Oxalis*.



Plate 27: *Actizera stellata* on a flowering *Oxalis* (left), *Zizula hylax* (middle) and their preferred habitat in Lake Ol Bolossat (right)

4.5.4 Environmental Changes and Their Effects on Invertebrates at Lake Ol Bolossat

Several environmental and habitat changes were observed to affect the diversity and abundance of invertebrates in and around Lake Ol Bolossat. These include:

- Invasive and introduced plant and animal species
- Decline of lake water levels
- Decline of native vegetation types
- Peat harvesting

i. Effects of invasive species on invertebrates

Both invasive plant and animal species were documented. Among invertebrates, the Louisiana crayfish (*Procambarus clarkii*)—originally introduced to Lake Naivasha—was reported in Lake Ol Bolossat (Wamiti, 2022; Terer *et al.*, 2019). *P. clarkii* is a highly opportunistic omnivore that consumes aquatic invertebrates, fish eggs, and vegetation. Its introduction poses a significant threat to ecological balance, as invasive species are widely recognized as major drivers of biodiversity loss globally (Venter *et al.*, 2006).



Plate 28: Louisiana Crayfish, one of the invasive species in Lake Ol Bolossat

Among the invasive plants observed were Eucalyptus species, thistles (*Cirsium* spp.), and *Salvinia molesta*. Aquatic habitats bordered by Eucalyptus trees supported almost no aquatic invertebrates, likely due to the allelopathic effects of the trees' essential oils. Areas of the lake infested with *Salvinia molesta* also had significantly fewer aquatic invertebrates compared to those with native vegetation (Wamiti & Njoroge, 2023).

In the eastern and central parts of the lake, particularly in Central Ward, thistles were dominant. Though the flowers attracted numerous African honey bees (*Apis mellifera*), the bees appeared unable to access sufficient nectar, suggesting these invasive plants may offer limited foraging value for pollinators.

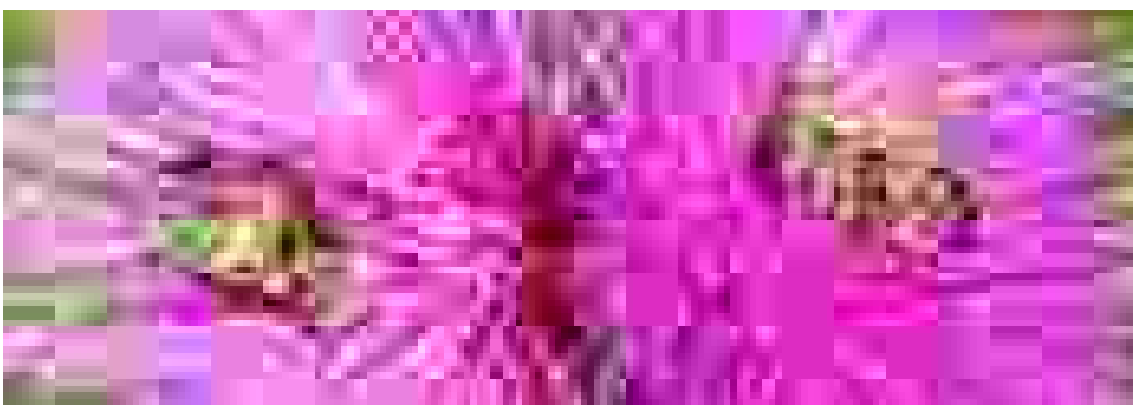


Plate 29: A solitary bee foraging on thistle flowers (left) and an African honey bee (right)

ii. Effects of Lake water level decline

This survey was conducted during a recovery phase following a prolonged drought that had completely dried Lake Ol Bolossat. During this period, many previously aquatic habitats were still desiccated or only partially inundated. As a result, the diversity and abundance of aquatic invertebrates observed during the survey were

markedly lower than those recorded in earlier assessments. It is anticipated that, as the lake continues to recover hydrologically, aquatic invertebrate communities will gradually recolonize the area, provided that suitable habitat conditions are restored.

iii. Effects of declining native vegetation cover

There was evidence of widespread loss of native vegetation, particularly trees. In many areas, native trees had been replaced by exotic species, especially Eucalyptus, which was widely planted near the lake margins. On the adjacent escarpment, large expanses were left bare. This vegetation loss appears to be linked to altered nesting behavior in the African honey bee (*Apis mellifera*). In the absence of cavities provided by large native trees, several bee colonies (n = 4) were observed nesting in the ground near the lake.



Plate 30: Colonies of the African honey bees on the ground in Lake Ol Bolossat , November 2023

The disappearance of native riparian and aquatic vegetation also had cascading effects on invertebrate communities. Sites with dense marginal vegetation consistently supported greater abundance and diversity of aquatic macroinvertebrates, as previously observed. The reduction in dragonfly populations recorded during the survey may reflect seasonal variation, but the lack of aquatic vegetation likely also contributed. Aquatic and emergent plants provide critical breeding, foraging, and perching habitats for many invertebrate taxa, especially Odonata.

iv. Effects of peat harvesting on invertebrates

Although localized, peat harvesting was documented in several areas around the lake. If this activity expands, it could increase the lake's depth by removing surface layers, potentially leading to permanent inundation of areas currently dominated by grasses and herbaceous flowering plants. These vegetation types are essential for sustaining bees and other pollinators. Consequently, widespread peat extraction could alter the composition of plant and invertebrate communities and reduce available habitat for important pollinators.

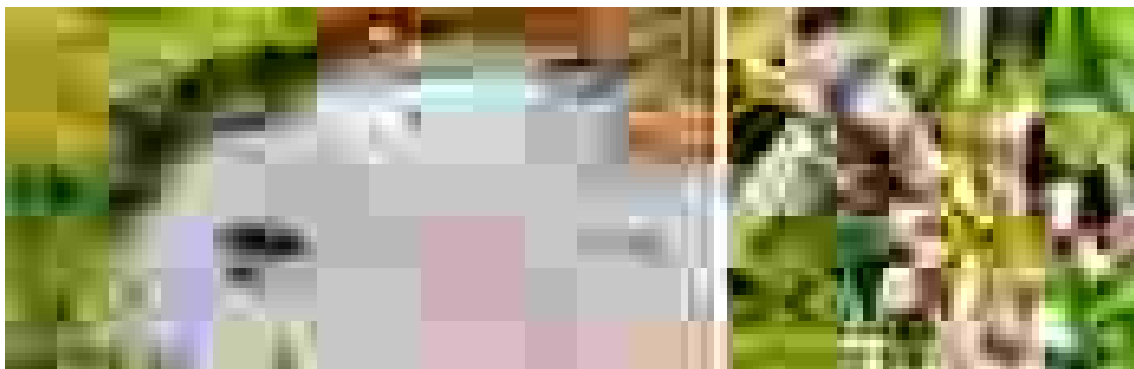


Plate 31: A flooded peat mine (left) and a honey bee foraging on *Oxalis* sp. in a grass area (right)

4.5.5 Endemic and Unique Species

Three noteworthy invertebrate species were documented near the lake: two endemic grasshoppers—*Parasphena kinangopa* and *Pezocatantops impotens*—and one unique (locally restricted) species. *P. kinangopa* is a gaudy grasshopper in the family Pyrgomorphidae, while *P. impotens* is a short-horned grasshopper (Acrididae). Both species are confined to high-altitude habitats and exhibit flightlessness due to the absence of wings.

According to Hemp (2010), montane regions in East Africa host a high diversity and endemism of Saltatoria (grasshoppers, locusts, and katydids), attributed largely to their limited dispersal capabilities. This has led to significant local speciation, with many mountains in Kenya harboring their own unique taxa. Within the genus *Parasphena*, species include *P. teitensis*, *P. keniensis*, *P. ngongensis*, *P. chyuluensis*, *P. elgonensis*, *P. cheranganica*, *P. meruensis*, *P. mauensis*, *P. kulalensis*, *P. nairobiensis*, and *P. naivashensis*, among others. The genus *Pezocatantops* includes *P. kinangopi* and *P. ngongi*, the former also endemic to the Kinangop region.

Only one individual of each of the two endemic species was encountered during this survey, suggesting their populations may be in decline. Habitat degradation, including the loss of adjacent Aberdare forest sections, may be a contributing factor. These forest portions are known to support other endemic species, including various butterflies and dragonflies. Unfortunately, the complete disappearance of this forest section likely led to the local extinction of several specialized invertebrates. Restoration of this indigenous forest fragment is urgently needed to recover these biodiversity elements.



Plate 32: The endemic *Parasphena kinangopa* (left) and *Pezocatantops kinangopi* (right)

The unique species was a crustacean commonly known as Horseshoe or Tadpole shrimp. It is normally found in wetlands that periodically dry up completely. This is the very first time that we encountered it in Lake Ol Bolossat.



Plate 33: A Horseshoe or Tadpole shrimp from Lake Ol Bolossat, November, 2023

Table 16: A list of encountered and other known rare species found in the grasslands and forests round Lake Ol Bolossat

Order	Family	Genus	Species	Habitat	IUCN Status
Orthoptera	Pyrgomorphidae	<i>Parasphena</i>	<i>kinangopa</i>	Highland grasslands	Not Evaluated
Orthoptera	Acrididae	<i>Pezocatantops</i>	<i>kinangopi</i>	Highland grasslands	NE
Lepidoptera	Nymphalidae	<i>Neptis</i>	<i>kikuyuensis</i>	Highland forests	NE
Lepidoptera	Nymphalidae	<i>Charaxes</i>	<i>nandina</i>	Highland forests	NE
Odonata	Gomphidae	<i>Notogomphus</i>	<i>maathaiae</i>	Highland forests	Endangered
Odonata	Chlorocyphidae	<i>Platycypha</i>	<i>amboniensis</i>	Highland forests	Critically endangered
Odonata	Coenagrionidae	<i>Pseudagrion</i>	<i>bicoerulans</i>	Highland forests & grasslands	Vulnerable

4.5.6 Species of Economic Importance

The areas surrounding the lake demonstrate significant potential for economic activities that align with biodiversity conservation. Beekeeping is particularly promising due to the prevalence of ground-nesting bee colonies (Plate 30, top). These colonies can be transferred into modern hives, creating sustainable sources of income through honey and other apicultural products. Importantly, this approach supports pollinator conservation within a largely agricultural community.

Additionally, the floating mats of *Salvinia molesta* (Plate 34, bottom) harbor numerous aquatic earthworms. These organisms can be commercially explored as potential bait for fishing, offering a nature-based enterprise opportunity.



Plate 34: Live bee hives along the lake shores in Weru Ward (top) and aquatic earthworms in *Salvinia molesta* roots (bottom)

4.5.7 Proposed Future Monitoring Framework

Rationale for Invertebrate-Based Monitoring

Globally, the use of invertebrates, especially aquatic ones, as bioindicators of ecosystem change is gaining prominence. Several factors make invertebrates reliable bio indicators of ecosystem changes. They include their relative ease of sampling, their residency in a small area most of their time and the fact that they differ in their tolerance to pollution. The use of insects as indicators of change ranges from simple to complex.

For community-led monitoring programs, we recommend methods that are simple, replicable, and easily understood by non-specialists. These include:

- Presence/absence data
- Changes in abundance and species diversity of selected indicator species (Table 17)
- Use of basic biotic indices such as South African Scoring System (SASS)

i. Terrestrial ecosystems

Butterflies as Indicators of Forest Restoration

Butterflies are very good indicators of ecosystem health. Changes in their communities can be used to assess the success of forest restoration efforts (Ndandika *et al.*, 2025, Mobeen, 2016). The lake's immediate catchment area is noticeably deforested. Restoration using native tree species is expected to gradually support the return of forest-dependent butterfly species. The reappearance of genera such as *Charaxes*, *Papilio*, and *Neptis*, which were absent in the study area but remain in the nearby Aberdare Forest, would signal passive ecological recovery. Their presence/absence as well as abundances can be monitored seasonally at least twice in a year for trends.

Termites as Indicators of Soil Carbon and Overall Soil Health

Termites also offer valuable insights into ecosystem changes. Along the lake shores, one species and a few termite mounds were observed. Termites thrive in warm climates and are rarely found in temperate or high-altitude tropical regions. An increase in termite diversity and mound abundance could indicate a warming climate and improved soil health specifically higher soil carbon levels, often associated with vegetation recovery.

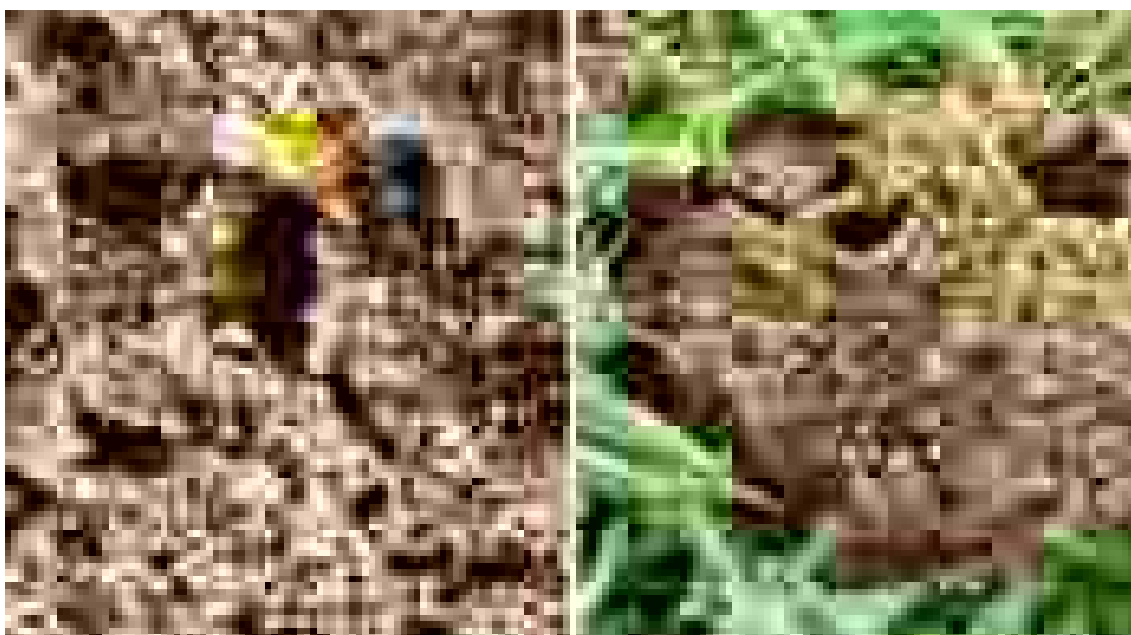


Plate 35: A live termite mound in Weru W-ard, Lake Ol Bolossat in November 2023

ii. Aquatic ecosystems

Monitoring should differentiate between the lake itself and the rivers and streams that flow into or out of it.

Dragonflies as Indicators of Water Quality and Habitat Integrity

Dragonflies are very good indicators of water and habitat qualities (de Moor, 2017). Within the lake, changes in both abundance and diversity of adult dragonflies are recommended. Dragonflies are umbrella species, representing broader biodiversity

and habitat conditions when resources limit comprehensive surveys. Periodically counting the number of dragonflies along established transects can provide a simple assessment of habitat quality.

General Aquatic Invertebrates as a Measure of Water Quality

In streams and river waters, we recommend the use of biological indices such as the South African Scoring System (SASS) (Dickens & Graham, 2002). Although developed in South Africa, SASS has been widely applied across Africa and is ISO-certified. It provides a standardized, user-friendly methodology to:

- Assess the ecological state of aquatic ecosystems
- Detect the spatial and temporal trends in ecological state
- Identify emerging environmental concerns
- Set ecological management goals
- Evaluate development impacts
- Predict ecosystem changes in the due to developments

Fireflies as Indicators of Wetland Restoration

Fireflies which are insects in the family Lampyridae are bioluminescent beetles typically found in wet, marshy environments. They are associated with specific wetland habitats, making them good indicators of the presence and quality of those habitats (Pérez *et al.*, 2023). Their presence signals healthy wetland conditions, yet many populations are locally declining due to habitat loss, particularly from wetland drainage and overgrazing.

A single firefly was observed and collected near the lake in Gatimu Ward, suggesting that remnants of suitable habitat still exist. We hypothesize that a resurgence in firefly populations could occur if conservation and restoration of the lake’s marshy zones are implemented effectively. Monitoring firefly abundance over time would offer an accessible, community-friendly measure of wetland restoration success. Fireflies are nocturnal in activity. Ol Bolossat being a hippo infested lake, the safest method to monitor the fireflies will be by use of light lure traps. Use of two light lure traps set 100 m apart in each of the administrative wards for 2 nights in a week during flight periods is recommended. The total numbers of captured fireflies will be recorded over time.

Table 17: A list of recommended invertebrate’s indicator groups for monitoring

Order	Family/Genera/Species	Ecological indication/measure
Lepidoptera	Nymphalidae (Brush-footed butterflies)	Forest recovery
Lepidoptera	Papilionidae (Swallow tail butterflies)	Forest recovery
Odonata (Dragonflies)	All species	Water quality & aquatic vegetation health
Isoptera (Termites)	All species	Soil carbon levels
Coleoptera	Lampyridae (Fireflies)	Wetlands intergrity



Plate 36: Children and community members from Lake Ol Bolossat areas trying their hand in sampling for invertebrates

4.5.8 Conclusions and Recommendations

Based on our findings, we conclude that Lake Ol Bolossat supports a rich diversity of invertebrates, which is likely to increase significantly if the wetland is protected and native vegetation is restored. The lake also serves as an important habitat for rare and possibly endemic invertebrate species, underscoring its conservation value.

However, seasonal changes and ongoing habitat degradation have contributed to the observed low abundance and diversity of certain taxa, such as dragonflies. These findings highlight the critical role of ecological conditions in shaping invertebrate communities and the urgent need for targeted conservation interventions.

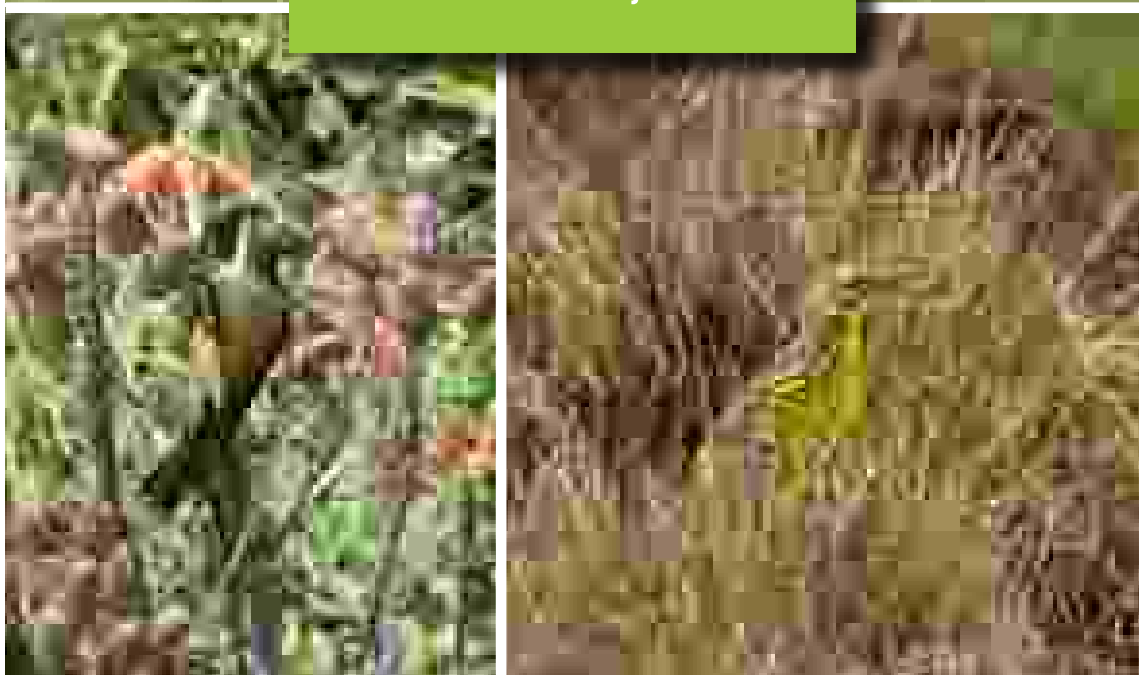
Recommendations

- Conduct surveys across multiple seasons, particularly during both the wet and dry periods, to capture seasonal dynamics in invertebrate diversity and abundance.
- Restore native vegetation in and around the lake to improve habitat quality and promote biodiversity recovery.
- Implement control and removal measures for invasive species, specifically the thistle weed, which threatens native plant communities and overall ecosystem integrity. Studies may be needed to determine the best removal method.
- Protect the lake and its catchment areas by regulating human and livestock access. Controlled access will facilitate natural regeneration and reduce pressures on sensitive habitats, thereby supporting the return of native flora and fauna.
- Promote citizen involvement in conservation and especially in biodiversity monitoring efforts. Community-based monitoring can enhance local stewardship, build ecological knowledge, and support long-term sustainability. However, there will be a need for capacity building on basic data collection and interpretation for monitoring.
- Explore conservation-linked livelihood opportunities, such as community-based beekeeping, which can offer economic incentives while contributing to pollinator conservation and habitat restoration.



TAXA - BIRDS

By Henry Ndithia,
Samuel Gushu
& Amina Njoki



4.6 Taxa: Birds

4.6.1 Introduction

Birds are an important taxon in ecological research due to their roles in both environmental processes and human well-being. As one of the most well-studied animal groups, birds are widely used as indicators of ecological integrity, particularly through assessments of their distribution, abundance, and temporal trends. Consequently, bird populations are frequently employed to monitor the health status of ecosystems.

Changes in bird community composition—such as those that occur when a pristine forest is transformed into a secondary forest by anthropogenic activities—can serve as early warning signals of environmental degradation. Birds are highly sensitive to even slight alterations in their environment, with observable shifts in key physiological and behavioral traits such as breeding timing, molt patterns, movement, and migration. These traits make birds particularly valuable indicators of climate change and habitat alteration.

Despite these well-known attributes, the full potential of birds as ecological sentinels remains underutilized in environmental monitoring and research. In many ecosystems, insufficient attention has been given to tracking bird community structure, which limits our understanding of anthropogenic impacts. This gap contributes to delayed responses to ecosystem degradation, perpetuating biodiversity loss and ecosystem dysfunction. Such negative changes directly threaten community livelihoods and socio-economic development, particularly where people are closely tied to their natural environment. Ultimately, this neglect accelerates environmental decline, placing our rich natural heritage, and the species it supports, at increasing risk of extinction.

The overall aim of this rapid survey was to develop a quick understanding of the avifaunal abundance and diversity of Lake Ol Bolossat ecosystem in Nyandarua County. Specifically, it aimed to annotate bird species composition and bird community structure as a baseline on which future, more detailed study and monitoring, can be based.

4.6.2 Species Accumulation Curves and Habitat-Specific Patterns

During this study, we recorded a total of 779 individual birds, representing 162 species, using a combination of point counts (PC), timed species counts (TSC), and opportunistic observations (see Appendix 7 for a complete species checklist).

Species accumulation curves for the broader Lake Ol Bolossat ecosystem (encompassing both wetland and terrestrial habitats) suggest that the complete avian community was not fully captured during the survey period (Figure 15). Two planning models were used to estimate the expected species richness: one based on the average rate of species accumulation over the first five sampling days, and another excluding the first day and focusing on the subsequent five days. Both models projected a total species richness in the range of 200 to 375 species. This indicates that while the 162 species recorded represent a substantial portion of the

avifaunal diversity, the survey likely under-sampled the full community, particularly rarer or seasonally variable species (Figure 15).

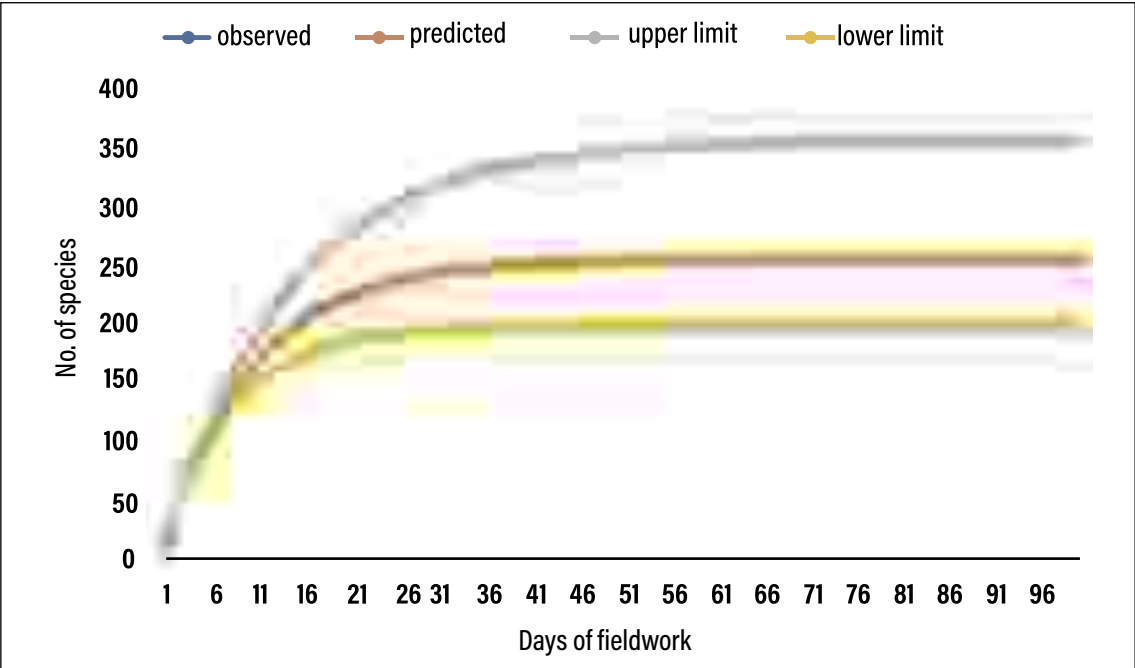


Figure 15: Bird species accumulation curves based on two potential regression models for successive survey days conducted at Lake Ol Bolossat.

i. Species encounter rates and relative abundance

Using timed species count (TSC) data, the grasslands adjacent to Lake Ol Bolossat had the highest species richness and abundance compared to other sampled habitats. In contrast, the riverine area adjacent to human settlements near Thompson’s Falls had the lowest species richness and bird abundance (Figure 16).

Across all three habitat types, a total of 118 bird species and 840 individuals were recorded using TSC (Figure 16).

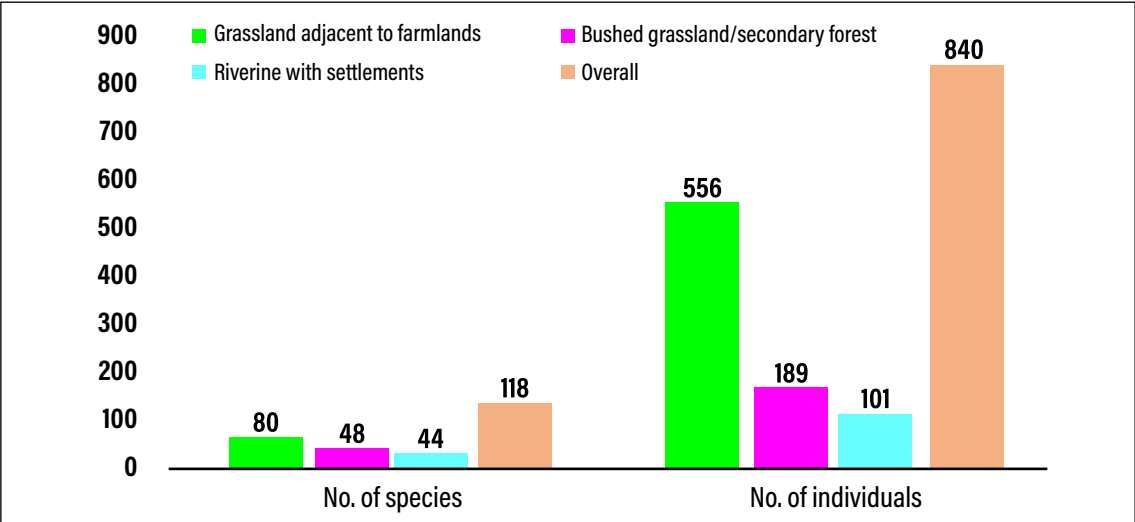


Figure 16: Habitat-specific species richness (number of species), species abundance (number of individuals) and the overall species richness and abundance.

The grassland habitat adjacent to the lake had the highest species richness and abundance, while the bushed-grasslands interspersed with secondary forest showed the lowest values for both metrics.

Among the species recorded from TSC data, Hadada Ibis (*Bostrychia hagedash*), Ring-necked Dove (*Streptopelia capicola*), and Common Fiscal (*Lanius collaris*) were the most abundant. In contrast, Speckled Mousebird (*Colius striatus*), Levallant's Cisticola (*Cisticola tinniens*), Common House Martin (*Delichon urbicum*), and Common Bulbul (*Pycnonotus barbatus*) were the least abundant species (Figure 17a).

From point count (PC) data, Barn Swallow (*Hirundo rustica*) and Egyptian Goose (*Alopochen aegyptiaca*) were the most frequently encountered species. Conversely, Grey Crowned Crane (*Baelearica regulorum*), Marsh Sandpiper (*Tringa stagnatilis*), and Cape Rook (*Corvus capensis*) were the least abundant (Figure 17b).

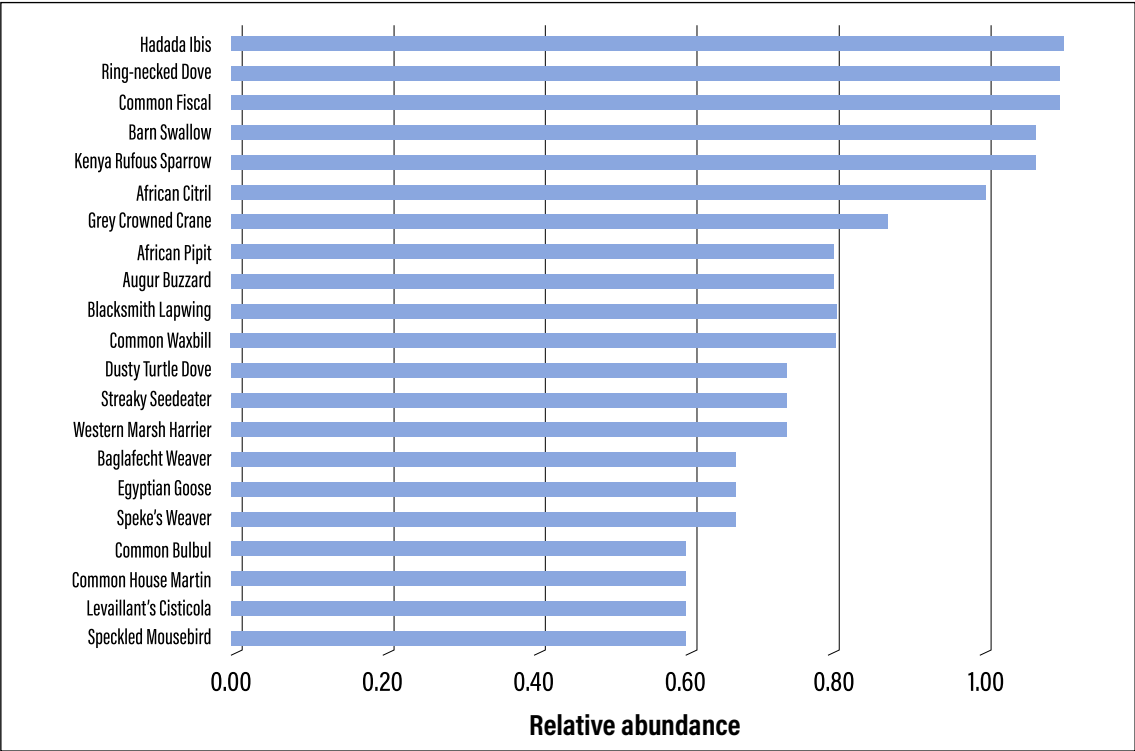


Figure 17: a

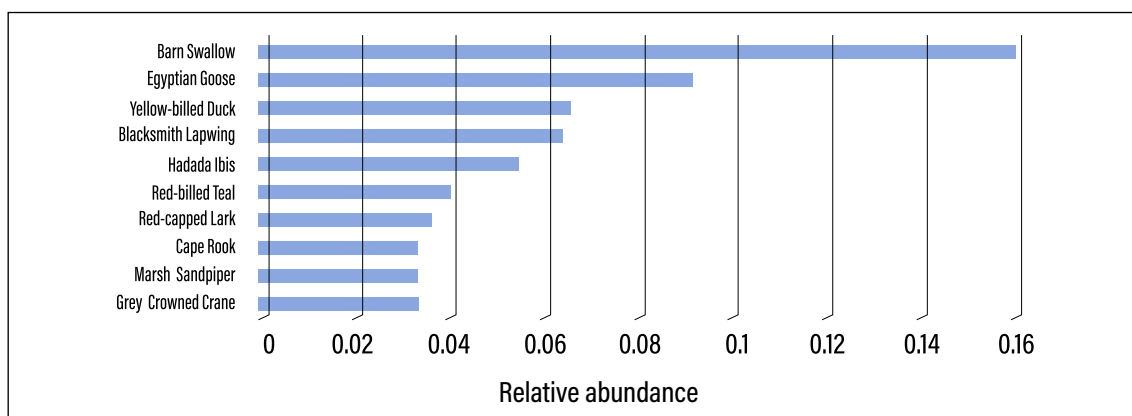


Figure 17: b

Figure 17: Relative abundance of the most abundant and the rarest bird species from timed species count data (17a) and using point count data (17b)

ii. Species of Conservation Interest

Lake Ol Bolossat provides habitat for at least 24 bird species of conservation concern (Table 16). These include:

Three globally endangered species, including Sharpe's Longclaw (*Macronyx sharpei*)—a grassland specialist endemic to the Nyandarua and other select Kenyan highland grasslands -and two species listed by IUCN as vulnerable {Tawny Eagle (*Aquila rapax*) and the Wolly-necked Stork (*Ciconia episcopus*) (Table 18). One invasive species, the House Sparrow (*Passer domesticus*) was also recorded (Table 18). Additionally, the area supports 20 Palearctic migrant species, and two intra-African migrant species, one of which is listed as vulnerable (Table 18; Appendix 7). These findings underscore the ecological importance of the area for both resident and migratory birds.



Photo by Omar Alhashshien

Pallid Harrier



Photo by David Jolley

Woolly-necked Stork

Table 18: Species of conservation interest recorded at Lake Ol Bolossat ecosystem during the 9-day rapid survey in November 2023

Common Name	Scientific Name	IUCN Status
Grey Crowned Crane	<i>Balearica regulorum</i>	Endangered
Steppe Eagle	<i>Aquila nipalensis</i>	Endangered; PM
Sharpe's Longclaw	<i>Macronyx sharpei</i>	Endangered; Endemic
Pallid Harrier	<i>Circus macrourus</i>	Near Threatened; PM
Tawny Eagle	<i>Aquila rapax</i>	Vulnerable
Wolly-necked Stork	<i>Ciconia episcopus</i>	Vulnerable; IM*
Wahlberg's Eagle	<i>Hieraaetus wahlbergi</i>	Least Concern; IM
Barn Swallow	<i>Hirundo rustica</i>	PM**
Common Buzzard	<i>Buteo buteo</i>	PM
Common House Martin	<i>Delichon urbicum</i>	PM
Common Snipe	<i>Gallinago gallinago</i>	PM
Eurasian Hobby	<i>Falco subbuteo</i>	PM
European Roller	<i>Coracias garrulus</i>	PM
Green Sandpiper	<i>Tringa ochropus</i>	PM
Lesser Kestrel	<i>Falco naumanni</i>	PM
Little Ringed Plover	<i>Charadrius dubius</i>	PM
Northern Wheatear	<i>Oenanthe oenanthe</i>	PM
Red-backed Shrike	<i>Lanius collurio</i>	PM
Ruff	<i>Calidris pugnax</i>	PM
Western Marsh Harrier	<i>Circus aeruginosus</i>	PM
Western Osprey	<i>Pandion haliaetus</i>	PM
Whinchat	<i>Saxicola rubetra</i>	PM
Wood Sandpiper	<i>Tringa glareola</i>	PM
House Sparrow	<i>Passer domesticus</i>	non-native***

***IM;- Intra-Africa migratory birds **PM:- Palearctic migrant, ***invasive species**

Bird Species Richness and Diversity indices

Bird species diversity indices revealed that grasslands adjacent to the lake had higher species diversity compared to bushed-grasslands with secondary forest (Table 19). However, despite the lower species richness, the bushed-grasslands with secondary forest exhibited greater evenness—indicating that individual birds in this habitat were more evenly distributed among all species occurring in this habitat (i.e., almost the same number of individuals per species present in this habitat type) .

This suggests that while grasslands support more species, a few species dominate in numbers, whereas in the bushed-grassland–secondary forest mosaic, each species was represented by a relatively equal number of individuals.

Table 19: Species diversity and evenness of different habitat types

Habitat	Species Diversity	Evenness
Grassland adjacent to the lake	3.46	0.789
Bushed grassland/secondary forest	2.97	0.830
Overall	3.53	0.791

Species Similarity across Habitats

Analysis of species similarity between grasslands and bushed-grasslands with secondary forest showed low overlap in species composition. The similarity index was only 26%, indicating that 62% of the bird species were unique to one of the two habitats (Figure 18). This means that of the 100 species recorded in these two habitat types, 62 were unique to either one of them.

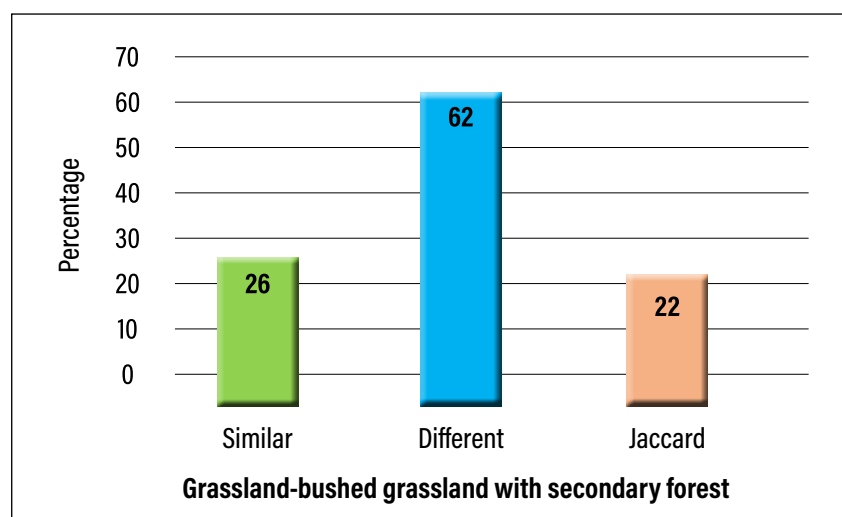


Figure 18: Species similarity index between two habitat type (grasslands and bushed-grassland with secondary forest)

Forest-dependency categories

For both the grassland and the bushed-grassland with secondary forest, there was low records of forest-dependent species (FF and F) (Figure 19). In general, the non-forest species (non-f) had the largest proportion followed by forest visitors (f) (Figure 19).

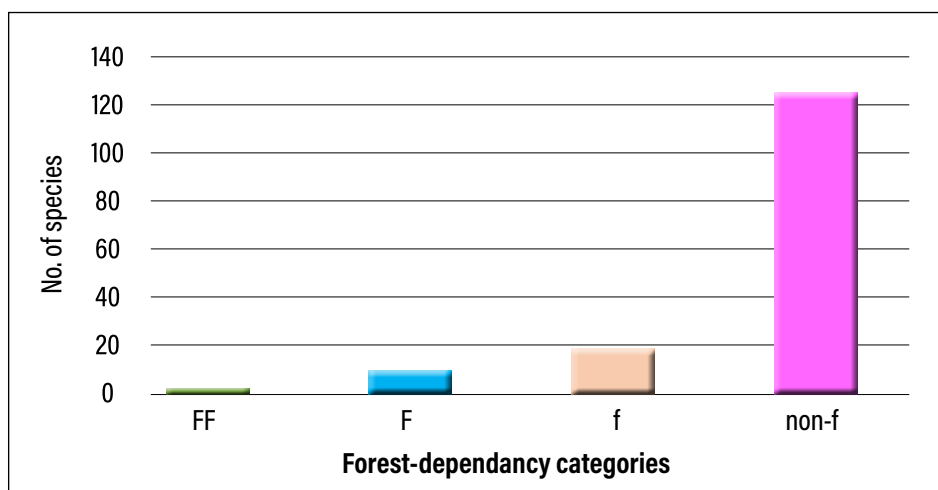


Figure 19: Proportion of the species assemblage occurring under the four forest dependency categories

4.6.3 Discussion

Species Accumulation Curves

In this study, a total of 162 bird species were recorded (Appendix 7) over a nine-day survey period at Lake Ol Bolossat. This relatively short timeframe likely limited the comprehensiveness of species detection. Species accumulation modeling using two comparative growth curves with slightly different initial rates of increase (average of the first five days, and average of consequent five days excluding the first day), suggests the total species richness for Lake Ol Bolossat may lie between 200 and 375 species, assuming continued sampling for up to 100 days (Fig. 15). This projected richness is notably higher than that observed in Maasai Mau Forest, where similar projections estimated between 200 and 250 bird species over a comparable study duration.

Species Encounter Rates and Relative Abundance

The grassland habitat adjacent to Lake Ol Bolossat supported the highest bird species richness and abundance. In contrast, bushed-grassland with secondary forest and riverine habitats exhibited relatively lower species richness and abundance (Fig. 16). These differences are consistent with the size and extent of each habitat type: grasslands dominate the landscape, whereas the bushed-grasslands and riverine areas constitute smaller, more fragmented habitats.

Sampling effort was proportionally allocated based on habitat size using two complementary techniques: Timed Species Counts (TSC) and Point Counts (PC). These methods provide valuable insight into both species richness and relative abundance, helping to identify common and rare species. Such information is critical for prioritizing species and habitats for conservation attention.

Species of Conservation Interest

The survey identified 24 bird species of conservation concern, including:

- Endangered species
- Vulnerable species
- 1 Endemic species

Additionally, 20 Palearctic migrants and 2 Intra-African migrant species were recorded. Of particular note are:

- Steppe Eagle (Endangered)
- Pallid Harrier (Near-Threatened)
- Woolly-necked Stork (Vulnerable, Intra-African migrant)

This array of threatened, endemic, and migratory species highlights the critical conservation value of Lake Ol Bolossat. The wetland serves as a key wintering site for Palearctic migrants and as a migratory stopover for species moving within Africa, thus affirming its national and international importance.

Bird Species Richness and Diversity Indices

The bushed-grassland with secondary forest exhibited higher species evenness than the grassland, indicating a more balanced distribution of individuals across species. In contrast, the grassland, while having higher species richness and diversity (Table 19), displayed lower evenness, implying dominance by a few species.

Species diversity reflects both richness and evenness, and is a key indicator of community structure. The observed differences underscore the importance of conserving heterogeneous habitats to support both generalist and specialist bird species.

Species Similarity

There was low species similarity (26%) between the grassland and the bushed-grassland with secondary forest habitats. Of the 100 species recorded across these two habitats, 62 were unique to one habitat type. This highlights the ecological heterogeneity of the Lake Ol Bolossat ecosystem, which includes grasslands, wetlands, riverine areas, and farmlands. This contributes substantial variation in species diversity and species composition. It may also likely to stem from diverse micro-habitats that are uniquely suitable to certain bird species. The Lake ecosystem is a heterogeneous environment, compared to the Maasai Mau Forest which has been shown to have 50% similarity in species composition; therefore, becoming a more homogenous environment.

Forest Dependency Categories

Few species in the survey were classified as forest-dependent (FF or F), consistent with the absence of intact forest cover in the Lake Ol Bolossat landscape. Most recorded species were either forest visitors (f) or non-forest species (non-f), reflecting the dominance of open and semi-open habitats such as grasslands and farmlands.

As defined by Bennun *et al.*, (1996):

- FF species are forest specialists requiring intact forest interiors, although some may persist in secondary patches if ecological needs are met.
- F species are generalists found in both intact and edge habitats.
- f species are common in forests but breed in non-forest habitats.
- Non-f species have no forest association and are typically grassland or farmland birds.

4.6.4 Conclusions and Recommendations

With a recorded total of 162 bird species, and the potential to support up to 375, Lake Ol Bolossat exhibits high avian species diversity and richness, underscoring its significant potential for ecotourism. This ecotourism potential should be harnessed through an integrated approach, involving all local stakeholders, including surrounding communities. By engaging communities meaningfully, ecotourism could generate income to support local livelihoods, thereby reducing anthropogenic pressures that contribute to ecosystem degradation. Enabling local communities to derive non-destructive benefits from the lake ecosystem would be a major step toward securing the future of Lake Ol Bolossat and the species that inhabit it.

To safeguard the lake from land grabbing and other harmful human activities, the official gazettement of the ecosystem and the provision of reserve status are essential. This legal protection would ensure that the lake's ecological integrity is maintained and that its biodiversity is preserved for both ecotourism and conservation purposes.

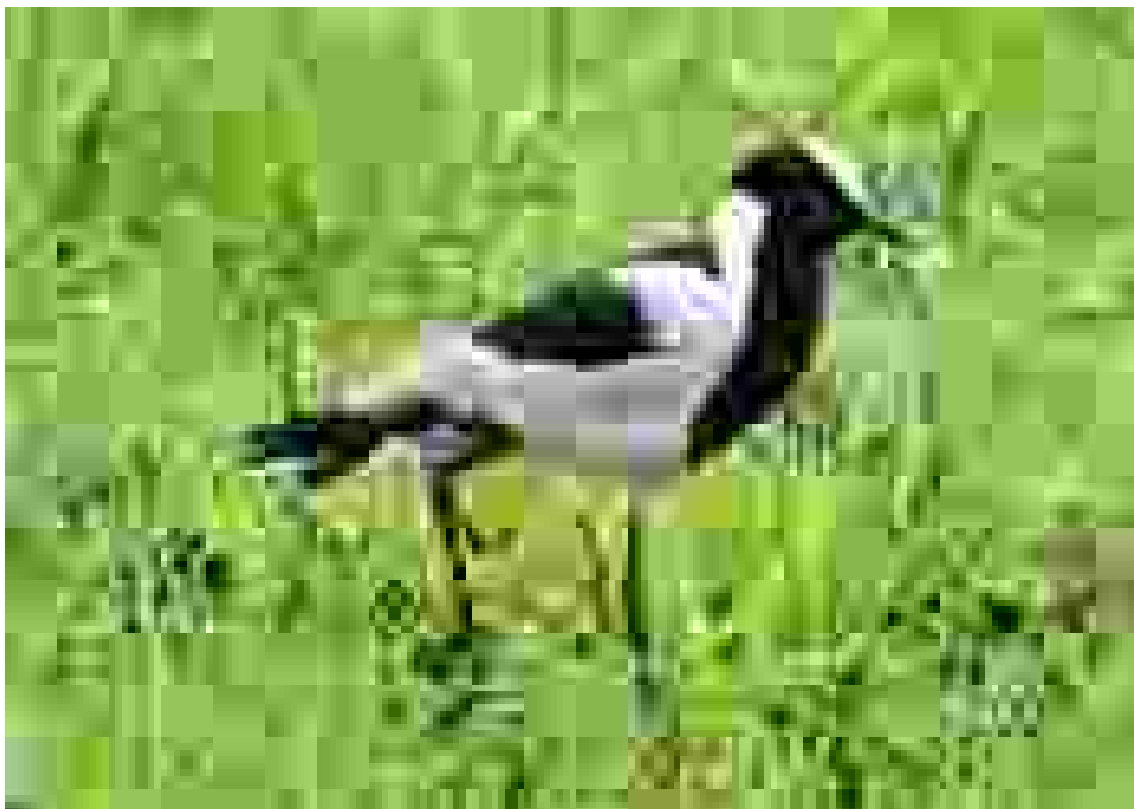
An integrated conservation strategy should be initiated, allowing local communities to benefit from the lake while also contributing to its protection. For example, communities could be permitted to graze a limited number of livestock per household at a nominal fee, which could be used to support reserve management. Additionally, a regulated grazing regime should be developed to address the current issue of overgrazing. These measures can be effectively implemented through a participatory management plan.

Furthermore, a designated sanctuary zone should be set aside within the lake ecosystem to protect a significant proportion of threatened, rare and endemic species, such as Sharpe's Longclaw, Grey Crowned Crane. In this area, human activities, particularly grazing, should be prohibited to prevent nest destruction, egg trampling, and chick mortality caused by livestock. Such a sanctuary would provide a safe breeding habitat for species of conservation concern.

It is also strongly recommended that Lake Ol Bolossat be designated as a Ramsar Site, based on Criterion 1 and Criterion 2 of the Ramsar Convention.

- Criterion 1: The lake represents a rare or unique example of a near-natural wetland type within its biogeographic region.
- Criterion 2: It supports vulnerable, endangered, or critically endangered species and threatened ecological communities

Lake Ol Bolossat qualifies under both criteria and merits international recognition and protection due to its role in sustaining vital biodiversity. In addition to supporting endemic and threatened species, it serves as an important wintering ground for Palearctic and intra-African migratory birds.



Blacksmith Lapwing



Jackson's Widowbird



TAXA - FISH AND WATER QUALITY

By Joseph Gathua
& Gilbert Kosgei

4.7 Fish and Water Quality

4.7.1 Introduction

Lakes provide numerous goods and services, including essential intangible ecosystem services such as habitat provision, water for human, livestock, and wildlife consumption, agricultural support, fisheries, recreation and tourism, nutrient and sediment retention, climate and hydrological regulation, and cultural values (MEA, 2005; Schallenberg *et al.*, 2013). Lakes and their catchments host high biodiversity and play vital ecological, economic, and cultural roles in human wellbeing (MEA, 2005). Each lake's ecological condition and the ecosystem services it offers are shaped by factors such as its morphology, climatic conditions, catchment characteristics, and human activities. Cox and Lima (2006) described lakes as isolated and insular systems that play a significant role in promoting speciation.

Human activities have had profound impacts on lakes globally, altering the quality of in-lake habitats, a key indicator of healthy aquatic ecosystems. Notable pressures include pollution, river diversion and abstraction, and the introduction of invasive species (Zacharia *et al.*, 2013). Many fish and aquatic invertebrates undertake localized migrations between rivers, lakes, and river mouths as part of their life cycle, particularly during spawning. Consequently, assessing aquatic biota, especially fish, has become a widely accepted method for evaluating lake health. Fish serve critical roles not only as a source of food for humans but also as biological indicators of water quality and contributors to ecosystem processes such as food web dynamics, nutrient cycling, and habitat engineering.

Lake Ol Bolossat is a small, natural, high-altitude alkaline lake (43.3 km²) situated in the Satima Escarpment of Central Kenya. It receives inflow from the Aberdare Ranges through numerous springs and streams traversing farmlands. On the western side, streams originate from the Dundori Hills and discharge into the lake. Soil erosion from adjacent farms has been reported to reduce the lake's water retention capacity (Mathenge, 2014). While the lake is moderately saline, the fresh inflow from streams and springs dilutes the water before it exits via the Ewaso Narok River to the north. Lake Ol Bolossat is designated as Kenya's 61st Important Bird and Biodiversity Area (IBA) (Okumu, 2017).

The surrounding communities engage primarily in agriculture and livestock rearing, cultivating both subsistence and commercial crops and rearing cattle and sheep. Fishing in the lake is practiced on a part-time basis, and aquaculture using earthen ponds has been introduced in parts of the catchment. However, aquaculture has posed threats to native and endemic fish species, including potential replacement and hybridization (Dieleman *et al.*, 2017; Wasonga *et al.*, 2017). These economic activities significantly influence water quality, biodiversity patterns, and human wellbeing.

4.7.2 Water Quality

The water quality parameters assessed during the survey included pH, total dissolved solids (TDS), surface water temperature, salinity, electrical conductivity

(EC), nitrates, and phosphates. EC and TDS trends closely mirrored each other, with TDS values being slightly higher, as expected.

Across sampled sites, the average EC was 506 $\mu\text{S}/\text{cm}$, ranging from 53 $\mu\text{S}/\text{cm}$ at the Nyandarua National Polytechnic stream to 3532 $\mu\text{S}/\text{cm}$ at Ground Zero in Weru Ward. Within the lake itself, EC averaged 768 $\mu\text{S}/\text{cm}$, ranging from 152 $\mu\text{S}/\text{cm}$ at Mashimoni (Hippo) Pool to 3532 $\mu\text{S}/\text{cm}$ at Ground Zero. In rivers, EC values were lower, averaging 99 $\mu\text{S}/\text{cm}$ and ranging from 53 $\mu\text{S}/\text{cm}$ (Nyandarua National Polytechnic stream) to 135 $\mu\text{S}/\text{cm}$ (Ground Zero).

TDS values followed a similar trend. The average TDS across all sites was 253 ppm, with the lowest at 27 ppm (Nyandarua National Polytechnic stream) and the highest at 1765 ppm (Ground Zero). River sites recorded an average TDS of 49 ppm, ranging from 27 ppm (Nyandarua National Polytechnic stream) to 67 ppm (Manguo Bridge). Within the lake, TDS averaged 355 ppm, ranging from 76 ppm (Mashimoni Pool) to 1765 ppm (Ground Zero) (Figure 20, Appendix 8).

The elevated EC and TDS levels at Ground Zero and Rurii, both located on the western side of the lake, are likely attributed to anthropogenic activities that introduce soluble salts into the aquatic system. These may include runoff from agrochemical use in farms. The relatively low EC and TDS values in rivers suggest that geological sources (e.g., rock weathering) are not the primary contributors. Instead, the dilution effect from inflowing rivers, streams, and springs in the northern part of the lake likely accounts for the lower conductivity and TDS levels observed there.

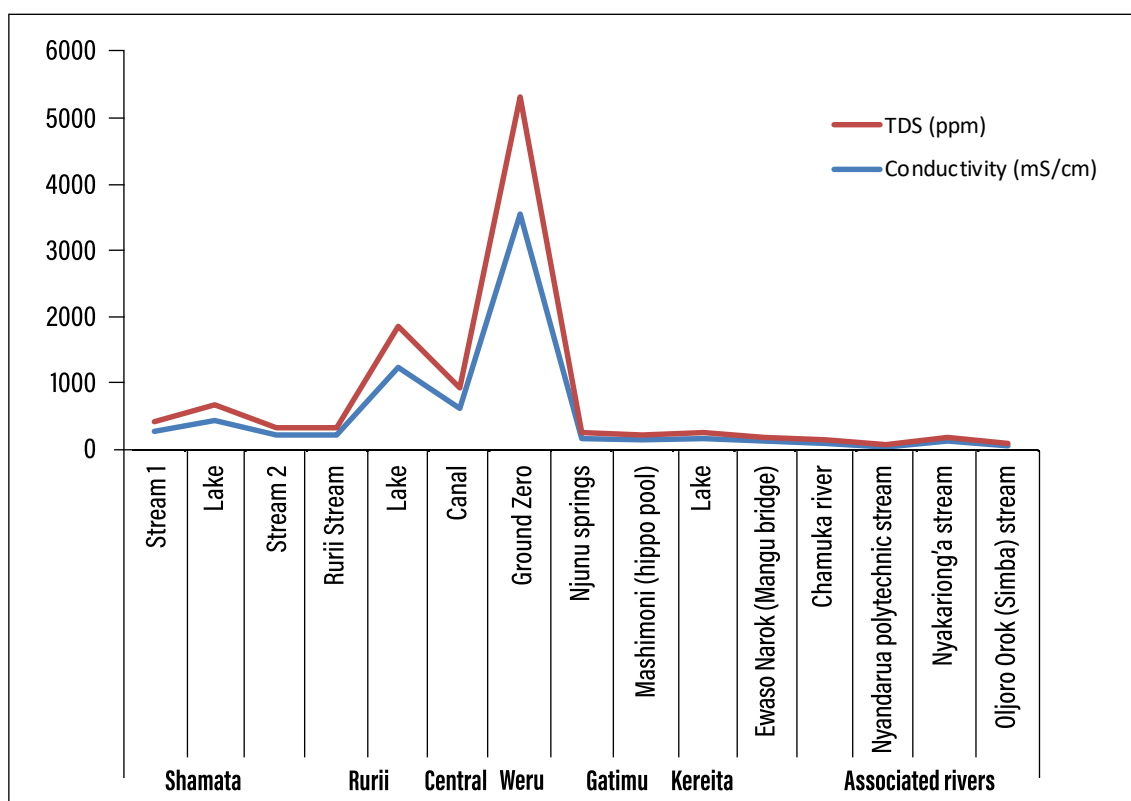


Figure 20: Electrical conductivity and total dissolved solutes (TDS) across the sampling sites

4.7.3 Salinity and Habitat-Specific Patterns

Salinity levels across all sampling sites averaged 0.254 PSU, with values ranging from 0.02 PSU at Nyandarua National Polytechnic stream to a maximum of 1.85 PSU at Ground Zero. Within the lake, the average salinity was higher at 0.359 PSU, varying between 0.07 PSU at Mashimoni and 1.85 PSU at Ground Zero. In the river systems, average salinity was considerably lower at 0.044 PSU, ranging from 0.02 PSU at Mashimoni to 0.06 PSU at Ewaso Narok and Nyakariang'a streams. Salinity patterns mirrored those of electrical conductivity and total dissolved solids (TDS), with Ground Zero and Rurii exhibiting the highest levels, suggesting a common anthropogenic source of contamination, likely linked to intensive agrochemical usage (Figure 21).

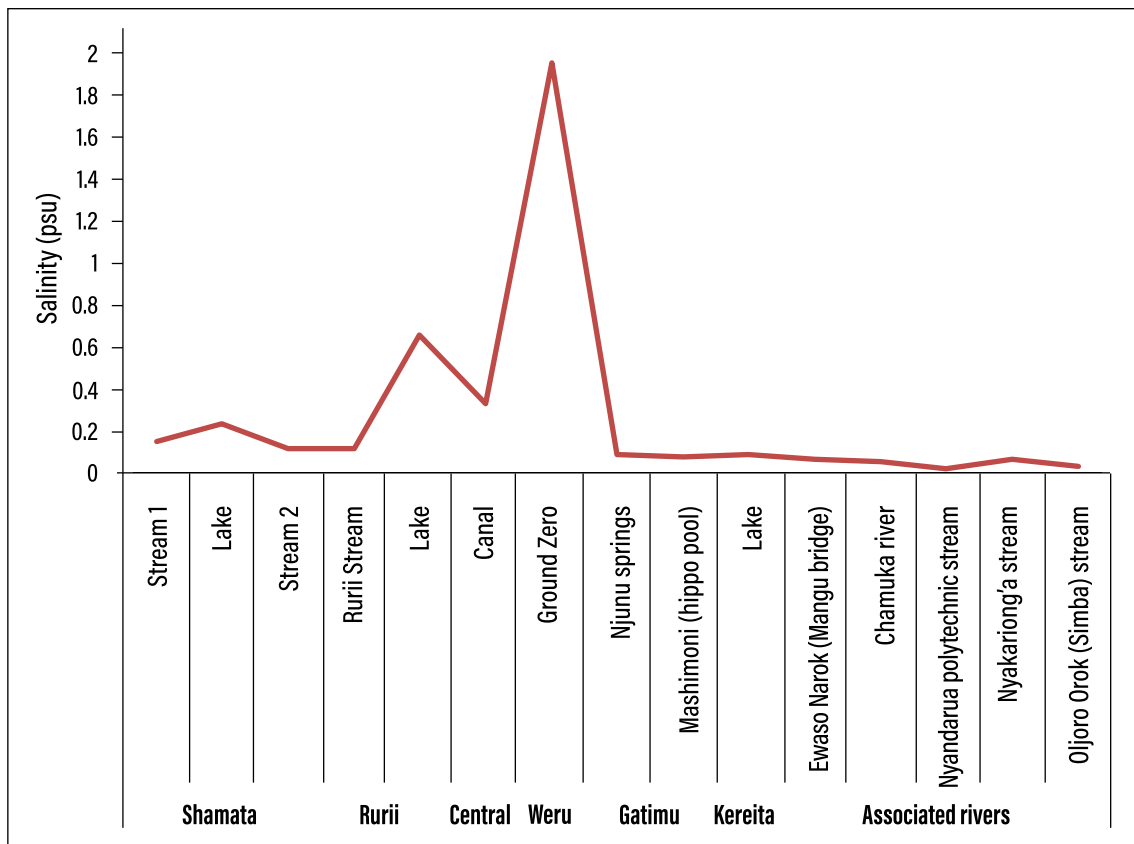


Figure 21: Salinity concentration across sampling sites

The pH was slightly alkaline averaging 7.48 and ranged from 7.16 in Rurii to 8.02 at Mashimoni. Within the lake, average pH was 7.48 and ranged from 7.16 at Rurii to 8.02 at Mashimoni while in the rivers; the average pH was 7.54 and ranged from 7.26 in Ewaso Narok to 7.88 at Nyakariang’a stream. Gatimu and Kereita wards sampling sites had relatively higher pH values compared to other sites (Figure 22).

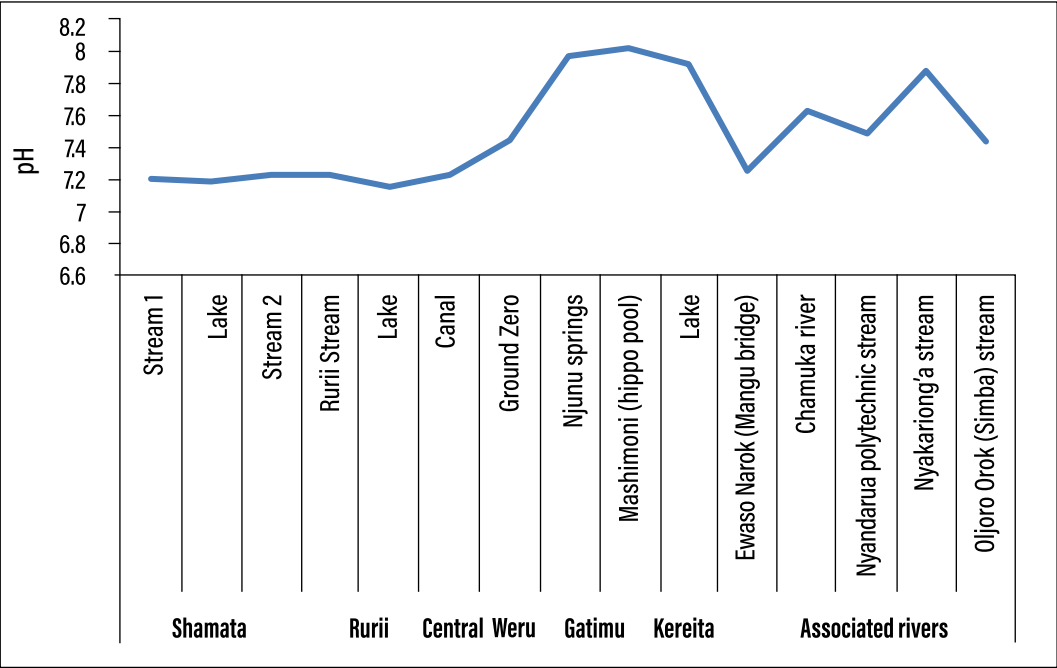


Figure 22: Water pH levels across the sampling sites



4.7.4 Surface Water Temperature

Surface water temperatures across all sites averaged 19.26°C, with a minimum of 15.15°C at Nyandarua National Polytechnic stream and a maximum of 26.34°C at Mashimoni. Within the lake, temperatures averaged 20.36°C, ranging from 15.73°C at the Central Ward canal to 26.34°C at Mashimoni pool. Riverine temperatures were cooler, averaging 17.04°C, and ranged from 15.15°C to 19.06°C, the latter recorded at Nyakariang'a stream (Figure 23). The observed variation in temperature may reflect differences in canopy cover, water depth, and inflow characteristics.

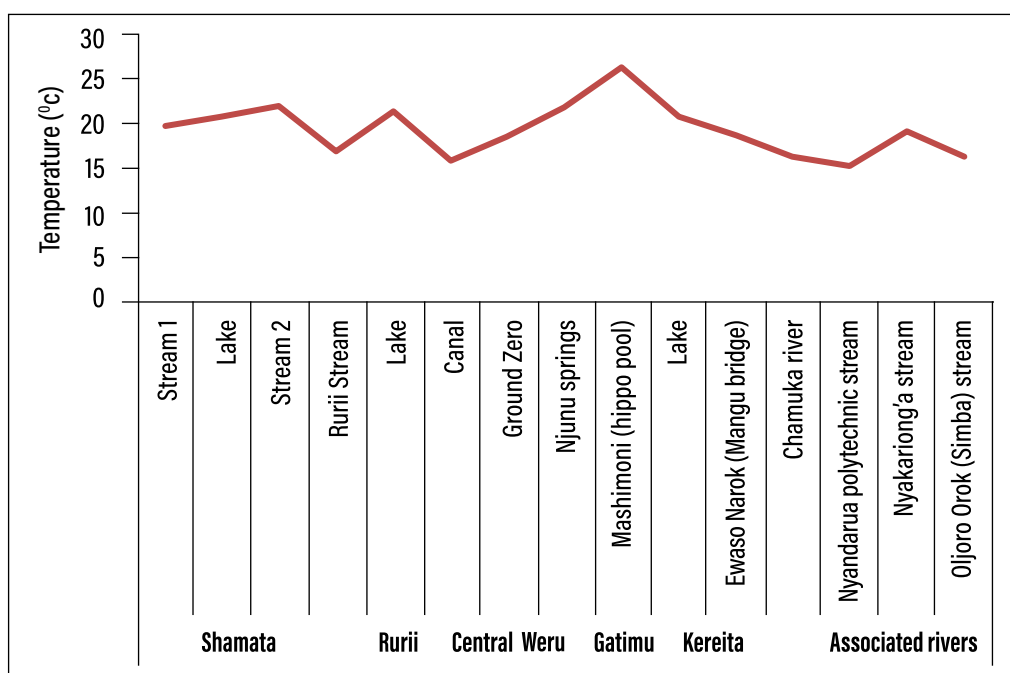


Figure 23: Surface water temperature across sampling sites

4.7.5 Nutrients: Nitrates and Phosphates

Nitrate concentrations varied substantially, from a high of 3.26 ppm at Ol Joro Orok stream to a low of 0.4 ppm at a stream in Shamata. Notably, Njunu Springs—one of the key natural inputs into the lake—had elevated nitrate levels at 2.66 ppm, indicating potential nitrate leaching from surrounding agricultural soils. Within the lake, the average nitrate concentration was 1.09 ppm, whereas river systems had a slightly higher average of 1.26 ppm, pointing to an inflow of agriculturally derived nitrates via these rivers.

Phosphate concentrations were generally low and more stable compared to nitrates, ranging from 0.16 ppm to a maximum of 0.96 ppm. Concentrations exceeding 0.5 ppm were recorded only at Rurii and Kereita, both lake locations, likely influenced by local runoff or sediment release. The average phosphate concentration was 0.41 ppm in lake waters and 0.25 ppm in rivers (Figure 24).

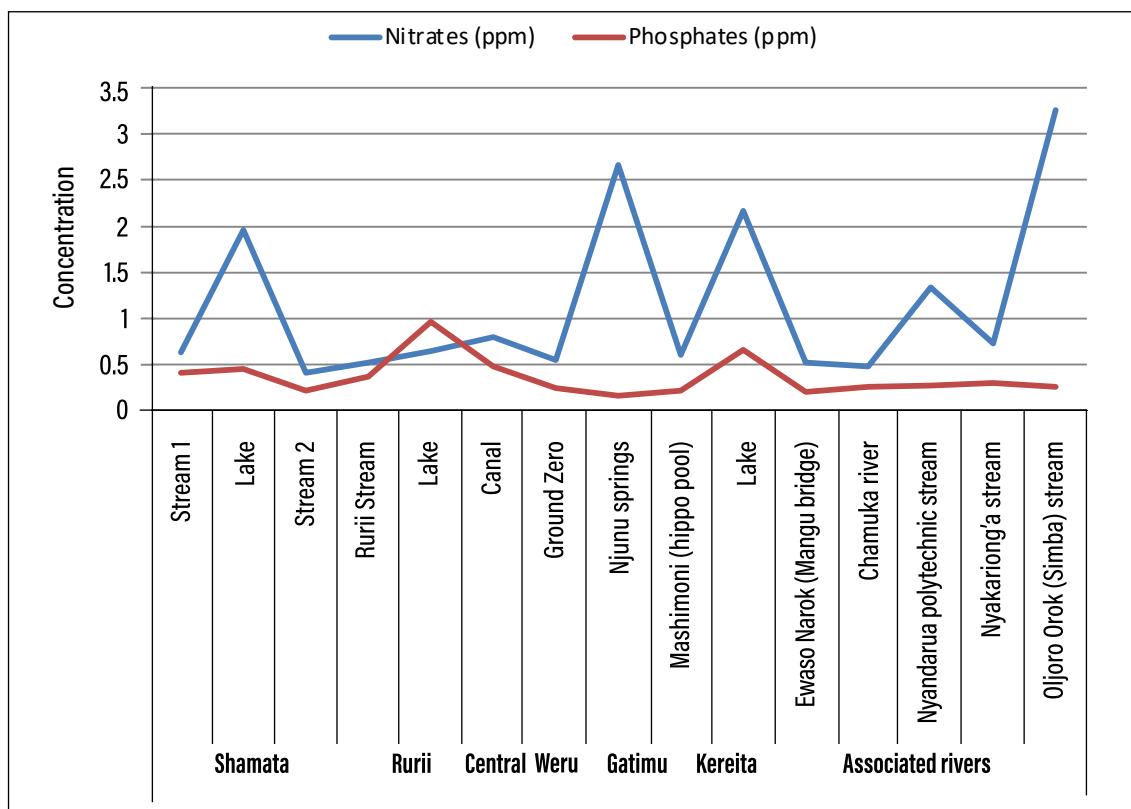


Figure 24: Concentrations of nitrate and phosphate across the sampled sites.

Nitrate levels showed high spatial variability, with peak concentrations observed in agricultural catchments, particularly at Ol Joro Orok stream and Njunu Springs. Phosphate concentrations were generally lower and more stable across sites, with elevated levels recorded only at Rurii and Kereita within the lake. These patterns suggest differential nutrient loading, likely driven by land-use activities and runoff dynamics.

4.7.6 Fish

A total of four fish species were recorded during the survey: *Oreochromis spilurus*, *Pseudocrenilabrus multicolor victoriae*, *Clarias gariepinus*, and *Enteromius paludinosus* (Table 20). This is lower than findings from the most recent 2019 survey, which documented seven species (Terer *et al.*, 2019), and literature reporting eight species historically (Nyingi, 2013). The observed decline is likely due to the recent desiccation of Lake Ol Bolossat. Since the sampling was conducted shortly after the onset of rains, the lake was in the early stages of recovery, and full fish recolonization had not yet occurred.

All species collected are currently classified as Least Concern on the IUCN Red List. Notably, *Oreochromis spilurus* and *Clarias gariepinus* are of significant

commercial value to local communities and were once key to the local fisheries economy, which has since collapsed due to the lake's drying. The remaining species, although of lesser commercial interest, still contribute to household protein intake and subsistence incomes. Observations of docked boats and abandoned gillnets illustrate the economic disruption caused by the lake's decline.

Interestingly, *Pseudocrenilabrus multicolor victoriae* is an introduced species, likely originating from the Lake Victoria basin, possibly via the ornamental fish trade. This poses potential risks to native biodiversity and ecosystem balance.

Table 20: List of fish species collected

Ward	Transect/ habitat	Species	IUCN Status	Economic importance	Abundance
Shamata	Lake	<i>Enteromius paludinosus</i>	LC	Subsistence	3
Rurii	Lake	<i>Enteromius paludinosus</i>	LC	Subsistence	16
Central	canal	<i>Enteromius paludinosus</i>	LC	Subsistence	3
Weru	Lake	<i>Pseudocrenilabrus multicolor victoriae</i>	LC	Aquarium, subsistence	1
		<i>Enteromius paludinosus</i>	LC	Subsistence	8
Gatimu	Njunu springs	<i>Enteromius paludinosus</i>	LC	Subsistence	34
		<i>Pseudocrenilabrus multicolor victoriae</i>	LC	Aquarium, subsistence	3
		<i>Clarias gariepinus</i>	LC	Subsistence, commercial, aquaculture, gamefish	observed
Gatimu	Mashimoni (hippo pool)	<i>Oreochromis spilurus</i>	LC	Subsistence, commercial, aquaculture, aquarium	1
		<i>Pseudocrenilabrus multicolor victoriae</i>	LC	Aquarium, subsistence	8
Kereita	Lake	<i>Enteromius paludinosus</i>	LC	Subsistence	17
		<i>Oreochromis spilurus</i>	LC	Subsistence, commercial, aquaculture, aquarium	15
		<i>Pseudocrenilabrus multicolor victoriae</i>	LC	Aquarium, subsistence	9
Associated rivers	Ewaso Narok (Manguo bridge)	<i>Enteromius paludinosus</i>	LC	Subsistence	observed
		<i>Pseudocrenilabrus multicolor victoriae</i>	LC	Aquarium, subsistence	observed

4.7.7 Conclusions and Recommendations

This survey documented only four fish species in Lake Ol Bolossat, supporting concerns about declining aquatic biodiversity. The lake's partial recovery following the rains suggests that recolonization is ongoing and may improve with time. Springs on the southeastern side, key sources of inflow, must be protected to sustain this recovery.

Clarias gariepinus and *Oreochromis spilurus* are important for food security and livelihoods, reaching sizes suitable for harvest. Conservation efforts should thus prioritize the protection and restoration of critical habitats, especially wetlands, which serve as spawning and nursery grounds during dry periods.

Globally, freshwater fish are increasingly threatened by anthropogenic pressures, including habitat loss, fragmentation, and climate change (Arthington *et al.*, 2016). The recent drying of the lake underscores this vulnerability. A locally led co-management approach is needed to protect the ecological processes and fish diversity within this dynamic wetland ecosystem.

Kenya's Fisheries Management and Development Act, 2016 offers a strong policy framework to support fisheries conservation. The establishment of Beach Management Units (BMUs) under the Fisheries Act (Cap 378, 2007) is a particularly useful co-management strategy and could be piloted in Lake Ol Bolossat.

Recommendations

Further Survey

This survey was conducted during the rainy season when the lake was in a recovery phase, and fish species were just beginning to recolonize their former habitats. Therefore, a follow-up survey is recommended once the lake has stabilized and recolonization is more advanced.

A survey during the dry season is also necessary to establish changes in fish diversity in relation to water quality. It is important to note that the lake is currently considered slightly alkaline, a condition likely exacerbated by reduced input from springs. This alkalinity may increase further during the dry season, potentially affecting fish composition.

Additionally, the source of high (TDS) and electrical conductivity observed on the western side of the lake, particularly in Weru and Rurii, requires further investigation. Special attention should be paid to establishments discharging water into the lake, such as flower farms.

Conservation and Management

The following recommendations are proposed to support the conservation and management of the wetland as an important biodiversity hotspot in Central Kenya:

Since the lake's only freshwater input comes from springs and small rivers, effective management of these water sources is crucial. The Water Resources Authority (WRA), in collaboration with Water Resource Users Associations (WRUAs), should strengthen the enforcement of water resource management policies within these river systems. Shared water intakes in the springs should be encouraged, as collective action allows communities to pool resources for pipe repairs—unlike the current system where individuals handle their own piping, leading to frequent leakages.

Controlled grazing around the lake must be implemented. Hundreds of livestock were observed during the assessment, and it appears that when the lake dried up, many locals increased their herds to exploit the temporarily exposed grazing land. This pressure is likely to intensify during future dry periods and, if left unchecked, could severely degrade the ecosystem. The natural grassland surrounding the lake has already been damaged and can only regenerate under a controlled grazing regime. Riparian vegetation, which serves as critical spawning and nursery grounds for fish, must be protected and restored.

Several large-scale flower farms are located in the lake's catchment, particularly around Dundori Ridge. Some, such as Primarosa, are situated very close to the lake. The use of agrochemicals and the improper discharge of effluents from these farms risk polluting the lake, with significant negative impacts on biodiversity. Similarly, small-scale farms use inorganic fertilizers, herbicides, and pesticides, which can also enter the lake and, over time, alter invertebrate composition.

Fisheries are a valuable component of the community's socio-economic activities and thus require better management. The establishment of a Beach Management Unit (BMU) in Lake Ol Bolossat should be explored to promote devolved and community-led resource management.

The potential of Lake Ol Bolossat as a tourism destination cannot be overstated. Its designation as an IBA has already placed it on the global map, particularly among birdwatchers. Other eco-friendly ventures such as sport fishing, aquaculture, boat rides, and recreational activities could also be developed further. The frequent visits by both local and international tourists, especially over weekends, indicate the lake's promise as a tourism hub. The county government, in collaboration with other stakeholders, should invest in harnessing and expanding this potential.



TAXA - BIODIVERSITY HOTSPOT SPATIAL ANALYSIS

By Dickens Odeny & Awuor Fredrick

4.8 Biodiversity Hotspot Spatial Analysis for Lake Ol Bolossat

4.8.1 Introduction

Biodiversity hotspots are areas characterized by exceptionally high species richness, including a significant number of endemic species, and are simultaneously under considerable threat from anthropogenic activities. These threats include deforestation, habitat degradation, pollution, and the accelerating impacts of climate change. The conservation value of biodiversity hotspots lies not only in their biological uniqueness but also in the urgency of protecting them due to the magnitude of human-induced threats they face.

Hotspots are typically defined using a combination of biogeographic, jurisdictional, and ecological parameters, allowing for targeted conservation and restoration planning. Due to their ecological sensitivity and species uniqueness, these areas often receive priority from conservation organizations and government agencies, as preserving them can yield disproportionately large benefits for global biodiversity.

The concept of biodiversity hotspots integrates scientific assessment of biological diversity with other biophysical and socio-ecological variables to enhance conservation decision-making. Numerous conservation bodies have adopted the hotspot model as a strategic investment approach (Sloan *et al.*, 2014). However, critiques of the hotspot approach highlight its limitations—particularly its reliance on species counts and geographic endemism, which may overlook areas of ecological transition and other vital ecological dynamics (Jepson & Canney, 2001; Marchese, 2015).

To address these gaps, newer frameworks emphasize biodiversity integrity and consider broader taxa beyond plants, which were traditionally used as umbrella indicators for other species groups (Marchese, 2015). This inclusive, multi-taxa approach aims to develop more representative and resilient conservation strategies.

4.8.2 Ground Truthing and Land Use/Land Cover (LULC) Analysis

Ground truthing within the Lake Ol Bolossat Management Plan area identified seven principal land use/land cover (LULC) types: lake, swamp, grassland, farmland, woodlots, shrubland, and forest (see Appendix 9). The lake and swamp, comprising the Ol Bolossat Wetland, are ecologically dynamic due to periodic flooding and aquatic vegetation succession.

Forests, composed predominantly of indigenous tree species, are primarily located along the Satima Escarpment, often in mosaics with shrublands. Grasslands—used largely for livestock grazing—are subject to seasonal variation and may periodically transition to fallow farmland depending on flooding regimes. Farmlands are associated with human settlements and active cultivation of various crops. Woodlots, mainly consisting of exotic Eucalyptus plantations, have expanded substantially in recent years, prompting their classification as a distinct land use type.

Among all LULC categories (Table 21), farmlands and grasslands dominate the landscape, each covering approximately 38% of the total area. Woodlots account for 11%, followed by forests (10%) and shrublands (2%). At the ward level, Weru Ward contains the largest extent of farmland (31%), followed by Rurii (21%), while Kiriita and Manguo area (Igwamiti Ward) show minimal farmland presence. Grasslands are most extensive in Gatimu Ward (28%) and Weru (24%).

Woodlots are most prominent in Rurii Ward (53%), followed by Weru (32%). Shamata Ward exhibits the highest proportion of shrubland (67%), with Gatimu contributing the remaining 33%. The swampy wetland zone is entirely located within Manguo area - Igwamiti Ward (100%). Forested patches occur primarily in Central and Chaparungu area (Kiriita Ward), each contributing 50% to the total forest area.

Table 21: Land use and land cover types within the Lake Ol Bolosat mangement plan area (%)

Land Use	Central	Chaparungu	Gatimu	Kiriita	Manguo	Rurii	Shamata	Weru	Ziwani
Farmland	12	9	19	1	1	21	6	31	0
Forest	50	50	0	0	0	0	0	0	100
Grassland	12	6	28	3	6	21	0	24	1
Shrubland	0	0	33	0	0	0	67	0	0
Swamp	0	0	0	0	100	0	0	0	0
Woodlot	5	11	26	26	11	53	0	32	11



Plate 37: Land use and land cover types within the Lake Ol Bolosat Management Plan area

4.8.3 Crop Diversity and Distribution in Farmlands

Although farmlands and grasslands dominate land use, croplands are particularly important for understanding ecological transitions and anthropogenic pressures. Approximately 12 crop types are cultivated, with maize showing the highest distribution frequency (34%), followed by potato and oat (each at 12%), and wheat and cabbage (each at 6%) (Table 22).

Crops such as onion, sunflower, carrot, and avocado each register only 1% distribution frequency. Maize is widely grown in Gatimu and Weru Wards (9% each), with Rurii following (7%). Oat farming is concentrated in Rurii and Weru Wards (4% each). Potatoes are prevalent in Weru (4%) and Chaparungu area - Kiriita (3%), while wheat cultivation is most common in Gatimu and Weru (3% each). Beans are primarily grown in Weru (3%).

Table 22: The distribution frequency of types of crops in areas within Lake Ol Bolossat management plan area

Crop Type	Central	Chaparungu	Gatimu	Kiriita Ward	Manguo	Rurii	Shamata	Weru	Ziwa
Avocado	0	0	0	0	0	0	0	1	0
Beans	1	0	1	0	0	1	0	3	0
Cabbage	1	1	0	0	1	0	1	0	0
Carrots	1	0	0	0	0	0	0	0	0
Grass	0	0	0	0	0	0	0	1	0
Kales	0	0	1	1	0	0	0	0	0
Maize	3	3	9	0	0	7	3	9	0
Oat	1	0	0	0	0	4	1	4	0
Onion	1	0	0	0	0	0	0	0	0
Potato	1	3	1	0	0	1	0	4	0
Sunflower	0	0	1	0	0	0	0	0	0
Wheat	0	0	3	0	0	0	0	3	0



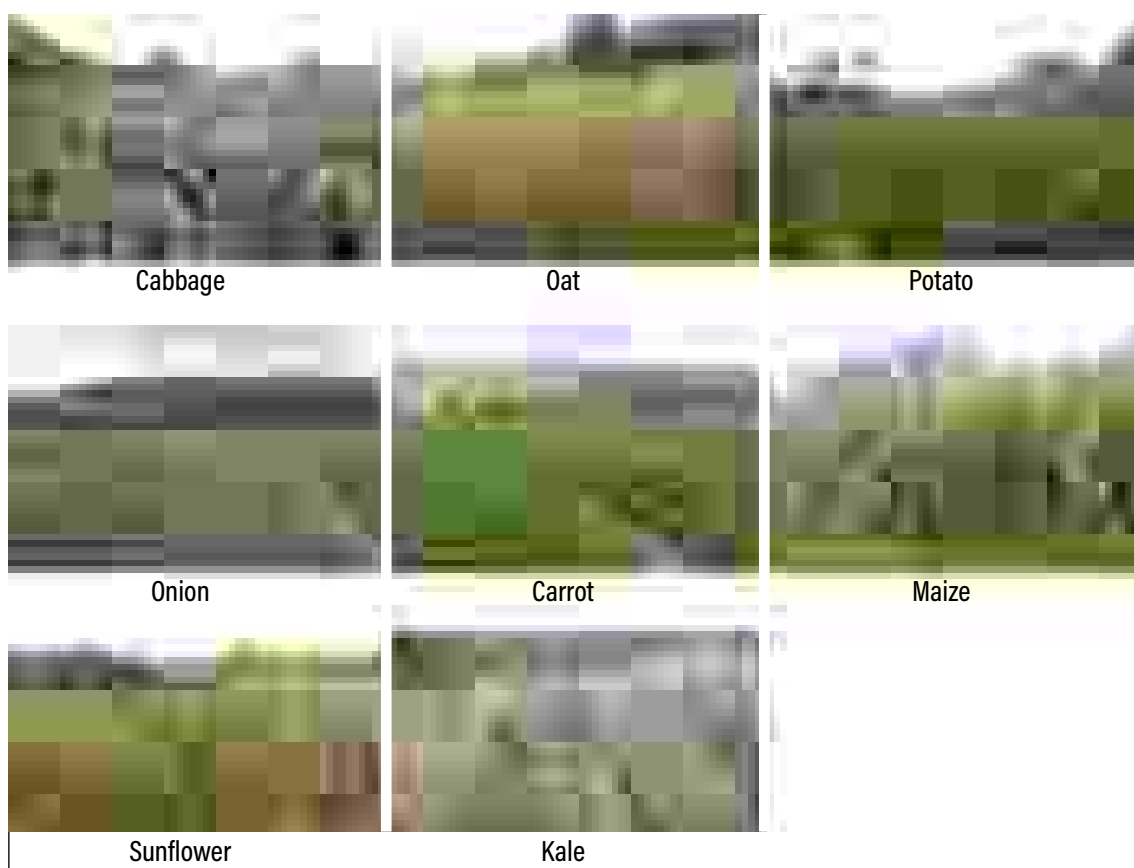


Plate 38: Types of crops grown on farmland around Lake Ol Bolossat

4.8.4 Land Use, Land Cover, and Fragmentation Dynamics

The land use and land cover (LULC) patterns around Lake Ol Bolossat have evolved significantly over time in terms of type, spatial extent, and fragmentation. The area under study is defined by the Lake Ol Bolossat Management Plan and has experienced severe landscape changes and the emergence of new land cover types from the 1970s through the 2020s.

Satellite imagery analysis was conducted for the years 1973, 1986, and 2019, focusing on the dry season (January–February) to ensure consistency in seasonal comparisons. The results indicate a dramatic increase in landscape fragmentation, with the number of fragments rising from 3,395 in 1973 to 32,158 in 1986, and sharply escalating to 219,137 fragments by 2019 (Table 23). This exponential increase suggests intensifying anthropogenic pressures and uncoordinated land use transitions.

In 1973, the main land cover types included forest/thickets, grasslands (dominated by tussocks), farmlands and ranches, wetlands (both vegetated and open water), and built-up areas. Built-up zones were minimal and mainly confined to the northern part of the area, around Nyahururu Town.

The wetland system in Ol Bolossat consists of dynamic open water zones and macrophyte-dominated areas, primarily sedges (Cyperaceae), which have shown considerable spatiotemporal variability from 1973 through the 2020s. The lake's

hydrological regime is highly variable, with instances of complete drying followed by flooding. In 1986, the lakebed dried entirely, exposing dark, organic-rich soils. During dry periods, approximately 323 hectares of wetland temporarily converted to grassland, 62 hectares transition to cultivated land, and about 827 hectares dry up completely.

Grasslands in the Lake Ol Bolossat landscape occur in two major formations: short grasses and tall grasses, commonly known as tussocks. These habitats are critical for grassland-dependent birds and small mammals, particularly rodents. In 1973, much of the grassland was under ranching, with large, regularly shaped polygons indicative of managed grazing. However, by 1986 and into the 2020s, these grassland patches had fragmented into irregular clusters, reflecting a shift toward unregulated and disorganized land use.

The tussock grasslands have notably declined in area over the study period, increasingly being replaced by short grasses and cultivated farmland. This shift is particularly evident near the lake, where flood regimes influence vegetation dynamics. Between 1973 and the 2020s, an estimated 10,137 hectares of grassland, both short and tussock, were lost to other land uses. Moreover, about 47% of tussock grassland was converted to short grass cover, and much of the original tussock areas were reduced to small, fragmented patches.

Forest and thicket cover was present in all three study years but has significantly declined in area and now exists mostly in small, fragmented clusters along the eastern escarpment. Much of this native vegetation has been replaced by Eucalyptus plantations (58 ha), cultivated land (190 ha), grasslands (267 ha), and built-up areas (15 ha) (Appendix 10).

Built-up areas were minimal in 1973, covering approximately 57 hectares, mostly dense settlements and infrastructure near Nyahururu, excluding dispersed rural housing. However, by the 2020s, built-up areas had expanded dramatically to over 300 hectares. Of this expansion, approximately 158 hectares emerged from former grassland, 41 hectares from sedge-dominated wetlands, and 4 hectares from former forest/thicket areas (Table 23, Appendix 10).

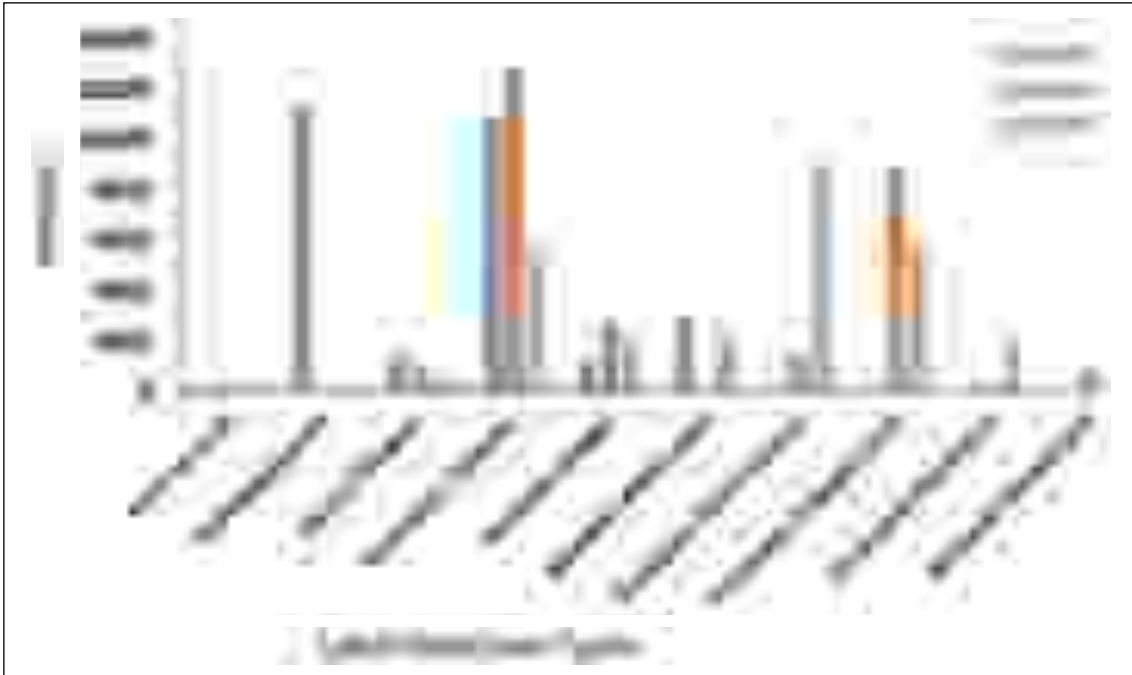


Figure 25: Land Use Land Cover change analysis from 1973 to 2019

Table 23: Land Use Land Cover change analysis from 1973 to 2020

LULC Type	Area (ha.)			Fragments (No.)		
	1973	1986	2019	1973	1986	2019
Forest/Thickets	1208	783	485	8	564	1012
Built-up area	57	170	292	6	478	2715
Wetland: Sedges	1207	2846	1900	407	3994	3742
Wetland: Water area	2886	0	2237	12	0	150
Grassland	0	1328	9335	0	1193	64946
Grassland: Tussocks	10840	12715	5643	2069	9297	62194
Farmland/Ranch	11304	0	0	814	0	0
Farmland/Cropped	0	8761	5825	0	12492	70922
Muddy Soil	0	827	0	0	104	0
Eucalyptus Plantation	0	177	1920	0	44	13627





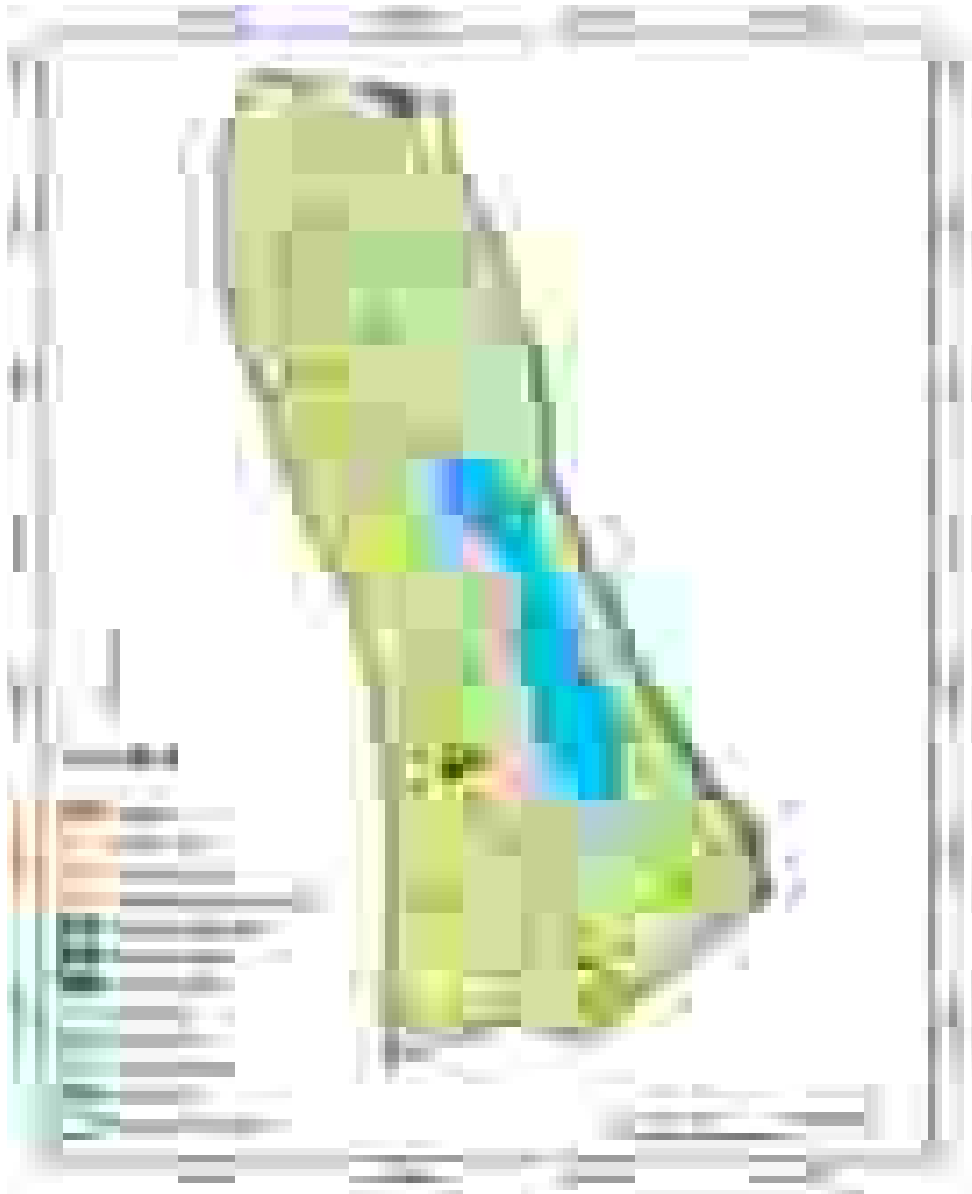


Figure 26: Land use land cover within the Lake Ol Bolossat Management area for the year 1973, 1986, and 2019

4.8.5 Biodiversity Hotspot

The spatial distribution of biodiversity hotspots across the Lake Ol Bolossat Management Plan area varies among administrative locations. Approximately 12% of the management area is classified as very hot for biodiversity conservation, these are zones identified as highly suitable for species conservation efforts. An additional 31% of the landscape falls under the moderately hot category, while the remaining 57% is considered less suitable as habitat for biodiversity conservation.

Among the locations, Weru contains the largest share of the very hot biodiversity zones, comprising 44% of the total high-priority conservation areas in the management region. Shamata and Rurii follow with 16% and 13%, respectively. The moderately hot zones are most prominent in Gatimu (representing 25% of this class), followed by Rurii (20%), and both Shamata and Weru (each contributing 18%).

Very hot biodiversity hotspots range in size from 7 ha in Nyahururu to 1,400 ha in Weru Location (Figure 27, Table 24). These hotspots are composed of numerous fragments, with individual fragment sizes typically ranging from 0.10 to 0.16 ha. Notably, Weru Location shows the highest variability in fragment sizes, including the largest contiguous patch measuring 34.56 ha (Table 24). In contrast, Gatimu and Kanyagia host relatively fewer and smaller very hot biodiversity zones.

Moderately hot areas are widespread in four main locations, with Gatimu leading at an estimated 2,203 ha, followed by Rurii (1,718 ha), Shamata (1,564 ha), and Weru (1,550 ha). Interestingly, despite Weru's prominence in very hot and moderately hot categories, it also has the largest area classified as less hot for biodiversity conservation.



Figure 27: Spatial distribution of biodiversity hotspots within L. Ol Bolossat Management Plan Area

Table 24: Biodiversity hotspot category

Location	Hotspot Category			Hotspot Category: Very Hot				
	Very Hot	Moderate	Less Hot	Fragments	Min.	Max.	Mean	Std
Weru	1400	1550	3936	8994	0.00	34.56	0.16	0.53
Shamata	623	1564	2127	5061	0.00	5.00	0.12	0.13
Rurii	434	1718	2469	3045	0.00	27.10	0.14	0.55
Gatimu	411	2203	3797	3707	0.00	1.44	0.11	0.07
Kanyagia	106	390	1302	863	0.00	1.44	0.12	0.11
Maina	89	168	461	629	0.00	1.80	0.14	0.15
Kiriita	83	513	681	733	0.00	0.72	0.11	0.08
Kaimbaga	26	363	705	253	0.00	0.45	0.10	0.05
Wanjohi	25	87	32	219	0.00	1.10	0.12	0.10
Leshau	8	12	7	56	0.09	0.54	0.14	0.09
Nyahururu	7	72	263	61	0.06	0.36	0.11	0.05

Species richness data from key taxonomic groups were unevenly distributed across hotspot categories. Invertebrate records were predominantly collected from moderate and less hot zones. However, an estimated 52% of invertebrate species richness variation can still be explained by the spatial arrangement of hotspot zones, indicating a spatial correlation with lower-tier habitats. Their richness tends to decrease with increasing hotspot value (Figure 28).

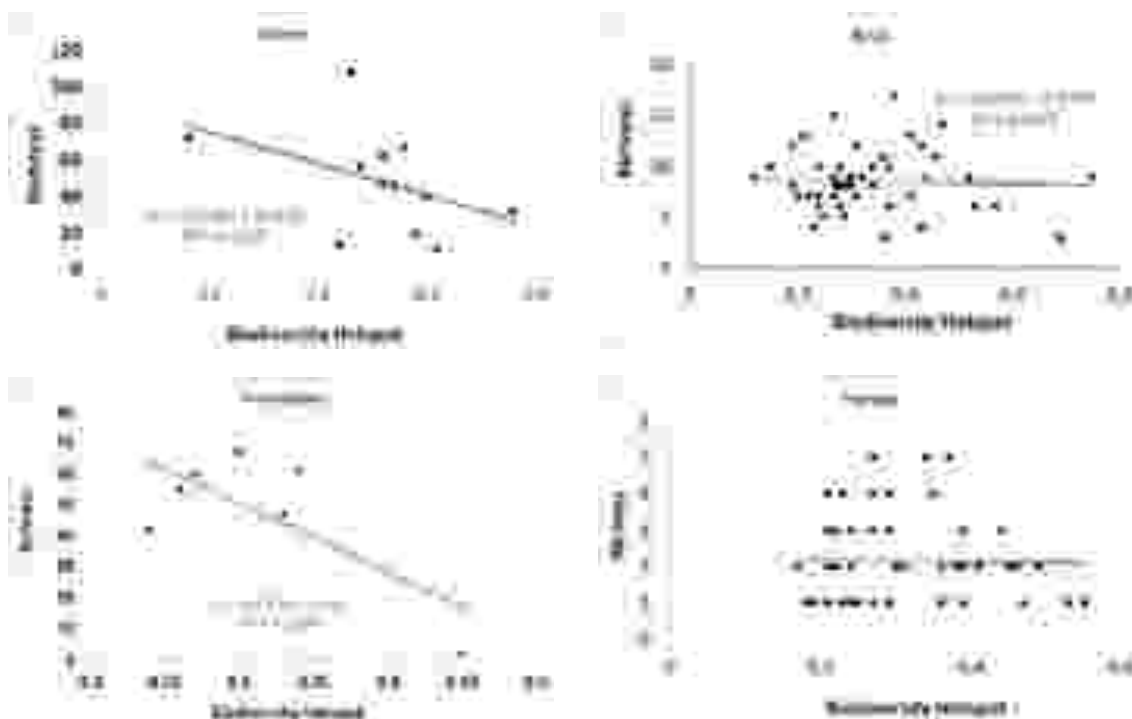


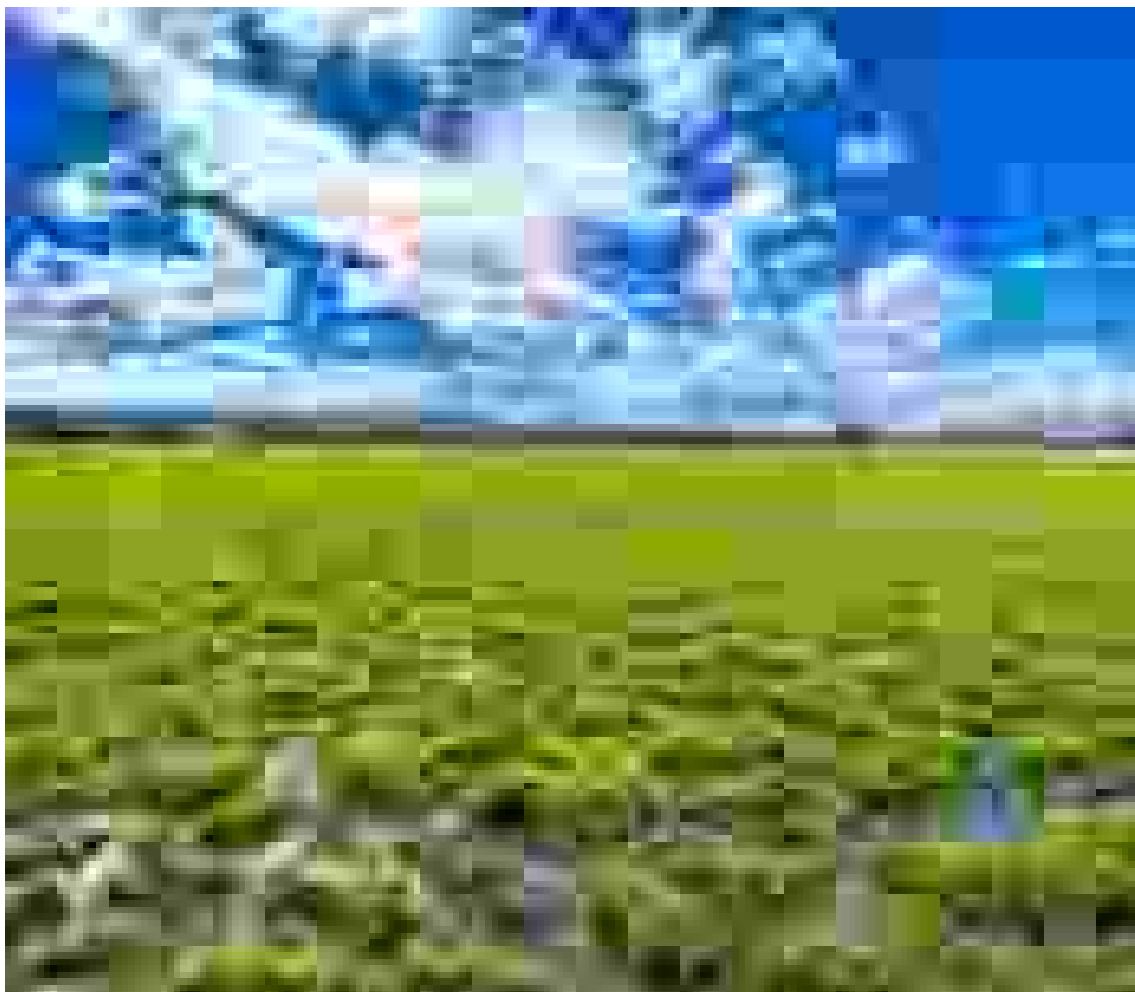
Figure 28: Biodiversity hotspots per species

Plant species data were mostly sampled within less and moderately hot areas, exhibiting a similar trend of declining richness with increasing hotspot classification. Bird records, in contrast, were more evenly distributed across all categories—less, moderate, and very hot—with no clear pattern of change in species richness across hotspot values. Thus, bird diversity appears relatively homogeneous around the lake.

Herpetofauna data points were primarily found in the less and moderately hot zones. Their distribution was also relatively uniform and did not exhibit a trend corresponding to hotspot intensity.

4.8.6 Conclusions and Recommendations

Apparently, most of the plant data were sampled in the less and moderately hot biodiversity areas. The trend shows plant species richness distribution is varied and decreases with the increase in hotspot values. The distribution of data points for birds ranged from less, moderately and few in the very hot areas. The distribution does not show changes with the increase in hotspot values. Thus, the distribution of bird species richness is nearly homogenous around the lake. Herpetofauna species data points occur in the less and moderate hot biodiversity areas around the lake. Their distribution varies less but does not show a trend with the increase in hotspot values around the lake.





SOCIO-ECONOMIC

By Charity Kinyua, PhD

4.9 Socio-Economic Characteristics

4.9.1 Introduction

The respondents exhibited moderate literacy levels and asset ownership but relatively good access to education and health services. However, infrastructural development was generally considered inadequate. Most households used pit latrines for sanitation. The road network and access to public transport were considered relatively adequate by the majority of respondents. Land tenure was primarily under family ownership, followed by settlement schemes. These findings are elaborated in the report.

Household Characteristics

The average household size was six members. Male-headed households constituted 75%, female-headed 24%, and 1% were reportedly headed by children. Most household heads (66%) were men in monogamous marriages, while 11% were widowed females. Regarding education levels, 38% of household heads had attained secondary education, 28% had primary education, 21% had attended college, and 8% had university-level education. A small percentage had only adult education (1%) or no formal education at all (2%).

Household Assets

Commonly owned assets included mobile phones, televisions, and radios. Ownership of motor vehicles, motorcycles, CD/VCD/DVD players, refrigerators, and satellite receivers was relatively rare (Table 25).

Table 25: Distribution of household assets

Variable	Responses %	Mean
Cars and trucks	49	1.102041
Motorcycle	76	1.144737
TV	209	1.210526
Satellite receiver	10	1
CD/ VCD/DVD player	45	1.133333
Mobile phones	253	2.43083
Radios	208	1.365385
Refrigerator	23	1

House Construction Materials

Approximately 97% of respondents lived in houses with iron sheet roofs; 1% had thatched roofs, and 2% used tiles. Wall materials varied: 36% had stone/brick/cement walls, 35% wood, 15% iron sheets, and 29% mud. Regarding flooring, 54% had stone/brick/cement floors, 43% had earth floors, 0.3% had wooden floors, and 3% had tiled floors.

Community Development Engagements

Only 38% of the 255 households surveyed reported membership in community development organizations. These groups primarily engaged in cash saving and

lending, and provided financial support during crises such as illness or death (Figure 29). The most commonly cited benefit of membership was access to financial capital. Other reported benefits included access to technical agricultural information, marketing support for agricultural produce, and financial assistance during emergencies. Reasons for non-membership (62%) included lack of awareness about the organizations, lack of interest, their non-existence in the area, financial constraints, time limitations, religious reasons, or opposition by spouses.



Figure 29: Activities of community development groups

Education Institutions

The study area had 32 nursery schools, 25 primary schools, and 14 secondary schools (Table 26).

Table 26: List of schools in the area

	Nursery Schools	Primary Schools	Secondary Schools
1	Subuku	Maryland	Weru
2	Muruai	Makereka	Lake Ol Bolossat
3	Makereka ECDE	Kianjata	Kimaru
4	Kanguu	Kianduba	Huhirio
5	Wisdom Pan Preschool	Ngurumo Highway	Senior School
6	Ngurumo ECDE	Mukindu	Eliab High School
7	St Bakita Preschool	Kibathi	Baari
8	Iriani Ecde	Karandi	Subuku
9	Mugathika	Kanjogu	Mukindu
10	Maryland	Iriani	Karandi
11	Kianduba	Equator	Kanguu
12	Mukindu	Wangatambuthi	Kahuho
13	Karandi	Subuku	Githunguchu
14	Kanjogu	Muruai	Gatimu Mixed
15	Kamaina	Kanguu	-
16	Kahingo	Gakoe	-
17	Masika	Ol Bolossat	-
18	Kimaru	Mugathika	-
19	Gatitu	Ritaya	-
20	Gakoe	Kimaru	-
21	Njunu ECDE	Baari	-
22	Joy Cente	Kamaina	-
23	Prestige	Kahingo	-
24	By Faith	Gatitu	-
25	Weru	Weru	-
26	Wangatambuthi	-	-
27	Equator	-	-
28	Kibathi	-	-
29	Ol Bolossat Primary ECDE	-	-
30	Ndemi Catholic Preschool	-	-
31	Baari Nursery	-	-
32	Little Angels Nursery School	-	-

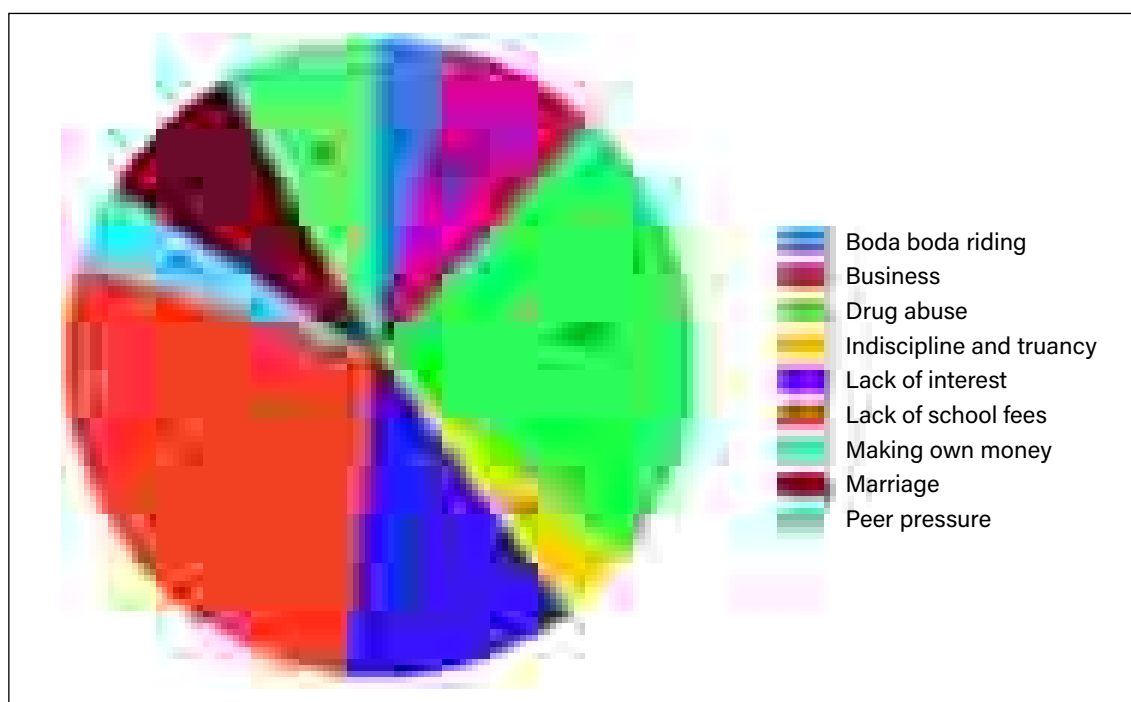
The average distance to the nearest nursery, primary and secondary schools was 1.5 km, 1.6 km and 3 km respectively, with maximum distances of 9 km, 9 km, and 13 km, respectively (Table 27),

Table 27: Distance to nearest schools

Variable	Responses	Mean
Distance to nearest nursery	241	1.44917
Distance to nearest primary	241	1.586515
Distance to nearest secondary	241	2.929461

Among 221 households, the average annual education expenditure was KES 92,630, though it ranged from KES 1,500 to KES 1,200,000.

Approximately 14% of the 254 households reported school dropout incidents, with 21 girls and 24 boys affected. The maximum number of girls dropping out in a single household was four, compared to a maximum of two boys. For boys, the main reasons for school dropout, in descending order, were: lack of school fees, drug abuse, lack of interest, desire to earn money, peer pressure, and marriage (Figure 30).

**Figure 30: Reasons boys dropped out of school**

For girls, the primary causes were early pregnancy, lack of school fees, marriage, lack of parental attention, lack of interest, and peer pressure (Figure 31).

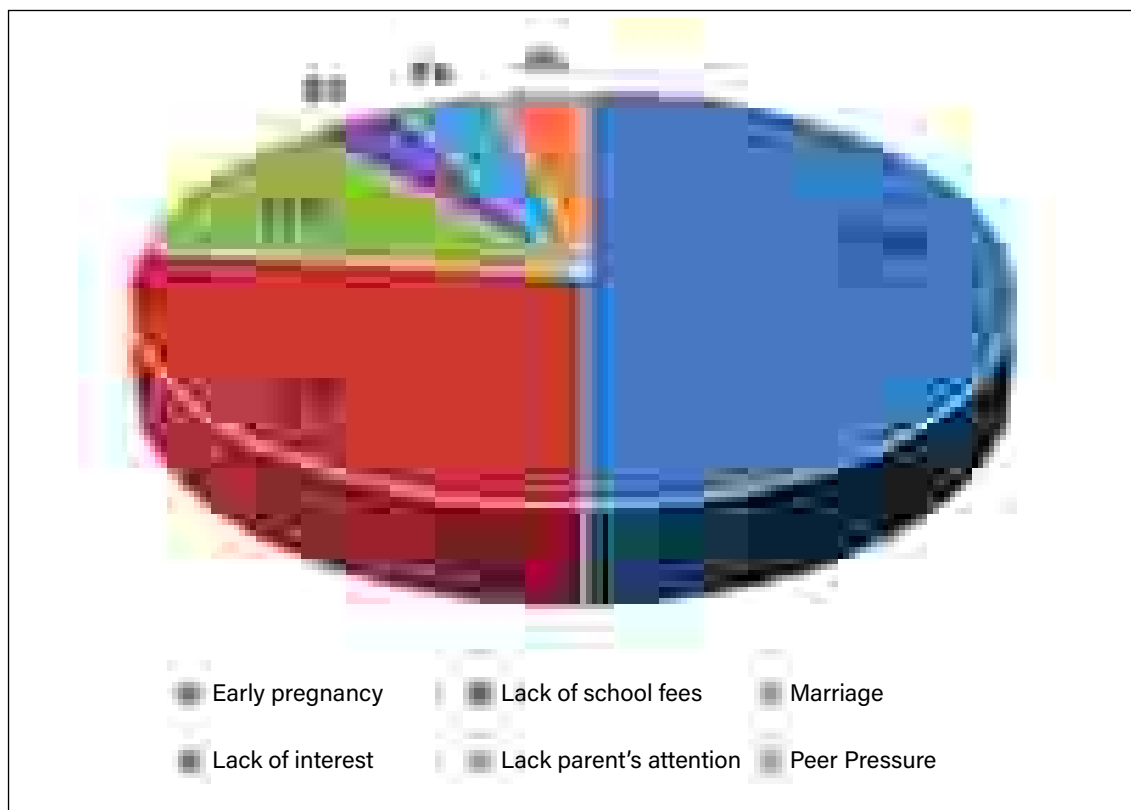


Figure 31: Reasons girls dropped out of school

The main challenges reported in accessing education included: lack of school fees (40%), inadequate school infrastructure (13%), impassable roads during the rainy season (12%), long distances to schools (11%), threats from wildlife (6%), student drug abuse (5%), and an insufficient number of qualified teachers (3%).

Infrastructure

The average distance to the nearest marram and tarmac roads was 1.5 km and 7 km, respectively. The maximum distances recorded were 17 km and 50 km. A majority (57%) of the 196 respondents indicated that public transport services in the area were adequate. The average distance to the nearest market centre was 5 km, with the furthest located 20 km away. The primary services offered in these markets included banking, shopping, and health services (Figure 32).



Figure 32: Services obtained from market centres

Respondents observed that infrastructure in the market centres had improved, attributed to the rise in economic activities in the area. The five most commonly sold wetland-derived products at market centres were fish (16%), maize (15%), potatoes (10%), beans (8%), and cabbage (7%) (Figure 33).



Figure 33: Wetland-derived products sold at the market centres

Beyond the immediate market centres, wetland-derived products were also traded in Nyahururu, Rurii, Kasuku, Mairo Inya, and via brokers, which emerged as the top five additional trade avenues (Figure 34).

Figure 34: Other centres where the wetland-derived products are traded

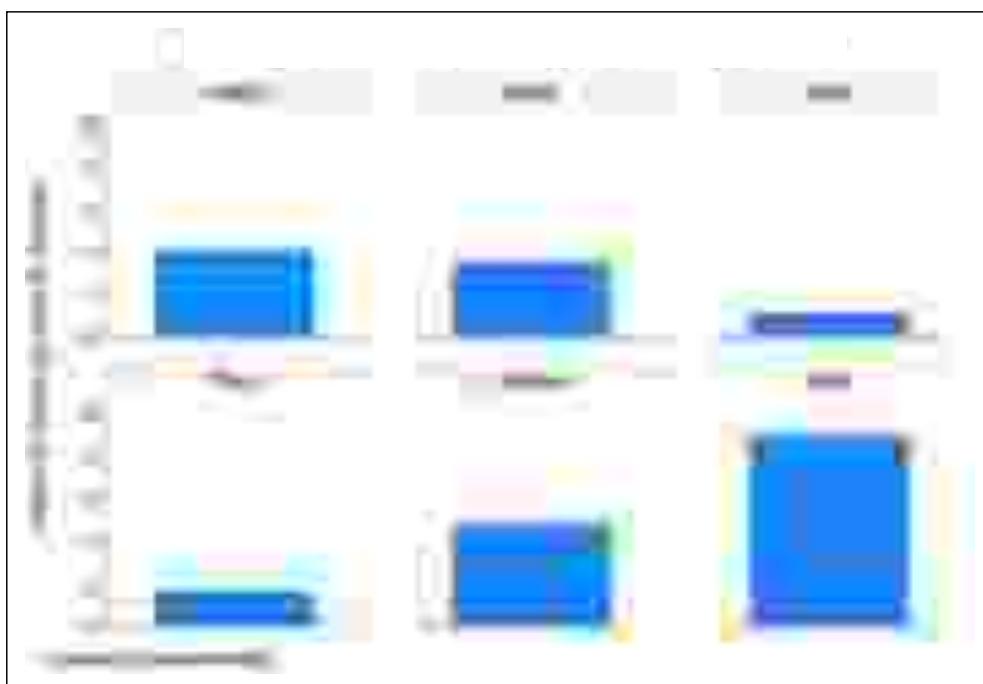
The three most prevalent human diseases in the Lake Ol Bolossat ecosystem were the common cold (23%), pneumonia (21%), and typhoid (18%). Respondents attributed these diseases mainly to cold weather conditions (34%), mosquitoes (14%), stagnant water (11%), adverse weather (9%), and contaminated water (8%). The diseases were most frequently reported during July (26%), the rainy season (10%), and June (9%). The average annual household healthcare expenditure, reported by 237 households, was KES 19,839.

Fifteen health facilities were identified across the study area, predominantly composed of dispensaries, and fairly distributed among wards (Table 28).

Table 28: Health facilities by ward

Health Facility	Central	Gatimu	Kiriita	Rurii	Shamata	Weru	Total
Afya Bora Hospital	0	0	6	0	0	11	17
JM Memorial Ol Kalou	0	0	0	0	1	0	1
Kasuku Dispensary	4	1	0	8	3	8	24
Kiribati Dispensary	0	0	0	0	1	0	1
Mukindu Dispensary	6	0	0	32	4	0	42
Ol Bolossat Dispensary	1	0	0	0	0	0	1
Rurii Dispensary	1	0	0	0	0	0	1
Subuku Dispensary	10	22	8	0	3	0	43
Baari Dispensary	2	0	9	0	12	2	25
Gatimu Dispensary	3	17	1	0	0	0	21
Gatimu Health Centre	0	4	3	0	1	9	17
Globe Health Facility	0	2	0	0	7	0	9
Kanguu Dispensary	0	0	0	0	0	10	10
Kirima Dispensary	13	2	13	0	8	4	40
Malatan Health Facility	1	0	0	0	1	0	2
Total	41	48	40	40	41	44	254

The average distance to the nearest health facility was 4 km and maximum distance reported was 30km. Kiriita Ward had the shortest distance to health facility (1.15 km) while Weru Ward had the longest average distance to health facility (8.96 km) (Figure 35).

**Figure 35: Average distance to nearest health facility by ward**

Land Tenure

Among the 255 households surveyed, land tenure was primarily through family land (56%), followed by settlement schemes (15%), trust land (10%), rented land (7%), government land (3%), and other forms (7%) such as leased or purchased parcels. The mean land price reported by 248 respondents was KES 1,801,005, ranging from KES 7,000 to 2,500,000. Land sizes varied between 0.125 acres and 26 acres, depending on tenure type (Table 29).

Table 29: Land tenure types

Variable	Responses	Mean	Std. dev.	Min	Max
Trust land size	22	3.73	3.05	0.25	10
Government land size	7	4.29	2.059	2	8
Rented land size	18	1.749	2.61	0.125	10
Settlement land size	33	4.459	6.28	0.125	24
Other land tenure size	16	6.25	3.40	1	12
Family land size	131	4.63	4.44	0.125	26

Land tenure was predominantly through family land in all wards except for Gatimu Ward where land tenure was predominantly settlement schemes. Land tenure through settlement schemes was also important in Shamata Ward (Figure 36).

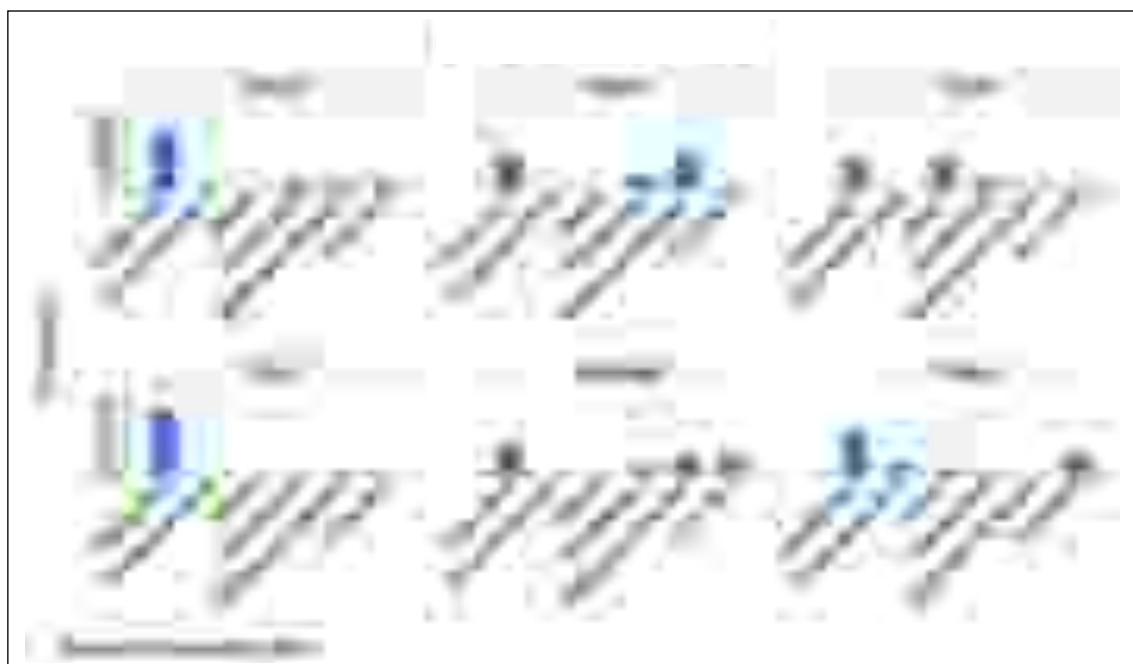


Figure 36: Land tenure by ward

Most land had formal legal status, with the majority under title deeds, and some held via allotment letters or informal self-allocation (Table 30).

Table 30: Land tenure type legal status

Legal status others	Frequency	%
Self-allocation	1	6
Titled	17	94
Responses	18	100
Trust land legal status	Frequency	%
Allotment letter	1	4
Self-allocation	7	29
Titled	16	67
Responses	24	100
Government land legal status	Frequency	%
Allotment letter	1	14
Titled	6	86
Responses	7	100
Rented land legal status	Frequency	%
Allotment letter	7	37
Self-allocation	1	5
Titled	11	58
Responses	19	100
Family land legal status	Frequency	%
Allotment letter	1	0.7
Self-allocation	1	0.7
Titled	141	98.6
Responses	143	100
Settlement land legal status	Frequency	%
Allotment letter	2	5
Titled	35	95
Responses	37	100

Figures 37 and 38 provide a spatial presentation of the distribution of the two dominant tenure types, family and settlement land.



Figure 37: Family land legal status by ward



Figure 38: Settlement schemes legal status by ward

Modes of land acquisition varied by tenure type. Family land was acquired mainly through purchase (68%) and inheritance (31%). Settlement land was acquired via purchase (58%), government allotment (31%), and inheritance (11%). Government land acquisition was through purchase (58%), school land exchange (14%), inheritance (14%), or allocation (14%). For rented land, acquisition modes included

renting (50%), leasing (28%), purchase (17%), and inheritance (6%). Trust land was obtained by purchase (45%), entrustment (42%), and inheritance (14%).

Most households (90%) settled in the area between the 1980s and early 2000s (Figure 39). The primary driver of migration was conflict (30%), followed by lack of land (14%), search for a better life (7%), need for fertile land (7%), and adventure (7%).

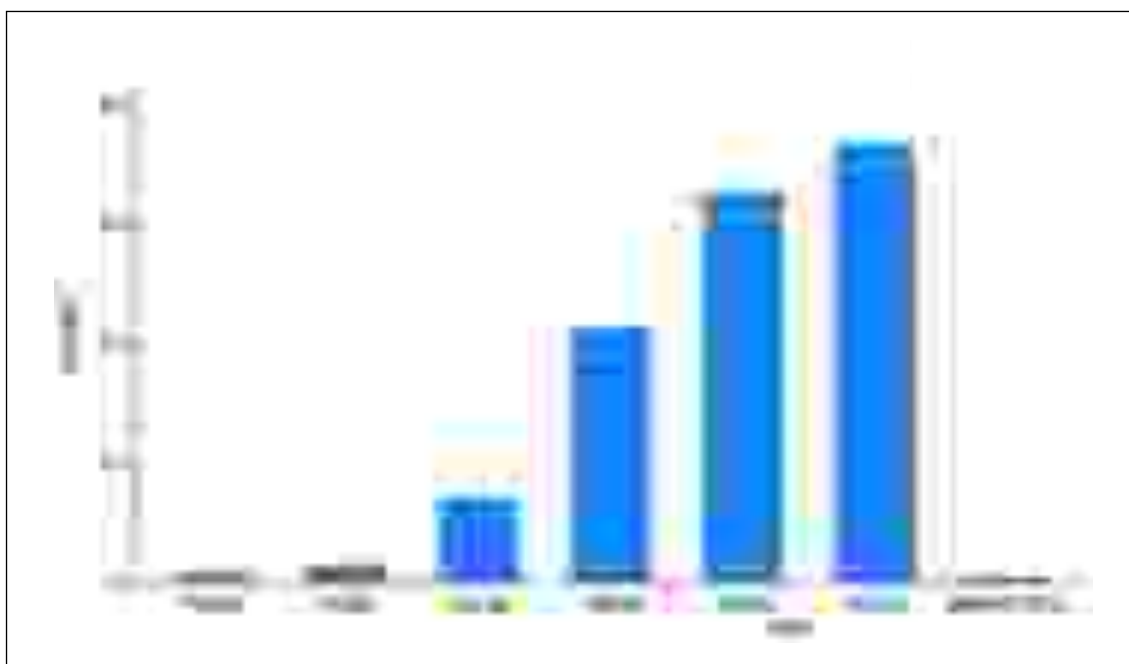


Figure 39: Year households settled in the wetland area

4.9.2 Utilization of Resources Around the Lake Ecosystem

The proximity of households to the wetland significantly influences resource use and human-wildlife interactions. Among the 255 households surveyed, the average distance from homesteads to the wetland boundary was 2.2 km, with a minimum of 0 km and a maximum of 8 km. Notably, 24% of the 254 respondents reported that their land directly bordered the lake. Proximity varied across wards, with households in Kiriita Ward living closest to the wetland on average, while those in Shamata Ward were furthest from the boundary (Table 31).

Table 31: Average distance from the wetland boundary by ward

Ward	Household distance to wetland in km (mean)
Central	2.13
Gatimu	2.01
Kiriita	1.18
Rurii	1.70
Shamata	3.63
Weru	2.60

Land adjacent to the lake was mainly used for grazing, rain-fed crop production, and farm forestry (Figure 40), highlighting the critical role of the wetland in sustaining local livelihoods.

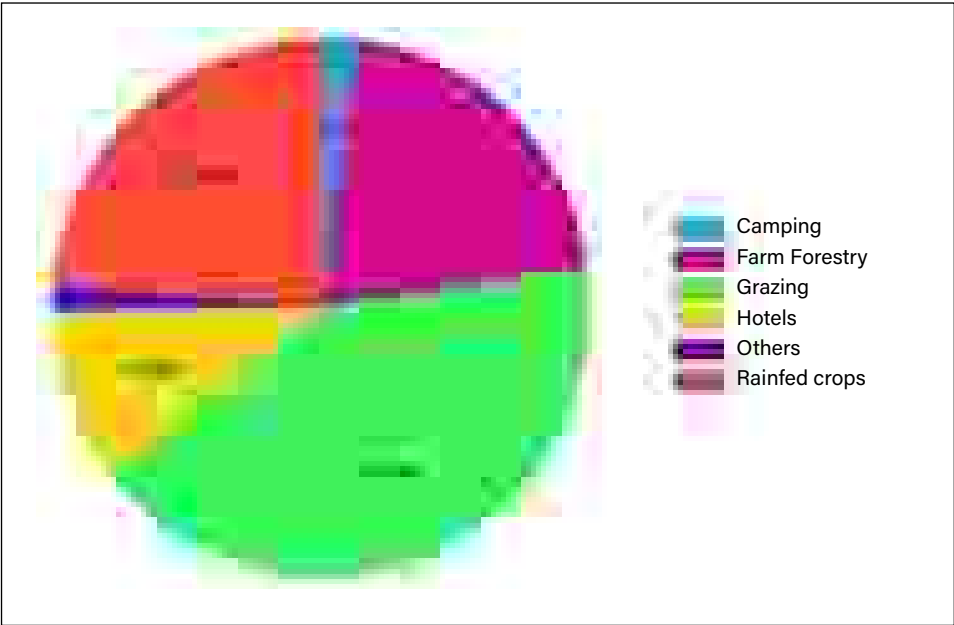


Figure 40: Land uses around the lake

Inside the lake, fishing was the most dominant activity, while the riparian zone supported farming and, to a lesser extent, hunting, as reported by 254 respondents (Figure 41).

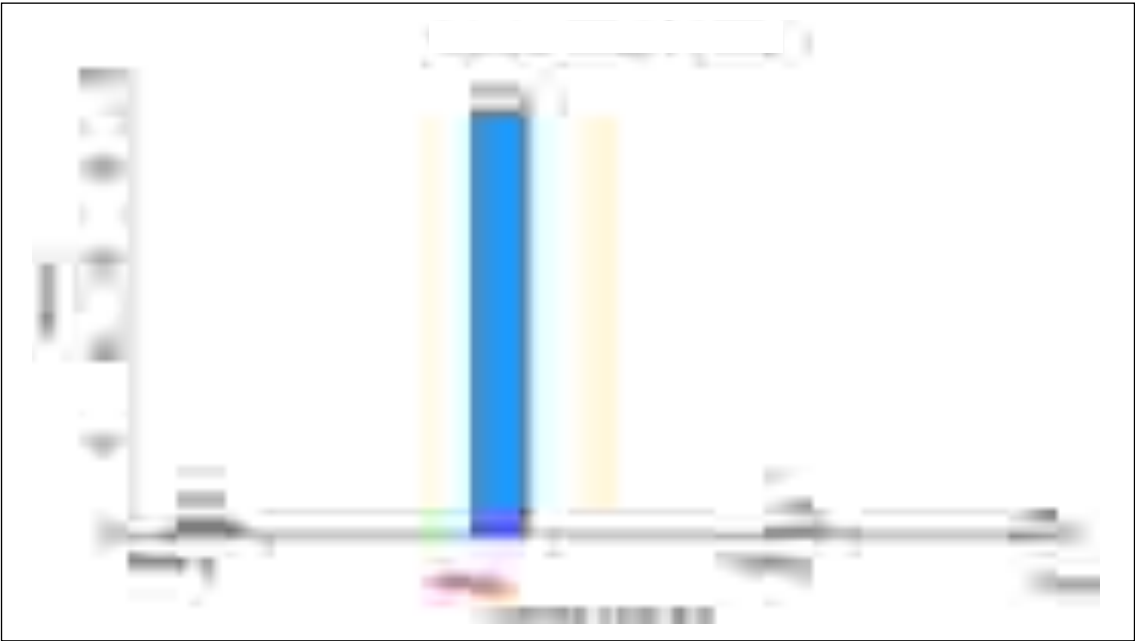


Figure 41: Activities inside the lake

According to 252 respondents, the main economic activities around the lake included farming (61%), business (16%), employment (9%), fishing (3%), and trading (7%) (Table 32).

Table 32: Main household economic activities

Economic activity	%
Farming	61
Business	16
Trading	7
Fishing	3
Employment	9
Others	4

The nine most commonly cultivated crops around the lake were maize (28%), potatoes (21%), beans (11%), cabbage (10%), wheat (7%), carrots (7%), kales (4%), peas (3%), and onions (3%) (Figure 42). Additional crops mentioned included spinach, arrowroots, cassava, African nightshade (*Solanum scabrum*), yams, strawberries, sunflower, and sweet potatoes.

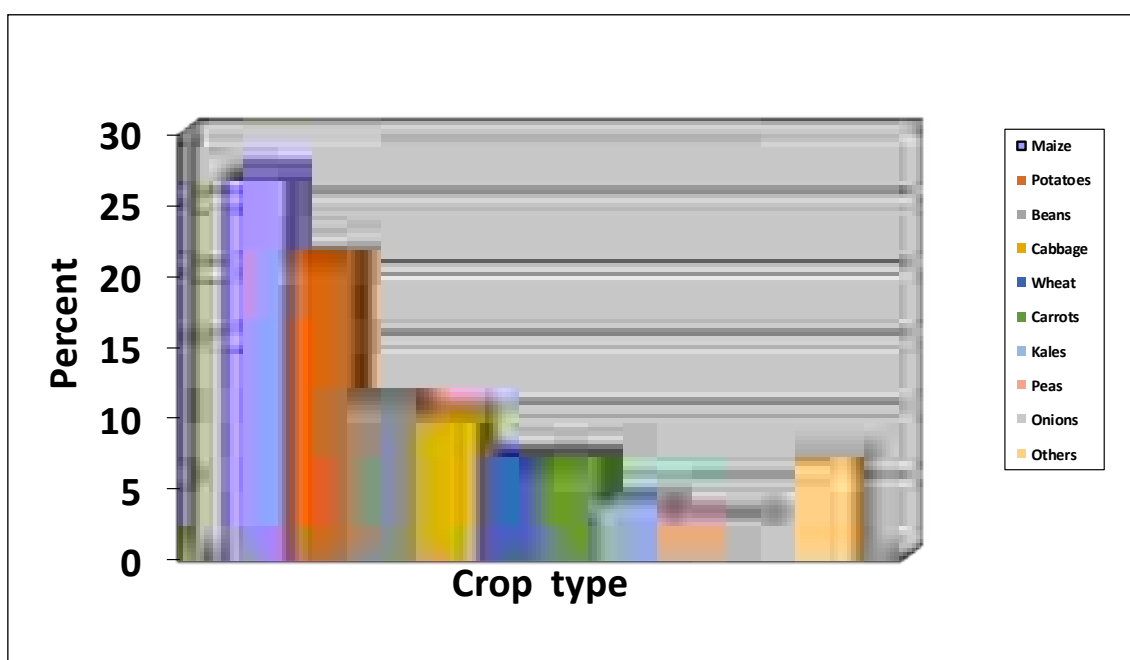


Figure 42: Common crops grown around the lake area

These findings were supported by key informants who emphasized maize, potatoes, beans, and various horticultural crops as the most important in the region.

Historically, the landscape has undergone a shift in agricultural practices. Key informants noted a transition from large-scale wheat farming during the colonial era to present-day small-scale agriculture due to ongoing land subdivision.

Additionally, there was a marked decline in pyrethrum farming following the collapse of the Pyrethrum Board of Kenya after the Structural Adjustment Policies (SAPs) of the early 1990s. This policy shift affected the profitability and viability of pyrethrum as a cash crop.

Farming was reported to be practiced by both men and women, although men were the majority (58% versus 42%). The average daily wage for farm laborers was KES 373. Factors influencing engagement in crop farming included adequate water supply (37%), fertile soils (26%), high crop yield potential (20%), favorable climatic conditions (6%), and land availability (4%) (Figure 43).

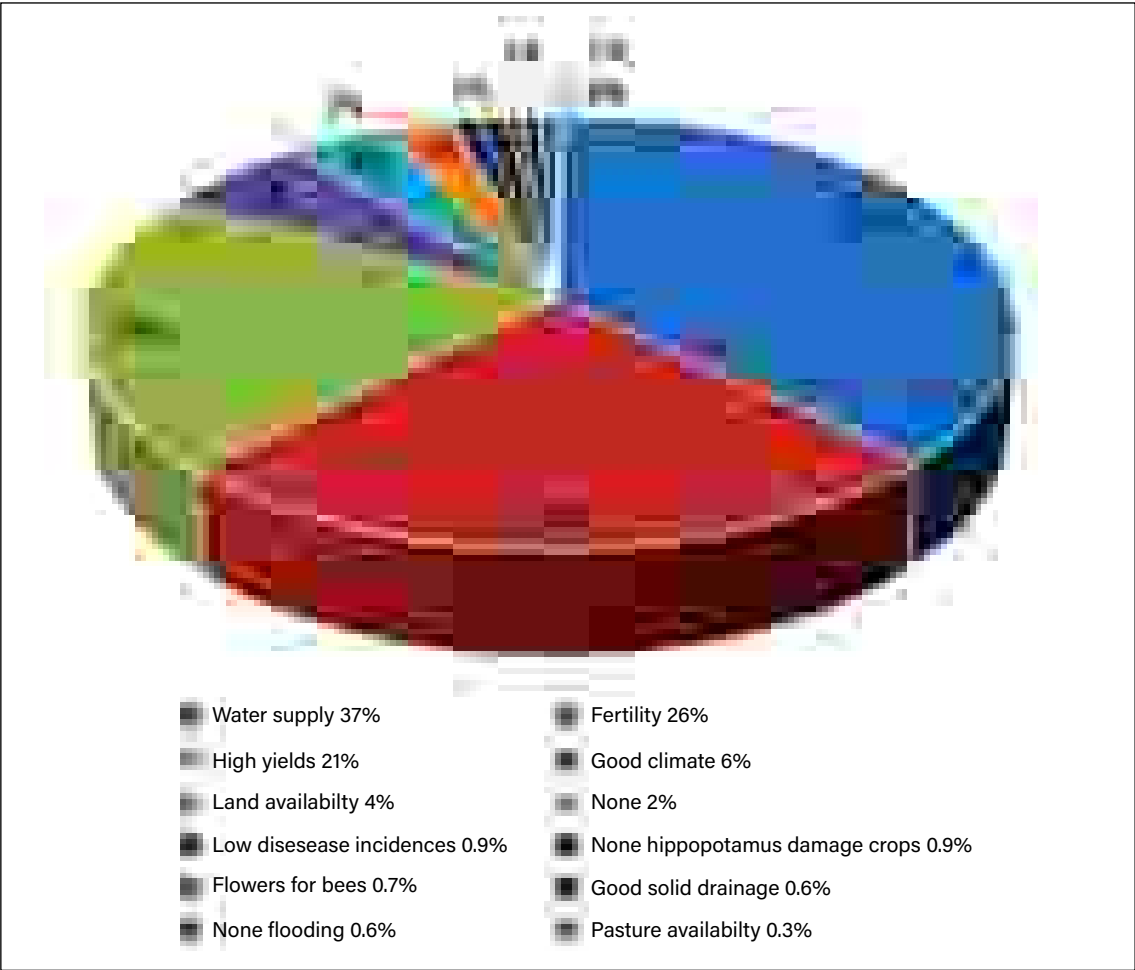


Figure 43: Advantages of farming around the lake

Farm produce was primarily marketed through brokers in local trading centers surrounding the lake ecosystem. These included Subuku (Central Ward), Nyahururu (Gatimu Ward), Mairo Inya (Kiriita Ward), Rurii (Rurii Ward), Ol Kalou (Shamata Ward), and Kasuku (Weru Ward), as reported by 248 respondents (Figure 44). The main drivers for selling crops were to pay school fees, meet household needs, and generate income.

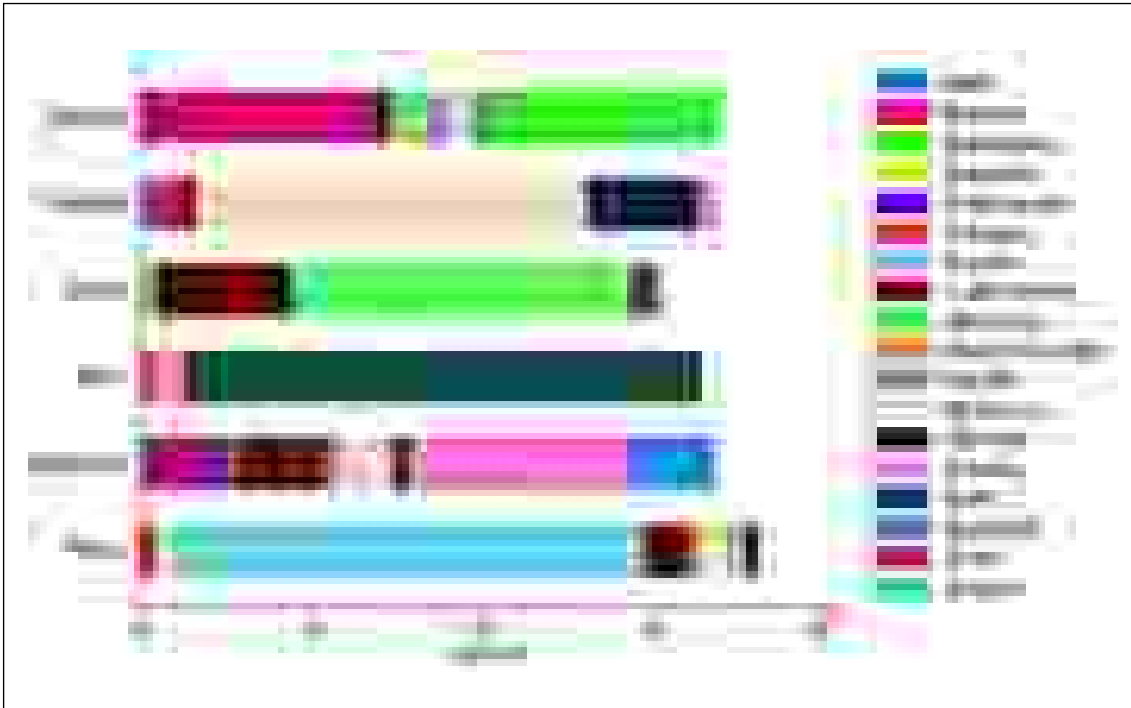


Figure 44: Market for farm produce by ward

However, trends in crop productivity have been declining over time. Respondents rated productivity as high between 30–45 years ago, medium 25–15 years ago, low over the last 10 years, and scarce or very low over the past 1–5 years (Figure 45).

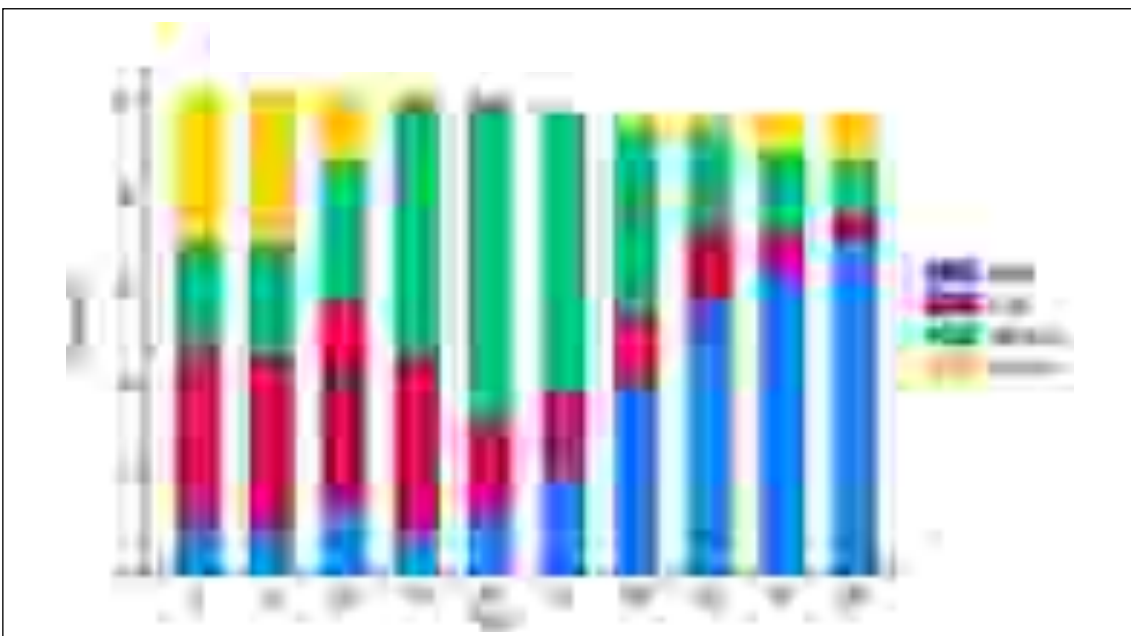


Figure 45: Crop productivity trend over the last 45 years

A key informant noted:

"Maize is the main crop grown in the area although productivity has been on the decline over the years but farmers are reluctant to adopt other more economical crops such as potatoes due to cultural influence" (R001).

Conversely, another informant emphasized a growing shift toward horticulture as an adaptive response:

"Crop production shifted in the 90's with an increased uptake of horticulture farming involving intense production of carrots, onions, potatoes production by local farmers to counter the decline in food crop productivity and generate income. Cut flower farming was also introduced around the same time although this is undertaken by large scale firms such as SUERA" (R012).

Despite the transition to irrigated horticulture, productivity remains a concern. As one respondent stated: *"Crop productivity has declined with the reduction of water for irrigation over the past few years in the dry season" (R004).*

There was broad consensus among key informants that the productivity of both maize and horticultural crops has been declining. Factors influencing this include reduced water availability, cultural preferences, and soil quality deterioration. Some informants highlighted the influence of farming practices, particularly the use of manure and inorganic fertilizers, on soil health and long-term crop productivity.

Farming Practices

Mixed cropping was practiced by 44% of 249 respondents, followed by crop rotation (21%), intercropping (19%), fallowing (7%), shifting cultivation (6%), and other practices (3%). Despite this diversity, monocropping remained the dominant approach across farms. While a few farmers engaged in cover cropping and agroforestry, these beneficial practices were not widespread (Figure 46).



Figure 46: Other farming practises

The prevalent practices, except for cover cropping and agroforestry, do not adequately preserve the integrity of soil structure and composition, potentially contributing to a persistent decline in crop productivity. These concerns were echoed by key informants, who linked poor farming practices to soil erosion, with topsoil being deposited into the lake, leading to siltation and a decline in soil fertility.

Regarding manure use, 70% of the 255 respondents indicated they apply manure in crop production, while 30% do not. The most commonly used manure was from

cattle (50%), with others including manure from sheep, poultry, goats, compost, and rabbit urine (Figure 47). The absence or inadequate use of manure and other organic matter undermines efforts to build soil organic matter, a critical determinant of soil health and fertility, possibly exacerbating declining crop yields.



Figure 47: Manure types in crop production

Use of inorganic fertilizers was widespread, with 74% of 254 respondents applying them in crop production. The most commonly used fertilizer was Diammonium Phosphate (DAP) (78%), followed by urea (10%), and NPK (3%). Others included foliar fertilizers, Calcium Ammonium Nitrate (CAN), phosphorous phosphate, and potassium phosphate. Heavy reliance on DAP may reduce soil pH, potentially affecting soil productivity and microbial balance.

Uptake of inorganic fertilizers has increased in recent years, partly replacing the use of organic manure. This shift is attributed to the decline in livestock numbers and the adoption of hybrid seeds, contrasting with earlier periods when larger land sizes allowed for more indigenous livestock and organic manure production. Key informants noted:

In the past, before population growth and subdivision of land farmers predominantly produced maize on a large scale, which was produced with organic manure from the large herds of livestock. However, that has changed and currently engage in small-scale production of maize and potatoes and rely heavily on inorganic fertilizers and pesticides (R003).

Maize production in the past was from indigenous varieties 'Kingi' and 'Githigu'. The indigenous maize varieties had high productivity and were produced with organic

manure with no need for application of inorganic fertilizers. Currently, production of the indigenous maize varieties has mostly ceased and the farmers are planting hybrid varieties but which require application of inorganic fertilizers and their productivity is not as high as that of the indigenous varieties (R011).

Maize production in the past relied on indigenous seeds but hybrid seeds have now been adopted since 2000s, and which give greater productivity although they have to apply fertilizer (R013).

Pesticide use was reported by 40% of 254 respondents, while 60% did not use any. Common pesticides included those targeting armyworms (19%), fungicides (16%), aphid control agents (9%), Ridomil Gold (8%), Duo Dip (5%), and G-omicide (4%). Others included rabbit urine, wheat rust powder, and products targeting cutworms and stalk borers (Figure 48).



Figure 48: Pesticides used in crop production

Key informants noted that the use of chemical inputs, including both inorganic fertilizers and pesticides, is a recent development in the area:

The modern farmer has adopted intense application of inorganic fertilizers and pesticides in crop production (R010).

Farmers currently engage in small scale production of maize and potatoes and rely heavily on inorganic fertilizers and pesticides (R003).

However, careless or excessive pesticide application poses risks to environmental health and may result in pollution and adverse human health impacts.

Extension Services

Extension services were primarily accessed through the private sector (61%) of 254 respondents, with 21% receiving support from government sources and 18% from NGOs. Among 106 respondents, only 20% reported access to government extension services, indicating a low presence of state support in agricultural advisory services.

4.9.3 Human-Wildlife Conflict /Wildlife Crop Damage

Approximately 42% of 252 respondents reported experiencing human-wildlife conflict, with 53% of 253 respondents noting crop damage by wildlife. Such conflicts have increased over time: they were rare in the 1970s and 1980s, moderate in the 1990s and early 2000s, and have become more frequent in recent years (Figure 49).

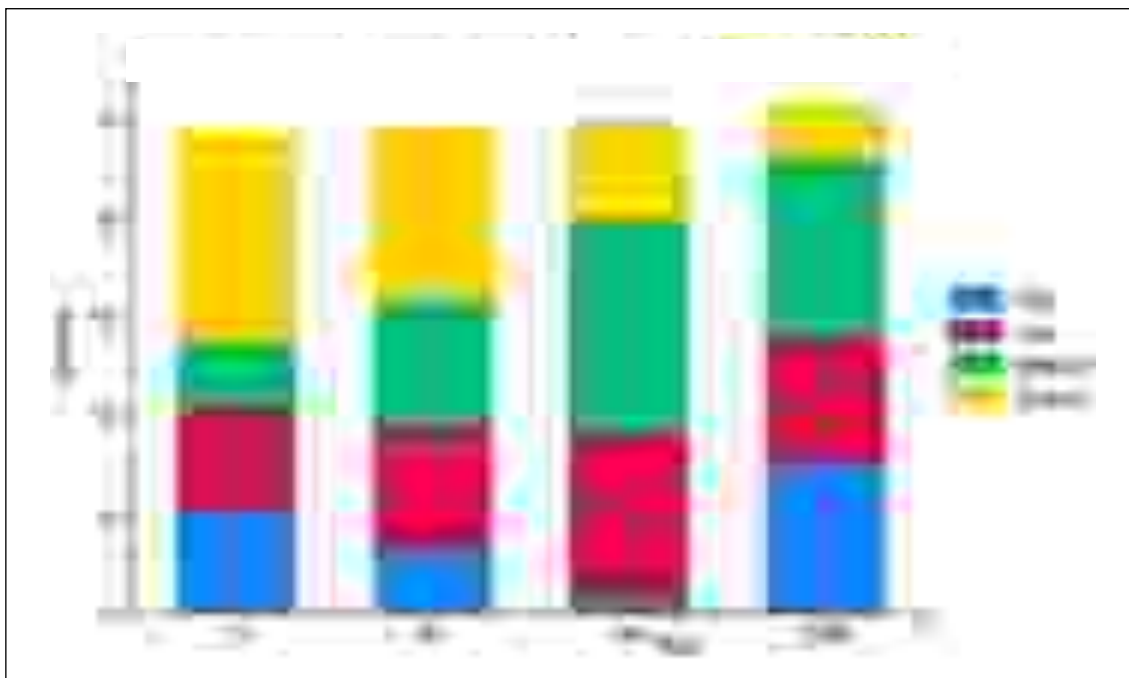


Figure 49: Human-wildlife conflict trend between 1970s and 2000s

Key informants attributed this rise to increased livestock grazing in the lake riparian zone, which has depleted grazing resources for hippopotamuses, forcing them to move into farmlands. Respondents identified wildlife responsible for crop damage as predominantly hippopotamuses (79%), followed by cranes (8%), porcupines (7%), mongoose (2%), hares (2%), elephants (1%), monkeys (0.7%), and ducks (0.3%). Harvest and maize seasons were the most affected. The most cited underlying driver of crop damage was drought, which led to insufficient grazing resources in natural habitats, resulting in intensified competition between hippopotamuses and livestock in the riparian areas.

Among 133 respondents, the average annual cost of crop damage by wildlife was estimated at KES 122,325, with a range between KES 90 and KES 3,000,000. Only 19% of 252 respondents reported actively guarding their crops, spending

an average of 7 hours per day at a cost of KES 350 per day. Notably, 79% of crop guards were men, compared to 21% women, suggesting gendered roles in mitigation efforts.

4.9.4 Water Sources, Uses and Distribution

Households in the study area relied on a range of water sources. Among 255 respondents, the most commonly cited sources were wells (65%), piped water (17%), boreholes (9%), springs (6%), and rivers (3%). The average daily household water consumption among 254 households was 162 litres. Only 13% of respondents reported paying for household water, incurring an average monthly cost of KES 622 for piped water or KES 15 per 20 litres when purchased per litre.

The primary water sources supporting domestic consumption included eight springs, thirteen rivers/streams, five public boreholes, and three public wells (Table 33). Additional sources mentioned were privately owned boreholes and wells, dams, and harvested rainwater. However, key challenges associated with these sources were drying up and pollution.



Table 33: Domestic water sources

No.	Springs	Ward	Rivers and streams	Ward	Boreholes	Ward	Wells	Ward
1	Gathima	Gatimu	Kwa Muthungu seasonal Stream	Central	Kanguu borehole	Gatimu	Waigoko	Central
2	Nduthi	Shamata	Simba River	Gatimu	Mwai borehole near China construction site	Central	Private wells	Gatimu/Kiriita
3	Kurubu	Shamata	Kwa head seasonal Stream	Central	Baari	Kiriita	Githungucu	Kiriita
4	Aberdares Springs Wanjohi	Kiriita	Kwa Gikonyo seasonal Stream	Central	Ziwani	Kiriita	Muruai	Kiriita
5	Baara	Kiriita	Kanguu River	Gatimu	Githomi's/ Mama Ben's	Kiriita	-	-
6	Kamunguka	Kiriita	Thia River Kanjogu	Gatimu	Ndemi	Kiriita	-	-
7	Kanguu	Gatimu	Kamukunga	Kiriita	-	-	-	-
8	Waigoko's Makereka Village	Central	Kurubu River	Shamata	-	-	-	-
9	-	-	Nduthi River	Shamata	-	-	-	-
10	-	-	Ngarenyiro (Manguo)	Kiriita	-	-	-	-
11	-	-	Downstream valleys, Makereka Village	Central	-	-	-	-
12	-	-	Njangiri	Kiriita	-	-	-	-
13	-	-	Shamuka	Gatimu	-	-	-	-

Notably, 31% of 251 respondents reported the presence of rivers and springs that flow into Lake Ol Bolossat. Historical accounts revealed a declining trend in river and spring flows, which were described as high during the 1970s–1980s, moderate in the 1990s, low in the 2000s, and scarce in the 2010s (Figure 50).

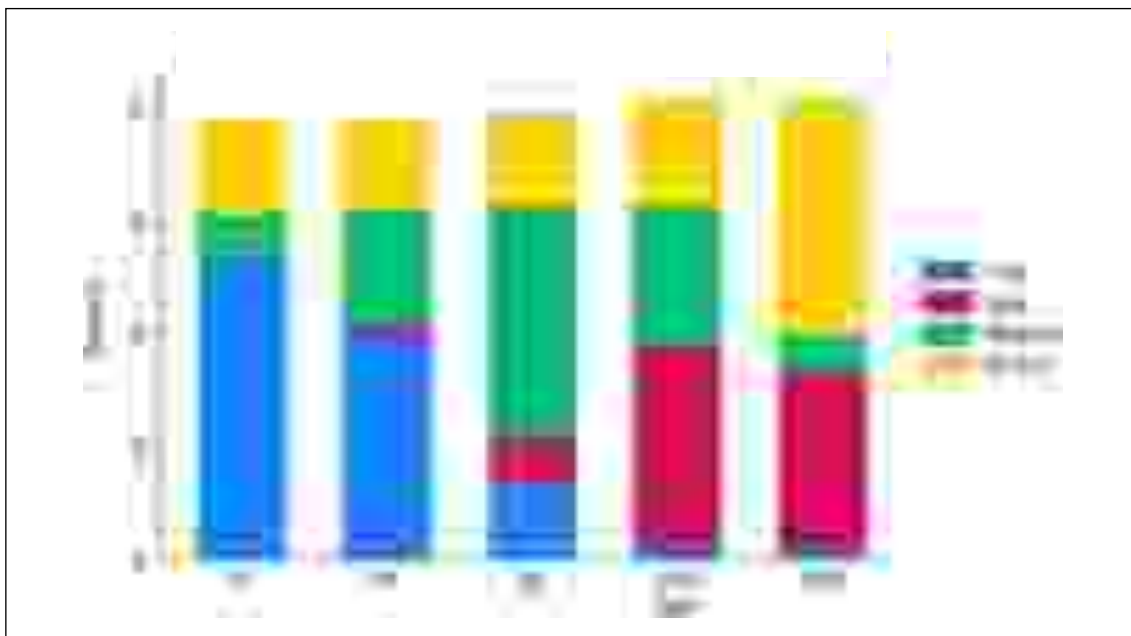


Figure 50: Trend of rivers/springs flow between 1970s and 2010

Key informants attributed this trend to increased water abstraction and diversion for domestic and irrigation uses, ultimately reducing recharge to the lake:

Agricultural production activities by settlers around the lake have often translated to abstraction of streams and rivers that originally recharged the lake (R002).

Diversion of rivers and springs for own consumption by the human occupants of the lake ecosystem has also contributed to a decline of the lake water levels over the years due to interference with recharging of the lake (R004).

An increase in human population has resulted in more diversion of water from recharging of the lake to household consumption (R006).

Other challenges affecting rivers and streams included pollution and siltation, largely attributed to agricultural practices. One key informant stated: *“The use of inorganic fertilizers and pesticides for crop production and their penetration into the water bodies causes pollution of the water systems” (R011).*

Conflicts between upstream and downstream users were reported by 10% (24 of 250) of respondents, stemming from water abstraction, pollution, and unequal access. To address these issues, riparian tree planting and fencing were the most frequently recommended strategies for protecting rivers and springs against drying, siltation, and pollution.

Only 6% (15 of 252) of respondents were aware of the existence of seven Water Resource Users Associations (WRUAs) (Table 34). These associations were predominantly led by men (59%), followed by women (19%) and youth (18%).

Table 34: Water Resource Users Associations

No.	List of WRUAs	Ward
1	Karogoine	Kiriita
2	Kisa	Gatimu
3	Ndemi	Kiriita
4	Nyandwas	Gatimu
5	Githunguchu	Kiriita
6	Nyakaja	Gatimu
7	Ol Bolossat	Kiriita

Water Supply Projects

About 28% (70 of 247) of respondents acknowledged the existence of water supply projects in their communities. These projects were also male-dominated, with 55% male leadership compared to 25% female and 20% youth representation. Twelve water supply projects were identified (Table 35). Challenges reported in the management of these projects included poor leadership, inadequate financing, and weak infrastructure management, alongside community conflicts. Improved governance and increased financial support were strongly recommended for better outcomes.

When it came to knowledge dissemination, 52% of 252 respondents reported receiving water resource management advice from the private sector, while 48% cited the government as a source.

Table 35: Water projects by ward

No.	Water Project	Ward
1	Nyakaja Water Project	Gatimu
2	Nduthi Water Project	Central
3	Karogoine Water Project	Kiriita
4	Kanguu Water Project	Gatimu
5	Kisa Well	Gatimu
6	Ndemi Water Project	Kiriita
7	Gakoe Village Water Project	Central
8	Karandi Water Project	Weru
9	Kianduba Water Supply Project	Weru
10	Leshau Water Project	Kiriita
11	Nduguthithu Water Project	Kiriita
12	Waruiru Farm	Weru

Rainwater Harvesting

Rainwater harvesting was practised by 43% of 255 respondents, primarily using gutter systems. The most common storage facilities were tanks (73%) and drums (16%), with others using jerricans, sufurias (cooking pots), or dams. Storage capacities ranged from 20 to 740,310 litres. The top three motivations for harvesting rainwater were to complement household water supply, secure clean and safe drinking water, and improve water availability for domestic use.

Table 36: Rainfed and irrigated crop production

Variable Responses	Mean	Std. dev.	Min	Max
Area under rainfed crops	109	294.4693	621.3678 .75	5000
Area under irrigated crops	47	79.94681	89.8154 1	300

Irrigation and Agricultural Water Use

Irrigation was far less common than rainfed agriculture (Table 36), with only 19% of 252 respondents reporting irrigation activities around Lake Ol Bolossat (Table 37), and 11% (28 of 253) practicing irrigation on their farms. Of those practicing irrigation, 29% used flood irrigation, 36% used sprinkler (overhead) systems, and 18% each used furrow and drip irrigation.

Table 37: Irrigation locations by ward

No.	Location Irrigated	Ward
1	Kangubiri	Central
2	Gakoe	Central
3	Ol Bolossat	Central
4	Nduthi	Central
5	Ngomna	Central
6	Kaka	Central
7	Kwa John	Central
8	Ngurumo	Central
9	Shiloh Farm	Shamata
10	Baari	Kiriita
11	Makereka	Central
13	Magdalena Farm Ol Joro Orok	Weru
14	Morri's Farm, Karandi	Weru
15	Ndemi	Kiriita
16	Rudisha	Central
17	Waruiru Farm, Amani Village	Weru
18	Yamarisk	Weru

The main water sources for irrigation included storage tanks (24%), boreholes (21%), springs (17%), streams (7%), wells (7%), and dams (7%). Irrigated crops primarily included vegetables and horticultural products (Figure 51). Irrigation was strongly associated with water abstraction from rivers, springs, and streams, with further concerns about chemical pollution due to increased use of pesticides and fertilizers, especially in greenhouse-based horticulture:

"Farming activities among the locals started small but have now become intensive characterized by a lot of water abstraction and diversion to support irrigation. Horticulture has been taken up and now there are green houses that have been setup. Horticulture however involves heavy use of chemicals which are polluting the ecosystem" (R002).



Figure 51: Main crops under irrigation

Only 7% (2 of 28) of irrigation practitioners paid for water, averaging KES 350 per month. The leading reasons for adopting irrigation were maintaining high yields (28%), generating extra income (21%), and improving crop productivity (10%). Women dominated irrigation activities, accounting for 60% of practitioners compared to 40% men.

Key challenges included blockage or breakage of irrigation pipes and high pumping costs, both in terms of labour and fuel. The majority of farmers (75%) received irrigation advice from the private sector, followed by government (14%) and NGOs (11%).

4.9.5 Livestock Production

Livestock production was practised by 122 of 253 respondents (48%). Respondents reported a decline in livestock production, attributed primarily to land

subdivision due to population growth. Livestock keeping is commonly integrated with crop farming, although both systems face increasing limitations. As one respondent noted,

“Livestock production was more expansive in the past because there was adequate land but with population increase there is limitation” (R007). Similarly, another noted that *“Livestock production is also practised alongside crop production but it has been on the decline in the recent past due to a reduction in availability of pasture for grazing” (R011).*

The primary sources of livestock fodder among 114 respondents were their own farms (72%), pastureland (4%), swamp areas (4%), and agrovet shops (4%). To cope with fodder shortages, households relied on a range of strategies including grazing in open fields, purchasing fodder from neighbours, using commercial feeds from agrovet shops, utilizing crop residues, and purchasing hay (Figure 52). This was confirmed by key informants, one of whom stated, *“In the last 2–3 years, fodder availability from own production has been a great challenge and we have had to buy hay to sustain the livestock” (R004).*

Grazing around Lake Ol Bolossat emerged as particularly important. One key informant highlighted that:

“Livestock production is characterized by intensified grazing around the lake especially during the dry season” (R008). The lake not only supports local livestock but also attracts pastoralists from outside the area. Indeed, 95% of respondents (105 of 110) indicated that non-residents often bring livestock to graze in the wetland area, reflecting the regional importance of the lake ecosystem for livestock production.



Figure 52: Coping strategies against fodder shortage

Livestock Holdings and Management

Average livestock holdings per household were reported as follows: 4 cattle, 22 chickens, 3 sheep, and 11 goats (Table 38).

Water consumption for livestock averaged 124 litres per day per household, with a cost of KES 18 per day for those purchasing water. Sixty-seven percent (67%) of livestock keepers had private wells to ensure water access during dry seasons.

In the dry season, livestock were primarily watered at home (36%), from dams (14%), boreholes (8%), and wells (8%). During the wet season, 73% watered livestock at home, with smaller proportions using roadside puddles (4%), dams (3%), harvested rainwater (3%), and farm storage (3%). The average distance to watering points increased significantly from 0.5 km in the wet season to 1.6 km in the dry season, with some households walking up to 15 km in the dry season compared to 4 km during the wet season.

Table 38: Livestock numbers per household

Variable	Responses	Mean	Std. dev.	Min	Max
Cattle	97	4.123711	5.228643	1	50
Chicken	101	21.92079	18.52711	1	100
Goats	42	2.97619	2.424349	1	16
Sheep	85	11.38824	12.59071	1	100

Most livestock were reared on a free-range basis (Table 39).

Table 39: Mode of livestock production

Cattle rearing mode	Frequency	%
Free range	74	72
Zero grazing	29	28
Total Responses	103	100
Chicken rearing mode	Frequency	%
Free range	57	56
Zero grazing	45	44
Total Responses	102	100
Goat rearing mode	Frequency	%
Free range	45	96
Zero grazing	2	4
Total responses	47	100
Sheep rearing mode	Frequency	%
Free range	77	89
Zero grazing	10	11
Total Responses	87	100

The livestock and livestock products fetched widely varied prices in the market (Table 40).

Table 40: Prices of livestock and livestock products in Kenya shillings

Variable	Observations	Mean	Std. dev.	Min	Max
Price of ram	108	10049.07	7236.066	1400	60000
Price of milk	108	48.92593	8.098348	38	70
Price of manure	102	2804.118	6280.804	100	30500
Price of hen	106	953.4906	1135.004	450	8000
Price of heifer	106	42866.04	60201.81	3500	630000
Price of he-goat	103	9353.398	3536.388	3000	19000
Price of female sheep	109	8127.523	6332.103	800	70000
Price of female goat	103	9489.32	5890.586	3000	55000
Price of egg tray	108	419.5833	201.8028	15	600
Price of donkey	97	18642.16	11655.98	2500	60000
Price of cow	108	65173.15	53466.85	5000	52000
Price of cock	106	1362.264	1562.139	100	15000
Price of calf	108	14125.14	6556.825	15	40000
Price of bull	109	58747.71	46414.83	20000	50000

Livestock Marketing and Socio-economic Role

Market engagement for livestock and their products remains largely informal. Livestock were mostly sold to brokers or through local arrangements (Figure 53). The major motivations for sale included raising school fees (11%), income generation (6%), and addressing emergencies (4%). Key informants highlighted the collapse of structured livestock markets, notably the Kenya Co-operative Creameries (KCC), which had supported hybrid breeds and artificial insemination in the 1980s and 1990s. Currently, most livestock are indigenous breeds such as Zebu cattle and Ndomba sheep, preferred for their resilience and low fodder demand. A key informant observed: *"KCC collapsed in the 90s and the farmers' market was destroyed... now government extension officers are only accessible if paid, and private extension officers are not available in the area"* (R012).

Although some dairy cooperatives still exist, their benefits have declined, contributing to a shift from livestock keeping to crop farming (R006). Men were dominant in livestock marketing (70%) compared to women (27%) and youth (3%). Average milk retention for household consumption was 2 litres/day per household, translating to 0.3 litres per capita for an average household size of six, within the WHO recommended intake of 0.2–0.4 L/day.



Figure 53: Livestock and livestock products marketing avenues

Constraints to Livestock Production

The main constraints cited included livestock diseases, pests, and high fodder costs. Common livestock diseases were foot-and-mouth disease, East Coast Fever, pneumonia, and Newcastle disease (Figure 54). Causes included ticks, extreme weather, poor-quality fodder, swampy conditions, and disease transmission from externally grazed livestock. The introduction of East Coast Fever, invasive weeds (e.g. *Cirsium vulgare*), and even new human diseases was linked to external herders grazing around the lake (R012).

Disease prevalence was highest in July (cold season), the dry season, and the rainy season. Treatment services were predominantly offered by the private sector (78%), followed by government services (18%) and NGOs (4%). Notably, 80% of respondents reported the absence of government extension services. In practice, retired government officers were often hired privately due to their accessibility and trusted expertise.



Figure 54: Common livestock diseases

4.9.6 Domestic Energy Sources

The main household energy sources were firewood, charcoal, and farm residues (Figure 55). Availability of alternatives such as gas, electricity, paraffin, biogas, cow dung, and sawdust was limited. Of 227 respondents, 84% sourced firewood from their own farms, 12% bought from neighbours, and 4% from forests, specifically Githima (71%) and Githinguchu (29%).

The average monthly expenditure on firewood was KES 1,739, with a typical bundle costing KES 7. These figures highlight the critical role of biomass energy in rural livelihoods, despite growing concerns over forest degradation and sustainability.

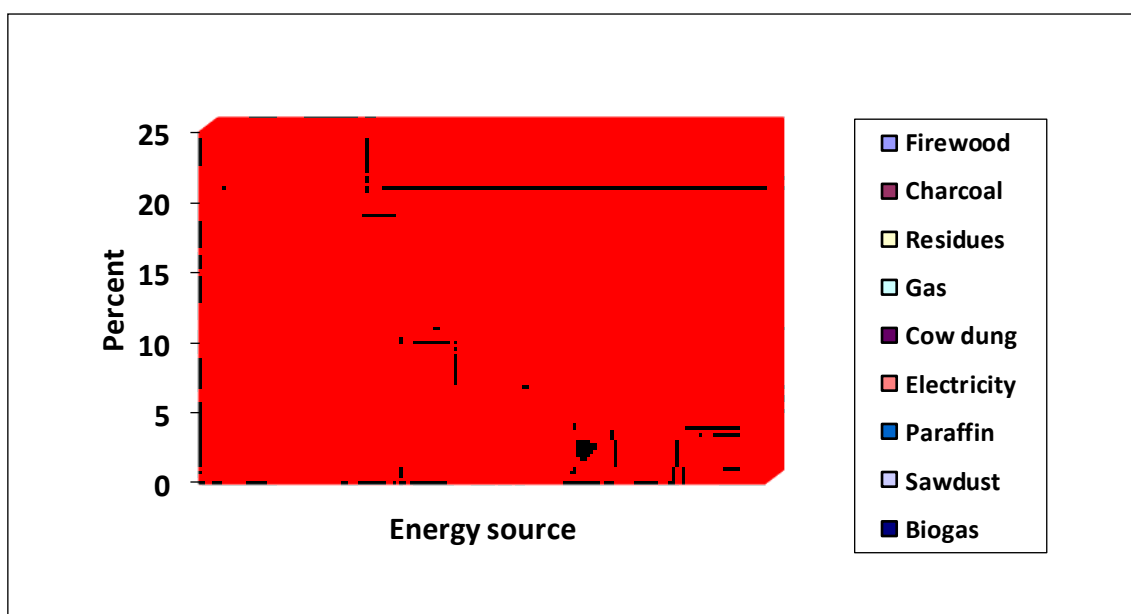


Figure 55: Domestic energy sources

4.9.7 Vegetation and Wildlife

Vegetation Types and Changes

When respondents first settled in the area, grasses were the dominant vegetation, as reported by 75% of respondents. In contrast, 22% indicated trees as the primary vegetation, while 3% reported herbs as dominant. This historical vegetation pattern of grassland interspersed with some forest cover was confirmed by key informants:

"The landscape around the lake has been transformed immensely from a grassland in the past to heavy forest cover occasioned by tree planting by the occupants of the lake ecosystem." The respondent indicated that in the past the lake was visible from Kasuku but not anymore due to the current heavy tree cover (R014).

"In the 1980s the area was total bush with no human settlement. The landscape was covered with grass, no trees" (R001).

"Tree cover was dense in the Satima Escarpment (Kirima Muruai) but there has been immense deforestation for settlement. There was also extensive grassland in the lake's riparian and catchment areas but most of it has now been depleted" (R002).

Currently, exotic trees dominate the tree cover, especially eucalyptus (53%), followed by cypress (27%) and grevillea (5%) (Figure 56). These observations are consistent with those of key informants:

"A recent development has been intense planting of eucalyptus tree around the lake" (R011).

"There has been increased planting of exotic tree species, predominantly eucalyptus" (R005).



Figure 56: Most common planted tree species

Despite the perception of forested cover, most land was observed by the researcher to be under cultivation. While natural grasses and wild vegetation were commonly reported by respondents (Figure 57), this finding appears to conflict with actual land use observed during field visits.



Figure 57: Most common vegetation currently

Wildlife Dynamics

During initial settlement, the most commonly observed wild animal species included: hippopotamus (37%), antelopes/ gazelles (14.7%), hare (13%), leopards (5%) and birds (5%) (Figure 58).



Figure 58: Most common animal species on initial settlement

Most common bird species on initial settlement were identified as cranes (28%), ducks (9%), weaverbirds (8%) doves (6%) and crows (6%) (Figure 59).



Figure 59: Most common bird species on initial settlement

Top five insect species on initial settlement were identified as grasshoppers (20%), butterflies (12%), bees (7%), ants (7%) and crickets (7%) (Figure 60).



Figure 60: Most common insects' species on initial settlement

Faunal Change Over Time

Of the 248 respondents, 52% believed there had been no change in animal species composition since settlement, while 48% reported changes. Among species perceived to have disappeared were antelopes (12%), cranes (10%), hares (6%), leopards (6%) and zebras (5%) (Figure 61). Key informants further identified skunks, Dik Diks, porcupines, waterbucks, giraffes and elephants as species no longer present in the area.



Figure 61: Species that have disappeared from the area

Twelve percent (12%) of 252 respondents reported the presence of new animal species. These included: hyenas (63%), birds (30%), foxes (4%), and hippopotamus (4%). New bird species identified were owl (71%), crow (14%), vulture-like birds (7%) and "new bird with long white tail" (7%). The only new insect species reported was armyworms (100%).

Nineteen percent (19%) of 249 respondents identified valuable species in the lake area. These included:

- Valuable insect species: butterflies, bees, grasshoppers and locusts (Table 41).

Table 41: Insect species of value

Insect species of value	Frequency	%
Bees	9	37.50
Butterfly	10	41.67
Grasshopper	2	8.33
Locust	2	8.33
Some eat worms that destroy crops	1	4.17
Total	24	100.00

- Animals: Fish (80%), hippopotamus (12%), hare (5%) and frogs (3%).
- Bird: Cranes (for sightseeing), ducks (meat), doves, guinea fowl (for domestication), pelicans and weaverbirds.
- Vegetation: Grass (65%), reeds (32%) and papyrus (3%).

Wildlife Trends Over Time

Birds were reported to have increased in the 1970s and 1980s, remained stable in the 1990s, and decreased in the 2000s (Figure 62).

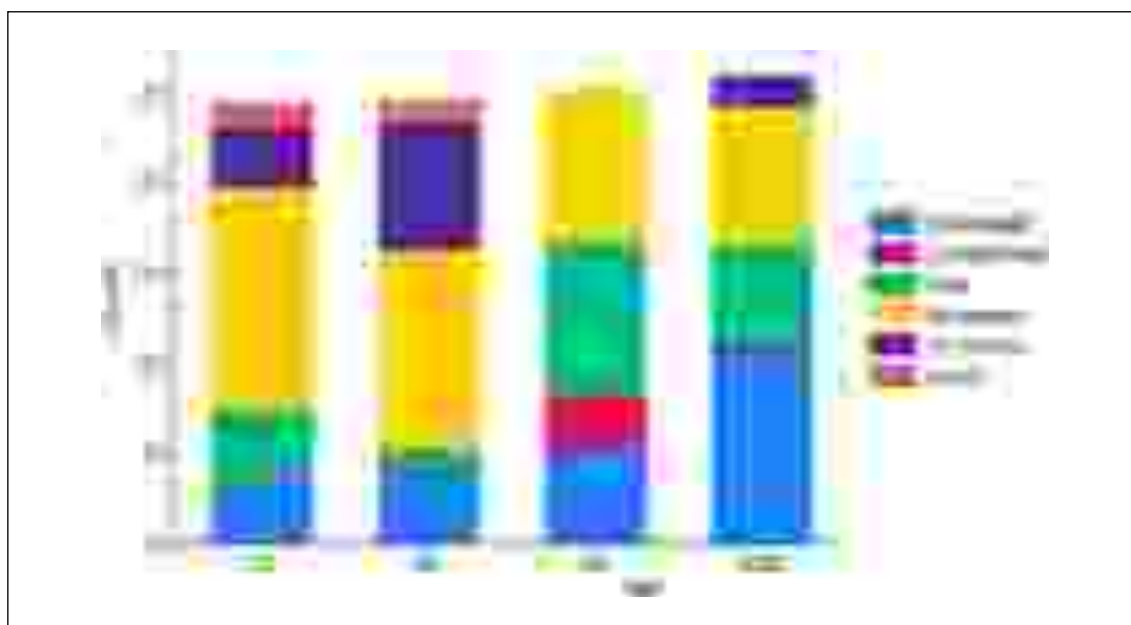


Figure 62: Trend of birds' population between 1970s and 2000s

Hippopotamus populations were noted to have increased from the 1970s through the 1990s, then declined in the 2000s (Figure 63).

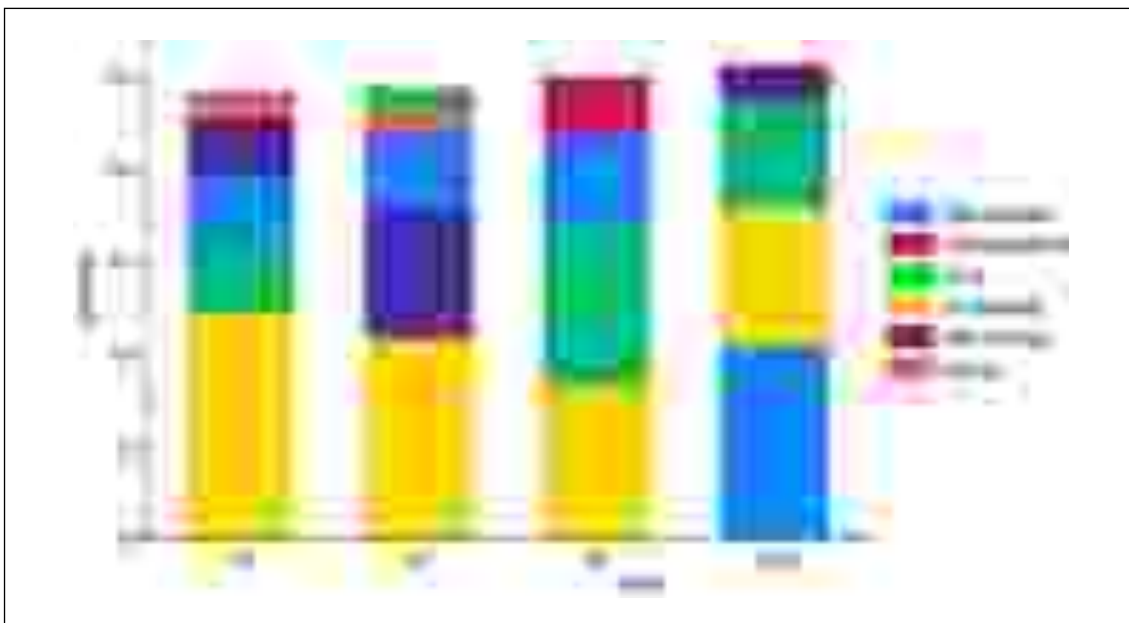


Figure 63: Hippopotamus population trend between 1970s and 2000s

4.9.8 Conservation and Management of the Lake Stakeholder Involvement

Only 19 out of 252 respondents (8%) reported being visited by government officials concerning the conservation of Lake Ol Bolossat. These visits mostly involved providing advice on avoiding hunting of hippopotamus and cranes, conserving the lake through afforestation of the catchment area, and stopping pollution. Other entities mentioned by respondents included the Kenya Wildlife Service (KWS), Kenya Forest Service (KFS), Crane Conservation Volunteers (CCV), county government officers, game wardens, NGOs, and the chief. These stakeholders undertook roles such as patrolling to prevent illegal activities like poaching, and promoting forest conservation through tree planting.

Furthermore, 102 of 252 respondents (41%) acknowledged the existence of rules governing the use of swamp resources. The main actors responsible for formulating these rules included KWS, government authorities, and CCV. Key regulations cited by the respondents included bans on hunting hippopotamus and cranes, grazing near bird nesting areas, overfishing, and cultivating too close to the lake margin. Violations of these rules reportedly led to penalties such as arrests, fines, or confiscation of fishing gear. Notably, some individuals caught illegally harvesting crane eggs were arrested by KWS, prosecuted at the Nyahururu Law Courts, and fined one million Kenya Shillings or sentenced up to 12 months imprisonment (R001).

Conflicts between local residents and regulatory authorities were reported by 44 out of 252 respondents (17%). These conflicts stemmed from illegal activities such as hunting of hippopotamus and overfishing, which often clashed with established conservation rules.

Past, Present and Future Wetland Conservation and Management Approaches

Only 39 of 252 respondents (15%) indicated awareness of ongoing conservation initiatives around Lake Ol Bolossat. These initiatives were spearheaded by CCV, Friends of Lake Ol Bolossat, local fishermen, and other individuals involved in tree planting. Identified participants in conservation activities included community members (18%), fishermen (11%), government agencies (9%), KWS (9%), teachers (9%), and CCV (6%).



Figure 64: Participants in lake conservation activities

While there is evidence of current community involvement in conservation through local community-based organizations (CBOs) such as CCV and Friends of Lake Ol Bolossat, this has not always been the case. Earlier management approaches often excluded community members. For instance, Friends of Lake Ol Bolossat currently engages local communities through collaborations with *Kiama* (a Kikuyu elders' cultural association), churches, schools, women's groups, and other welfare groups. However, a disconnect still persists. Some community members expressed that they had never been involved in management planning, with one respondent even expressing satisfaction with water recession due to grazing opportunities. This limited engagement is also reflected in the finding that only 8 of 248 respondents (3%) had previously participated in wetland celebration events.

Bird shooting was reported by 15 of 249 respondents (6%). Most attributed it to tourists (60%), followed by locals (33%) and poachers (7%). Bird shooting reportedly began in the 1970s, although two respondents believed it no longer

occurs. Only one out of 14 respondents reported direct benefits from bird shooting, primarily in the form of duck meat and fish.

Hotel presence around the lake was confirmed by 91 of 250 respondents (36%), who identified ten hotels in the area, with Kichakani being the most frequently mentioned (Figure 65).



Figure 65: Hotels in L. Ol Bolossat area

Perceptions of land ownership were also captured: 60% of respondents believed the lake is owned by the national government, 31% by the community, and 5% by the county government (Figure 66).



Figure 66: Land ownership

Only 43 out of 250 respondents (17%) had heard of the Integrated Management Plan (IMP) for the lake. Those familiar with the IMP indicated it emphasized fencing the lake, tree planting, and protecting endangered species. The plan was more commonly understood and referenced by key informants from government offices, local administration, CBOs, and the hospitality sector. They consistently emphasized that proper and inclusive implementation of the IMP, involving all stakeholders, is essential for effective lake management:

"The Integrated Management Plan to be implemented effectively with adequate engagement of all relevant stakeholders in a coordinated manner" (R005).

Despite its relevance, awareness of the IMP among community elders was notably low, suggesting a gap in policy dissemination at the grassroots level.

Views on the role of the county government in lake conservation were mixed. While some respondents believed the county had no role, others acknowledged involvement in tree planting, rule-setting, and enforcement. Encouragingly, signs of increasing political will were noted at both county and national levels. One notable example was a marathon organized on November 26th by the County Government, in collaboration with other stakeholders, to raise funds for restoration and conservation activities.

"The gazettement would require a lot of political will which has been largely lacking especially at county government level but is currently looking up at both the national and county government levels who have been supportive in lake restoration and conservation efforts " (R001).

4.9.9 Recommendations for Lake Management and Conservation

Survey respondents widely recommended fencing and tree planting as key interventions for managing Lake Ol Bolossat. While key informants generally agreed with these approaches, one noted that fencing may not be financially feasible. Instead, it was suggested that gazettement of the lake as a national reserve could offer a more sustainable and coordinated solution by establishing clear authority for protection and management among government agencies. As one informant explained:

"Overall, ownership and responsibility for management of the lake lacks clarity, making it fluid. Gazetting of the lake as a national reserve is needed to achieve clarity of lake management mandate and protection enforcement authority" (R012).

Beyond governance, gazettement was also perceived as a mechanism to facilitate restoration and attract tourism, which could, in turn, provide economic incentives for conservation. As highlighted by another informant:

"With ongoing restoration and global recognition, the lake would attract both local and international tourists who would sustainably support the community, government, and hotelier incomes. The income generation would provide incentive

for the locals, government, hoteliers, and other relevant stakeholders to conserve and protect the lake. An example would be promoting co-existence of the hippos with the people living around the lake” (R001).

However, community perspectives on lake restoration were nuanced. Some village elders perceived the lake’s fluctuations as part of a natural, divinely governed cycle, noting:

“It’s God’s decision whether the lake will exist or not; it has dried up multiple times in the past and recharged fully. If He decides to bring it back, He will. Otherwise, the learned should advise on the way forward for the management of the lake” (R011).

While cultural interpretations of lake dynamics are valid and rooted in historical memory, they must be integrated with scientific hydrology, which shows that lake recharge depends on rainfall feeding escarpments and catchments (R013).

Community Perceptions on Conservation Efforts

Local communities expressed a desire for solutions to human-wildlife conflict, especially regarding crop damage by wildlife, for which they requested compensation. Nevertheless, there was concern over potential evictions and interference with economic activities as part of conservation programs. For example, a respondent stated:

“There is a need for community engagement in management of the lake. The locals as key stakeholders should be exempted from paying to graze in the lake ecosystem. Instead, the outsiders including the Maasai and Samburus who come to graze during the dry season should be the ones to pay to graze in the lake” (R013).

These concerns highlight the need for equity, fairness, and inclusion in conservation planning and benefit-sharing mechanisms.

Summary of Findings

The study reveals widespread encroachment around Lake Ol Bolossat, with settlements extending up to the lake boundary. Economic activities such as crop farming and livestock keeping dominate, yet they are frequently unsustainable:

- Crop farming, especially horticulture, relies heavily on inorganic fertilizers and pesticides, often applied indiscriminately, leading to water pollution.
- Conversion of natural vegetation for farmland, combined with poor soil management practices, accelerates erosion and lake siltation.
- Water abstraction from rivers and streams for irrigation further reduces lake recharge.

Livestock keeping, while important for livelihoods, contributes to overgrazing, particularly in hippopotamus feeding areas, and disturbs bird breeding sites. Other pressures include forest harvesting, hunting, fishing, salt lick mining, and stone extraction, all of which degrade the lake’s biodiversity and ecosystem structure.

Although the lake is recognized both as a Wetland Protected Area and an Important Bird and Biodiversity Area (IBA), its management remains weak. Key issues include:

- Uncontrolled human settlement.
- Weak implementation of the Integrated Management Plan (IMP), hindered by:
- Poor coordination between government agencies.
- Unclear mandates and responsibilities.
- Inadequate financial support.
- Limited community involvement in decision-making.

4.9.10 Conclusions and Recommendations

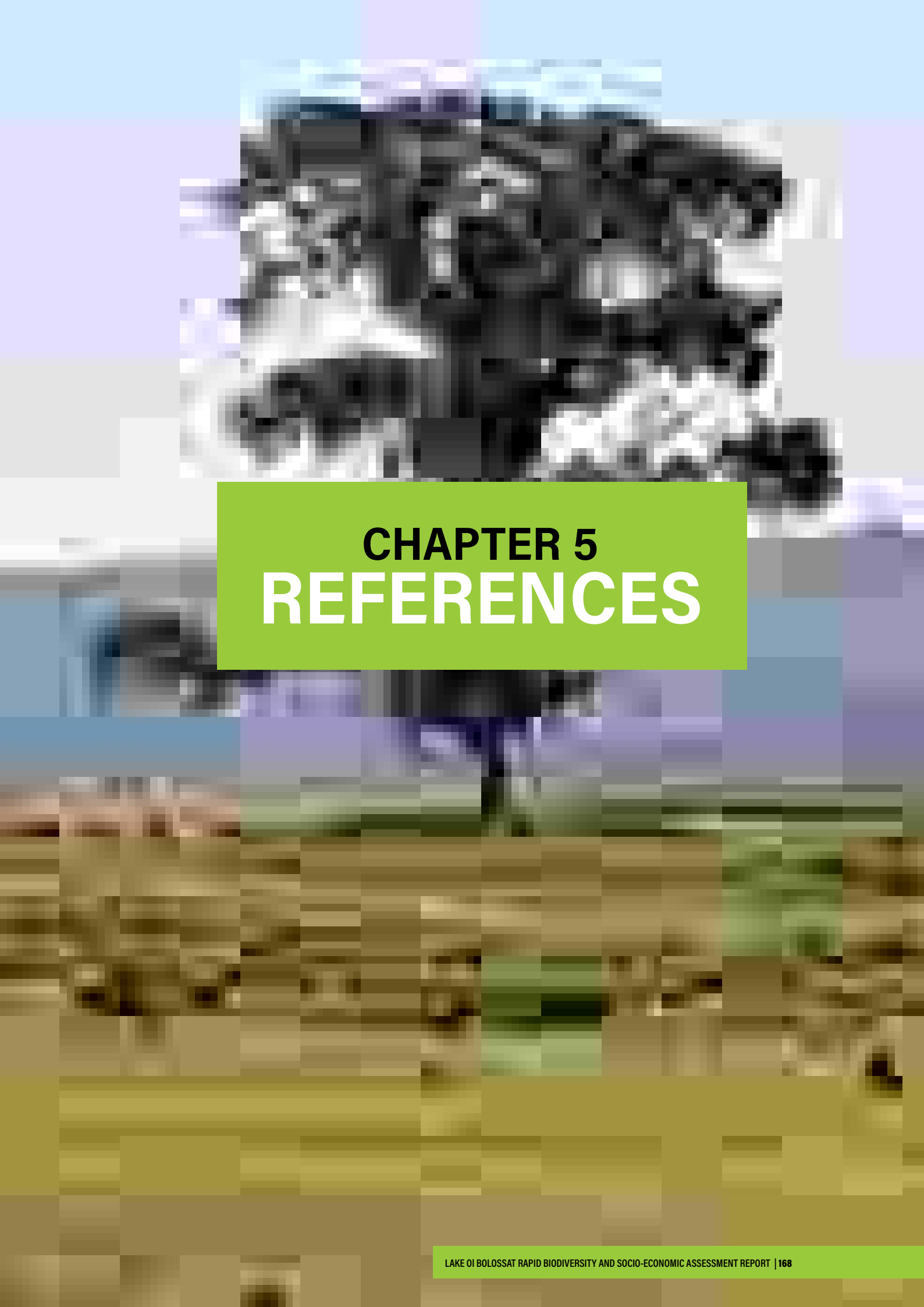
The sustainability of Lake Ol Bolossat and its surrounding ecosystems depends heavily on a coordinated approach that integrates biodiversity conservation with community well-being. This assessment underscores the need for stronger community engagement, infrastructural development, and institutional clarity to ensure the long-term protection of the lake's ecological integrity.

There is a need to strengthen community engagement through targeted capacity building efforts. These should focus on sustainable agriculture practices such as agroforestry, conservation agriculture, organic farming, integrated pest management (IPM), cover cropping, and closed-loop agriculture. These approaches not only enhance soil health and agricultural productivity but also reduce pressures on the fragile lake ecosystem.

At the same time, local infrastructure improvements, particularly in sanitation, road networks, health facilities, and schools, are essential. Such investments would improve the quality of life for communities living around the lake, thus creating a supportive environment for conservation efforts. These infrastructural developments should be prioritized by both county and national governments as part of broader development-conservation integration.

Citizen participation in conservation must also be promoted and institutionalized. Community members should be encouraged to take an active role in the protection of flora and fauna, participate in eco-tourism initiatives, and benefit equitably from revenue generated through tourism. These benefits would serve as direct incentives for conservation and reinforce the community's role as custodians of the lake ecosystem.

A key recommendation from this assessment is the listing of Lake Ol Bolossat as a Ramsar Site. This designation would not only elevate the lake's status at national and international levels but also help clarify institutional mandates for its protection. A Ramsar listing would support more coordinated enforcement of conservation measures, and crucially, enhance access to global conservation funding. With clear roles and responsibilities among relevant agencies, efforts to protect the lake and surrounding biodiversity would become more streamlined and effective.



CHAPTER 5 **REFERENCES**

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APPENDICES

Appendix A: Tables

Appendix 1: Plant Checklist of L. Ol Bolossat Ecosystem with the species life form, IUCN category and Invasive alien species indicated

(Note: H-Herb; S-Shrub; C-Climber; T-Tree; LC-Least concern; EN-Endangered; NT-Near Threatened; CR-Critically Endangered)

Family	Botanical name	Lifeform	IUCN	Invasive
Acanthaceae	<i>Asystasia mysorensis</i> T.Anderson	H		
Acanthaceae	<i>Barleria submollis</i> Lindau	H		
Acanthaceae	<i>Dicliptera maculata</i> Nees subsp. <i>usambarica</i> (Lindau) I.Darbysh.	H		
Acanthaceae	<i>Dyschoriste multicaulis</i> (Hochst ex. A.Rich.) Kuntze	H		
Acanthaceae	<i>Dyschoriste radicans</i> Nees	H		
Acanthaceae	<i>Hypoestes aristata</i> (Vahl) Roem. & Schult.	H	LC	
Acanthaceae	<i>Hypoestes forskalii</i> (Vahl) R.Br.	H	LC	
Acanthaceae	<i>Hypoestes triflora</i> (Forssk.) Roem. & Schult.	H		
Acanthaceae	<i>Kenyacanthus ndorensis</i> (Schweinf.) I. Darbsh. & C.A.Kiel	H		
Acanthaceae	<i>Thunbergia alata</i> Bojer ex Sims	H		
Acanthaceae	<i>Thunbergia fischeri</i> Engl.	H		
Acanthaceae	<i>Thunbergia gibsoni</i> S.Moore	H		
Agavaceae	<i>Agave sisalana</i> Perr. ex Engelm.	S		√
Amaranthaceae	<i>Achyranthes aspera</i> L.	H		
Amaranthaceae	<i>Achyranthes fasciculata</i> (Suess.) C.C.Towns.	H		
Amaranthaceae	<i>Amaranthus graecizans</i> L.	H		
Amaranthaceae	<i>Amaranthus hybridus</i> L.	H		
Amaranthaceae	<i>Amaranthus thunbergii</i> Moq.	H		
Amaranthaceae	<i>Chenopodiastrum murale</i> (L.)S.Fuentes, Uotila & Borsch	H		
Amaranthaceae	<i>Chenopodium album</i> L.	H		
Amaranthaceae	<i>Cyathula cylindrica</i> Moq.	H		
Amaranthaceae	<i>Dysphania carinata</i> Mosyakin & Clemants	H		
Amaranthaceae	<i>Dysphania schraderiana</i> (Schult.) Mosyakin & Clemants	H		
Amaranthaceae	<i>Oureta lanata</i> (L.) Kuntze	H		
Amaranthaceae	<i>Pupalia grandiflora</i> Peter	H		
Amaranthaceae	<i>Pupalia lappacea</i> (L.) A.Juss.	H	LC	
Amaranthaceae	<i>Sericocomopsis hildebrandtii</i> Schinz	H		
Amaryllidaceae	<i>Crinum macowanii</i> Baker	H		
Amaryllidaceae	<i>Scadoxus multiflorus</i> (Martyn) Raf.	H		
Anacardiaceae	<i>Searsia crenulata</i> (A.Rich) Moffett	S		
Anacardiaceae	<i>Searsia pyroides</i> (Burch.) Moffett subsp. <i>pyroides</i>	S	LC	
Apiaceae	<i>Berula erecta</i> (Huds.)Coville	H	LC	

Family	Botanical name	Lifeform	IUCN	Invasive
Apiaceae	<i>Centella asiatica</i> (L.) Urb.	H	LC	
Apiaceae	<i>Cyclospermum leptophyllum</i> (Pers.) Sprague ex Britton & P.Wilson	H		
Apiaceae	<i>Daucus incognitus</i> (C.Norman) Spalik, Reduron & Banasiak	H		
Apiaceae	<i>Daucus melananthus</i> (Hochst.) Reduron, Spalik & Banasiak	H		
Apiaceae	<i>Diplolophium africanum</i> Turcz.	H		
Apiaceae	<i>Haplosciadium abyssinicum</i> Hochst.	H		
Apiaceae	<i>Heteromorpha trifoliata</i> (H.L.Wendl.) Eckl. & Zeyh.	S		
Apiaceae	<i>Hydrocotyle mannii</i> Hook.f.	H	LC	
Apiaceae	<i>Hydrocotyle ranunculoides</i> L.f.	H	LC	
Apiaceae	<i>Lefebvrea atropurpurea</i> (Steud. ex A.Rich.) P.J.D.Winter	H		
Apiaceae	<i>Torilis arvensis</i> (Huds.) Link	H		
Apocynaceae	<i>Carissa spinarum</i> L.	S	LC	
Apocynaceae	<i>Cynanchum altiscandens</i> K.Schum.	C		
Apocynaceae	<i>Gomphocarpus fruticosus</i> (L.) Aint.f.	H		
Apocynaceae	<i>Gomphocarpus physocarpus</i> E. Mey.	H		
Apocynaceae	<i>Gomphocarpus semilunatus</i> A.Rich.	H		
Apocynaceae	<i>Gomphocarpus stenophyllus</i> Oliv.	H		
Apocynaceae	<i>Periploca linearifolia</i> Quart.-Dill. & A.Rich.	C		
Apocynaceae	<i>Secamone punctulata</i> Decne.	S		
Apocynaceae	<i>Vincetoxicum anomalum</i> (N.E.Br.) Meve & Liede	C		
Araceae	<i>Lemna</i> cf. <i>gibba</i> L.	H		
Araceae	<i>Zantedeschia aethiopica</i> (L.) Spreng.	H	LC	
Araliaceae	<i>Cussonia holstii</i> Engl.	T	LC	
Araliaceae	<i>Cussonia spicata</i> Thunb.	T		
Arecaceae	<i>Phoenix reclinata</i> Jacq.	T	LC	
Asparagaceae	<i>Albuca abyssinica</i> Jacq.	H		
Asparagaceae	<i>Anthericum angustifolium</i> A. Rich.	H		
Asparagaceae	<i>Asparagus racemosus</i> Willd.	S		
Asparagaceae	<i>Asparagus</i> sp.	H		
Asphodelaceae	<i>Aloe lateritia</i> Engl. var. <i>graminicola</i> (Reynolds) S.Carter	H		
Asphodelaceae	<i>Bulbine abyssinica</i> A. Rich.	H		
Aspleniaceae	<i>Thelypteris confluens</i> (Thunb.) C.V.Morton	H		
Asteraceae	<i>Acmella caulirhiza</i> Delile	H		
Asteraceae	<i>Ageratina adenophora</i> (Spreng.) R.M.King & H.Rob.	S		√
Asteraceae	<i>Ageratum conyzoides</i> L.	H	LC	√
Asteraceae	<i>Artemisia afra</i> Jacq. ex Willd.	S		
Asteraceae	<i>Artemisia</i> sp.	S		
Asteraceae	<i>Aspilia mossambicensis</i> (Oliv.) Wild	H		

Family	Botanical name	Lifeform	IUCN	Invasive
Asteraceae	<i>Baccharoides lasiopus</i> (O.Hoffm.) H.Rob.var. <i>acuta</i> (C.Jeffrey) Isawumi, El-Ghazaly & B.Nord.	S		
Asteraceae	<i>Berkheya spekeana</i> Oliv.	H		
Asteraceae	<i>Bidens flagellata</i> (Sherff) Mesfin	H		
Asteraceae	<i>Bidens kilimandscharica</i> (O.Hoffm.) Sherff	H		
Asteraceae	<i>Bidens pilosa</i> L.	H		
Asteraceae	<i>Bothriocline longipes</i> (Oliv. & Hiern) N.E.Br.	H		
Asteraceae	<i>Carduus afromontanus</i> R.E.Fr.	H		
Asteraceae	<i>Carduus nyassanus</i> (S.Moore) R.E.Fr.	H	LC	
Asteraceae	<i>Carduus schimperi</i> Sch.Bip. subsp. <i>schimperi</i>	H		
Asteraceae	<i>Centaurea melitensis</i> L.	H		
Asteraceae	<i>Cineraria deltoidea</i> Sond.	H		
Asteraceae	<i>Cirsium buchwaldii</i> O.Hoffm.	H		
Asteraceae	<i>Cirsium vulgare</i> (Savi) Ten.	H		√
Asteraceae	<i>Conyza newii</i> Oliv. & Hiern	H		
Asteraceae	<i>Cotula anthemoides</i> L.	H		
Asteraceae	<i>Cotula australis</i> Hook.f.	H		
Asteraceae	<i>Crassocephalum montuosum</i> (S.Moore) Milne-Redh.	H		
Asteraceae	<i>Crassocephalum picridifolium</i> (DC.) S.Moore	H		
Asteraceae	<i>Crassocephalum vitellinum</i> (Benth.) S.Moore	H		
Asteraceae	<i>Dichrocephala chrysanthemifolia</i> (Blume) DC.	H		
Asteraceae	<i>Dichrocephala integrifolia</i> (L.f.) Kuntze	H		
Asteraceae	<i>Echinops angustilobus</i> S.Moore	H		
Asteraceae	<i>Emilia integrifolia</i> Baker	H		
Asteraceae	<i>Erigeron bonariensis</i> L.	H		
Asteraceae	<i>Erigeron schimperi</i> (Sch.Bip. ex A.Rich.) Sch.Bip. ex Schweinf.	H		
Asteraceae	<i>Erigeron steudelii</i> (Sch.Bip. ex A.Rich.) Sch.Bip. H ex Schweinf.			
Asteraceae	<i>Eschenbachia subscaposa</i> (O.Hoffm.) G.L.Nesom	H		
Asteraceae	<i>Eschenbachia tigrensis</i> (Oliv. & Hiern) G.L.Nesom	H		
Asteraceae	<i>Ethulia vernonioides</i> (Schweinf.) M.G.Gilbert subsp. <i>vernonioides</i>	H		
Asteraceae	<i>Euryops brownei</i> S.Moore	S		
Asteraceae	<i>Euryops jacksonii</i> S.Moore	S		
Asteraceae	<i>Felicia muricata</i> (Thunb.) Nees	H		
Asteraceae	<i>Galinsoga parviflora</i> Cav.	H		
Asteraceae	<i>Gamochaeta purpurea</i> (L.) Cabrera	H		
Asteraceae	<i>Gerbera piloselloides</i> (L.) Cass.	H		
Asteraceae	<i>Gerbera viridifolia</i> (DC.) Sch.Bip. ssp. <i>viridifolia</i>	H		
Asteraceae	<i>Gnaphalium unionis</i> Sch.Bip. ex Oliv. & Hiern	H	LC	

Family	Botanical name	Lifeform	IUCN	Invasive
Asteraceae	<i>Gnaphalium unionis</i> Sch.Bip. ex Hochst. var. <i>rubriflorum</i> (Hilliard) Beentje	H		
Asteraceae	<i>Gorteria beguinotii</i> (Lanza) Stångb. & Anderb.	H		
Asteraceae	<i>Guizotia abyssinica</i> (L.f.) Cass.	H		
Asteraceae	<i>Guizotia scabra</i> (Vis.) Chiov.	H		
Asteraceae	<i>Gutenbergia cordifolia</i> Benth. ex Oliv.	H		
Asteraceae	<i>Gymnanthemum auriculiferum</i> (Hiern) Isawuwi	S	LC	
Asteraceae	<i>Gynura scandens</i> O.Hoffm.	C		
Asteraceae	<i>Helichrysum foetidum</i> (L.) Cass.	H		
Asteraceae	<i>Helichrysum forskahlii</i> (J.F.Gmel.) Hilliard & B.L.Burt	H		
Asteraceae	<i>Helichrysum globosum</i> Sch.Bip.	H		
Asteraceae	<i>Helichrysum nudifolium</i> (L.) Less.	H		
Asteraceae	<i>Helichrysum odoratissimum</i> (L.) Less.	H		
Asteraceae	<i>Helichrysum schimperi</i> (Sch.Bip.) Moeser	H		
Asteraceae	<i>Hoffmannanthus abbotianus</i> (O.Hoffm.)H.Rob., S.C.Keeley & Skvaria	S		
Asteraceae	<i>Hypochaeris glabra</i> L.	H		
Asteraceae	<i>Kleinia petraea</i> (R.E.Fr.) C.Jeffrey	H		
Asteraceae	<i>Lactuca inermis</i> Forssk.	H		
Asteraceae	<i>Lactuca serriola</i> L.	H		
Asteraceae	<i>Laggera brevipes</i> Oliv. & Hiern	H		
Asteraceae	<i>Laggera</i> sp.	H		
Asteraceae	<i>Micractis bojeri</i> DC.	H	LC	
Asteraceae	<i>Microglossa hildebrandtii</i> O.Hoffm.	S		
Asteraceae	<i>Nidorella elliotii</i> (S.Moore) Brenan	H		
Asteraceae	<i>Osteospermum vaillantii</i> (Decne.) Norl.	H		
Asteraceae	<i>Pluchea bequaertii</i> Robyns	H	LC	
Asteraceae	<i>Pluchea dioscoridis</i> (L.) DC.	H		
Asteraceae	<i>Pseudognaphalium luteoalbum</i> (L.) Hilliard & B.L.Burt	H		
Asteraceae	<i>Psiadia punctulata</i> Vatke	S		
Asteraceae	<i>Schkuhria pinnata</i> (Lam.) Kuntze ex Thell.	H		
Asteraceae	<i>Senecio deltoideus</i> Less.	H		
Asteraceae	<i>Senecio hadiensis</i> Forssk.	C		
Asteraceae	<i>Senecio madagascariensis</i> Poir.	H		✓
Asteraceae	<i>Senecio pseudosubsessilis</i> C.Jeffrey	H		EN
Asteraceae	<i>Senecio ruwenzoriensis</i> S.Moore	H		
Asteraceae	<i>Senecio subsessilis</i> Oliv. & Hiern	H		
Asteraceae	<i>Solanecio mannii</i> (Hook.f.) C.Jeffrey	S	LC	
Asteraceae	<i>Sonchus luxurians</i> (R.E.Fr.) C.Jeffrey	H		
Asteraceae	<i>Sonchus oleraceus</i> L.	H		
Asteraceae	<i>Sphaeranthus suaveolens</i> (Forssk.) DC.	H		
Asteraceae	<i>Tagetes minuta</i> L.	H		

Family	Botanical name	Lifeform	IUCN	Invasive
Asteraceae	<i>Taraxacum officinale</i> Weber ex F.H.Wigg.	H		
Asteraceae	<i>Tarchonanthus camphoratus</i> L.	T	LC	
Asteraceae	<i>Vernonia galamensis</i> (Cass.) Less. subsp. <i>afromontana</i> (R.E.Fr.) M.G.Gilbert var. <i>afromontana</i>	H		
Asteraceae	<i>Vernonia</i> sp.	H		
Asteraceae	<i>Xanthium strumarium</i> L.	H		
Balsaminaceae	<i>Impatiens meruensis</i> Gilg subsp. <i>cruciata</i> (T.C.E.Fr.) Grey-Wilson	H		
Basellaceae	<i>Basella alba</i> L.	H		
Berberidaceae	<i>Berberis holstii</i> Engl.	S		
Bignoniaceae	<i>Jacaranda mimosifolia</i> D.Don	T		√
Boraginaceae	<i>Cynoglossum coeruleum</i> Hochst. ex A.DC.	H		
Boraginaceae	<i>Cynoglossum lanceolatum</i> Forssk.	H		
Boraginaceae	<i>Echium plantagineum</i> L.	H		√
Brassicaceae	<i>Brassica</i> sp.	H		
Brassicaceae	<i>Capsella bursa-pastoris</i> (L.) Medik.	H		
Brassicaceae	<i>Erucastrum arabicum</i> Fisch. & C.A.Mey.	H		
Brassicaceae	<i>Lepidium bonariense</i> L.	H		
Brassicaceae	<i>Nasturtium officinale</i> W.T.Aiton	H	LC	
Brassicaceae	<i>Rorippa cryptantha</i> (Hochst. ex A. Rich.) Robyns & Boutique	H		
Brassicaceae	<i>Rorippa nudiuscula</i> (E.Mey. ex Sond.) Thell.	H		
Brassicaceae	<i>Sisymbrium irio</i> L.	H		
Brassicaceae	<i>Sisymbrium officinale</i> (L.) Scop.	H		
Cactaceae	<i>Austrocylindropuntia ?subulata</i> (Muehlenpf.) backeb	H		
Calceolariaceae	<i>Calceolaria tripartita</i> Ruiz & Pav.	H		
Campanulaceae	<i>Lobelia flaccida</i> (C.Presl) A.DC. subsp. <i>granvikii</i> (T.C.E.Fr.) Thulin	H		
Campanulaceae	<i>Lobelia holstii</i> Engl.	H		
Campanulaceae	<i>Monopsis stellarioides</i> (C.Presl) Urb. subsp. <i>schimperiana</i> (Urb.) Thulin	H		
Caryophyllaceae	<i>Cerastium lanceolatum</i> (Poir.) Volponi	H		
Caryophyllaceae	<i>Cerastium octandrum</i> Hochst. ex A.Rich. var. <i>adnivalis</i> (Chiov.) Möschl	H		
Caryophyllaceae	<i>Silene burchellii</i> Otth	H		
Caryophyllaceae	<i>Silene gallica</i> L.	H		
Caryophyllaceae	<i>Spergula arvensis</i> L.	H		
Celastraceae	<i>Gymnosporia heterophylla</i> (Eckl. & Zeyh.) Loes.	S		
Colchicaceae	<i>Wurmbea tenuis</i> (Hook f.) Bak.	H		
Commelinaceae	<i>Aneilema minutiflorum</i> Faden	H		
Commelinaceae	<i>Commelina africana</i> L.	H	LC	
Commelinaceae	<i>Commelina benghalensis</i> L.	H	LC	

Family	Botanical name	Lifeform	IUCN	Invasive
Commelinaceae	<i>Commelina purpurea</i> C.B.Clarke	H		
Commelinaceae	<i>Commelina reptans</i> Brenan	H		
Commelinaceae	<i>Commelina subulata</i> Roth	H		
Commelinaceae	<i>Cyanotis vaga</i> (Lour.) Schult. & Schult.f.	H		
Commelinaceae	<i>Floscopa glomerata</i> (Willd. ex Schult. & Schult.f.) Hassk.	H	LC	
Convolvulaceae	<i>Convolvulus sagittatus</i> Thunb.	C		
Convolvulaceae	<i>Cuscuta kilimanjari</i> Oliv. var. kilimanjari	H	LC	
Convolvulaceae	<i>Dichondra repens</i> J.R.Forst. & G.Forst.	H		
Convolvulaceae	<i>Falkia canescens</i> C.H.Wright	H		
Convolvulaceae	<i>Ipomoea cairica</i> (L.) Sweet	C	LC	√
Convolvulaceae	<i>Ipomoea obscura</i> (L.) Ker Gawl. var. obscura	H		
Crassulaceae	<i>Crassula alata</i> (Viv.) Berger	H		
Crassulaceae	<i>Crassula alba</i> Forssk.	H		
Crassulaceae	<i>Crassula granvikii</i> Mildbr.	H	LC	
Crassulaceae	<i>Crassula schimperi</i> Fisch. & C.A.Mey. subsp. <i>phyturus</i> (Mildbr.) R.Fern.	H		
Crassulaceae	<i>Kalanchoe delagoensis</i> Eckl. & Zeyh.	H		√
Crassulaceae	<i>Kalanchoe densiflora</i> Rolfe	H	LC	
Cucurbitaceae	<i>Cucumis ficifolius</i> A.Rich.	H		
Cucurbitaceae	<i>Lagenaria abyssinica</i> (Hook.f.) C.Jeffrey	C		
Cucurbitaceae	<i>Momordica friesiorum</i> (Harms) C.Jeffrey	C		
Cucurbitaceae	<i>Zehneria scabra</i> (L.f.) Sond.	C		
Cupressaceae	<i>Hesperocyparis lusitanica</i> (Mill.) Bartel	T		
Cupressaceae	<i>Juniperus procera</i> Hochst. ex Endl.	T	LC	
Cyperaceae	<i>Abildgaardia ovata</i> (Burm.f.) Kral	H		
Cyperaceae	<i>Bulbostylis</i> sp. √	H		
Cyperaceae	<i>Bulbostylis</i> sp. 2	H		
Cyperaceae	<i>Carex bequaertii</i> De Wild.	H	LC	
Cyperaceae	<i>Carex conferta</i> Hochst. ex A.Rich.	H	LC	
Cyperaceae	<i>Carex lycurus</i> K.Schum.	H		
Cyperaceae	<i>Cyperus cyperoides</i> (L.) Kuntze	H	LC	
Cyperaceae	<i>Cyperus denudatus</i> L.f.	H	LC	
Cyperaceae	<i>Cyperus dichrostachyus</i> Hochst. ex A.Rich.	H	LC	
Cyperaceae	<i>Cyperus digitatus</i> Roxb.	H	LC	
Cyperaceae	<i>Cyperus dives</i> Del.	H	LC	
Cyperaceae	<i>Cyperus elegantulus</i> Steud.	H	LC	
Cyperaceae	<i>Cyperus exaltatus</i> Retz.	H	LC	
Cyperaceae	<i>Cyperus latifolius</i> Poir	H	LC	
Cyperaceae	<i>Cyperus mundii</i> (Nees) Kunth	H	LC	
Cyperaceae	<i>Cyperus papyrus</i> L.	H	LC	
Cyperaceae	<i>Cyperus persquarrosus</i> T.Koyama	H	LC	
Cyperaceae	<i>Cyperus platycaulis</i> Baker	H		

Family	Botanical name	Lifeform	IUCN	Invasive
Cyperaceae	<i>Cyperus rigidifolius</i> Steud.	H	LC	
Cyperaceae	<i>Cyperus rubicundus</i> Vahl	H	LC	
Cyperaceae	<i>Eleocharis marginulata</i> Hochst. ex Steud.	H	LC	
Cyperaceae	<i>Fimbristylis</i> sp. ✓	H		
Cyperaceae	<i>Fuirena pubescens</i> (Poir.) Kunth	H		
Cyperaceae	<i>Fuirena welwitschii</i> Ridl.	H	LC	
Cyperaceae	<i>Isolepis fluitans</i> (L.) R.Br.	H	LC	
Cyperaceae	<i>Kyllinga</i> sp. ✓	H		
Cyperaceae	<i>Pycneus</i> sp. ✓	H		
Cyperaceae	<i>Schoenoplectiella articulata</i> (L.) Lye H LC			
Cyperaceae	<i>Schoenoplectiella brachyceras</i> (Hochst. ex A.Rich.) Lye	H		
Cyperaceae	<i>Schoenoplectiella corymbosa</i> (Roth ex Roem. & Schult.) J.R.Starr & Jim.Mejias	H	LC	
Dennstaedtiaceae	<i>Pteridium aquilinum</i> (L.) Kuhn	H		
Euphorbiaceae	<i>Croton macrostachyus</i> Hochst. ex Delile	S	LC	
Euphorbiaceae	<i>Croton megalocarpus</i> Hutch.	T	LC	
Euphorbiaceae	<i>Euphorbia inaequilatera</i> Sond.	H		
Euphorbiaceae	<i>Euphorbia ingens</i> E.Mey. ex Boiss.	T	LC	
Euphorbiaceae	<i>Euphorbia</i> sp. T			
Euphorbiaceae	<i>Ricinus communis</i> L.	S		
Fabaceae	<i>Acacia abyssinica</i> Hochst. ex Benth. subsp. <i>calophylla</i> Brenan	T		
Fabaceae	<i>Acacia mearnsii</i> De Wild.	T		
Fabaceae	<i>Acacia melanoxylon</i> R.Br.	S		✓
Fabaceae	<i>Albizia gummifera</i> (J.F.Gmel.) C.A.Sm. var. <i>ealaensis</i> (De Wild.) Brenan	T		
Fabaceae	<i>Argyrolobium rupestre</i> (E.Mey.) Walp. subsp. <i>kilimandscharicum</i> (Taub.) Polh.	H		
Fabaceae	<i>Chamaecrista usambarensis</i> (Taub.) Standley	H		
Fabaceae	<i>Colutea abyssinica</i> Kunth & C.D.Bouché	H		
Fabaceae	<i>Crotalaria agatiflora</i> Schweinf.	H	LC	
Fabaceae	<i>Crotalaria brevidens</i> Benth.	H		
Fabaceae	<i>Crotalaria incana</i> L.	H		
Fabaceae	<i>Crotalaria laburnifolia</i> L. subsp. <i>eldomae</i> (Baker f.) Polhill	H		
Fabaceae	<i>Crotalaria lachnocarpoides</i> Engl.	H		
Fabaceae	<i>Crotalaria spinosa</i> Hochst. ex Benth.	H		
Fabaceae	<i>Desmodium repandum</i> (Vahl) DC.	H		
Fabaceae	<i>Eriosema scioanum</i> subsp. <i>lejeunei</i> (Staner & De Craene) Verdc.	H		
Fabaceae	<i>Indigofera arrecta</i> Hochst. ex A.Rich.	H		
Fabaceae	<i>Indigofera atriceps</i> Hook.f.	S		

Family	Botanical name	Lifeform	IUCN	Invasive
Fabaceae	<i>Indigofera bogdanii</i> J. B. Gillett	H		
Fabaceae	<i>Indigofera brevicalyx</i> Baker f.	H		
Fabaceae	<i>Indigofera spicata</i> Forssk.	H		
Fabaceae	<i>Indigofera stenophylla</i> Guill. & Perr.	H		
Fabaceae	<i>Lotus corniculatus</i> L.	H		
Fabaceae	<i>Medicago laciniata</i> (L.) Mill.	H		
Fabaceae	<i>Medicago lupulina</i> L.	H		
Fabaceae	<i>Neonotonia wightii</i> (Wight & Arn.) J.A.Lackey	C	LC	
Fabaceae	<i>Senna bicapsularis</i> (L.) Roxb.	H	LC	√
Fabaceae	<i>Senna didymobotrya</i> (Fresen.) H.S.Irwin & Barneby	S	LC	√
Fabaceae	<i>Senna multiglandulosa</i> (Jacq.) H.S.Irwin & Barneby	S	LC	
Fabaceae	<i>Sesbania sesban</i> (L.) Merr.	T	LC	
Fabaceae	<i>Tara spinosa</i> (Molina) Britton & Rose	T		
Fabaceae	<i>Tephrosia interrupta</i> Hochst. & Steud. ex Engl. subsp. <i>interrupta</i>	S		
Fabaceae	<i>Tephrosia reptans</i> Bak.	H		
Fabaceae	<i>Trifolium burchellianum</i> subsp. <i>johnstonii</i> (Oliv.) H Cufod. ex J.B.Gillett			
Fabaceae	<i>Trifolium cryptopodium</i> Steud. ex A.Rich.	H		
Fabaceae	<i>Trifolium rueppellianum</i> Fresen.	H		
Fabaceae	<i>Trifolium semipilosum</i> Fresen.	H		
Fabaceae	<i>Trifolium usambarense</i> Taub.	H		
Fabaceae	<i>Vicia hirsuta</i> (L.) Gray	H		
Fabaceae	<i>Vicia villosa</i> Roth	H		
Gentianaceae	<i>Sebaea brachyphylla</i> Griseb.	H		
Gentianaceae	<i>Sebaea pentandra</i> E.Mey. var. <i>burchellii</i> (Gilg) Marais	H		
Geraniaceae	<i>Geranium aculeolatum</i> Oliv.	H		
Geraniaceae	<i>Geranium arabicum</i> Forssk.	H	LC	
Geraniaceae	<i>Geranium elamellatum</i> Kokwaro	H		
Geraniaceae	<i>Monsonia angustifolia</i> E.Mey. ex A.Rich.	H		
Geraniaceae	<i>Monsonia glauca</i> R.Knuth	H		
Gesneriaceae	<i>Streptocarpus glandulosissimus</i> Engl.	H		
Hamamelidaceae	<i>Trichocladus ellipticus</i> Eckl. & Zeyh. subsp. <i>malosanus</i> (Baker) Verdc.	T	LC	
Hypericaceae	<i>Hypericum scioanum</i> Chiov.	H		
Hypoxidaceae	<i>Hypoxis angustifolia</i> Lam.	H		
Hypoxidaceae	<i>Hypoxis filiformis</i> Baker	H		
Iridaceae	<i>Aristea alata</i> Baker	H		
Iridaceae	<i>Gladiolus dalenii</i> Van Geel subsp. <i>dalenii</i>	H		
Iridaceae	<i>Romulea fischeri</i> Pax	H		
Isoetaceae	<i>Isoetes fluitans</i> M.I.Romero	H		
Juncaceae	<i>Juncus oxycarpus</i> E.Mey. ex Kunth	H	LC	

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Lamiaceae	<i>Ajuga integrifolia</i> Buch.-Ham. ex D.Don	H		
Lamiaceae	<i>Clerodendrum johnstonii</i> Oliv.	S	LC	
Lamiaceae	<i>Clinopodium abyssinicum</i> (Benth.) Kuntze	H		
Lamiaceae	<i>Coleus barbatus</i> (Andrews) Benth. ex G.Don	S		
Lamiaceae	<i>Coleus maculosus</i> (Lam.) A.J.Paton subsp. <i>edulis</i> (Vatke) A.J.Paton	H		
Lamiaceae	<i>Coleus prostratus</i> (Gürke) A.J.Paton	H		
Lamiaceae	<i>Coleus sylvestris</i> (Gürke) A.J.Paton & Phillipson	H		
Lamiaceae	<i>Equilabium kamerunense</i> (Gurke) Mwany. & A.J.Paton	H		
Lamiaceae	<i>Leonotis nepetifolia</i> (L.) R.Br.	H		
Lamiaceae	<i>Leucas deflexa</i> Hook.f. var. <i>kondowensis</i> (Baker) Sebald	H		
Lamiaceae	<i>Leucas grandis</i> Vatke	H		
Lamiaceae	<i>Mentha aquatica</i> L.	H	LC	
Lamiaceae	<i>Micromeria biflora</i> (Buch.-Ham. ex D.Don) Benth.	H		
Lamiaceae	<i>Micromeria imbricata</i> (Forssk.) C.Chr.	H		
Lamiaceae	<i>Nepeta azurea</i> R.Br. ex Benth.	H		
Lamiaceae	<i>Ocimum decumbens</i> Gürke	H		
Lamiaceae	<i>Ocimum kilimandscharicum</i> Gürke	H		
Lamiaceae	<i>Ocimum lamiifolium</i> Hochst. ex Benth.	S		
Lamiaceae	<i>Rothea myrroides</i> (Hochst.) Steane & Mabb	S	LC	
Lamiaceae	<i>Salvia nilotica</i> Juss. ex. Jacq.	H		
Linderniaceae	<i>Craterostigma hirsutum</i> S.Moore	H		
Linderniaceae	<i>Craterostigma newtonii</i> (Engl.) E.B.Fisch., Schaferh. & Kai Mull.	H	LC	
Linderniaceae	<i>Craterostigma pumilum</i> Hochst.	H		
Linderniaceae	<i>Lindernia parviflora</i> (Roxb.) Haines	H	LC	
Loranthaceae	<i>Englerina woodfordioides</i> (Schweinf.) Balle	H		
Loranthaceae	<i>Phragmanthera dschallensis</i> (Engl.) M.G.Gilbert	H		
Lythraceae	<i>Lythrum rotundifolium</i> Hochst. ex A.Rich.	H		
Malvaceae	<i>Abutilon mauritianum</i> (Jacq.) Medik.	H		
Malvaceae	<i>Dombeya burgessiae</i> Gerrard ex Harv.	T	LC	
Malvaceae	<i>Dombeya kirkii</i> Mast.	T		
Malvaceae	<i>Dombeya torrida</i> (J.F.Gmel.) Bamps subsp. <i>torrida</i>	T		
Malvaceae	<i>Hibiscus calyphyllus</i> Cav.	S	LC	
Malvaceae	<i>Hibiscus cannabinus</i> L.	H		
Malvaceae	<i>Malva verticillata</i> L.	H		
Malvaceae	<i>Pavonia urens</i> Cav.	H		
Malvaceae	<i>Sida schimperiana</i> Hochst. ex A.Rich.	S		
Malvaceae	<i>Sida tenuicarpa</i> Vollesen	H		
Malvaceae	<i>Urena lobata</i> L.	H	LC	
Meliaceae	<i>Ekebergia capensis</i> Sparrm.	S	LC	
Menispermaceae	<i>Cissampelos mucronata</i> A.Rich.	H		

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Menispermaceae	<i>Cissampelos pareira</i> L.	H		
Menispermaceae	<i>Stephania abyssinica</i> (Quart.-Dill. & A.Rich.) Walp.	H		
Moraceae	<i>Ficus natalensis</i> Hochst.	T	LC	
Musaceae	<i>Ensete ventricosum</i> (Welw.) Cheesman	H	LC	
Myrtaceae	<i>Eucalyptus camaldulensis</i> Dehnh.	T	NT	
Myrtaceae	<i>Eucalyptus</i> sp.	T		
Myrtaceae	<i>Melaleuca armillaris</i> (Sol. ex Gaertn.) Sm.	T	LC	
Myrtaceae	<i>Melaleuca citrina</i> (Curtis) Dum.Cours	T		
Myrtaceae	<i>Syzygium cordatum</i> Hochst. ex Krauss	T	LC	
Oleaceae	<i>Fraxinus pennsylvanica</i> Marshall	T	CR	√
Oleaceae	<i>Jasminum fluminense</i> Vell. subsp. <i>fluminense</i>	C		
Oleaceae	<i>Olea europaea</i> L. subsp. <i>cuspidata</i> (Wall. & G.Don) Cif.	T		
Onagraceae	<i>Epilobium hirsutum</i> L.	H	LC	
Onagraceae	<i>Ludwigia abyssinica</i> A.Rich.	H	LC	
Onagraceae	<i>Ludwigia adscendens</i> (L.) H.Hara subsp. <i>diffusa</i> (Forssk.) P.H. Raven	H		
Onagraceae	<i>Oenothera tetraptera</i> Cav.	H		
Ophioglossaceae	<i>Ophioglossum polyphyllum</i> A.Braun ex Seub.	H		
Orchidaceae	<i>Eulophia streptopetala</i> Lindl.	H		
Orchidaceae	<i>Herbenaria</i> sp.	H		
Orchidaceae	<i>Polystachya</i> sp.	H		
Orchidaceae	<i>Satyrium fimbriatum</i> Summerh.	H		
Orobanchaceae	<i>Cycnium jamesii</i> (Skan) O.J.Hansen	H		
Orobanchaceae	<i>Cycnium tubulosum</i> (L.f.) Engl.	H		
Orobanchaceae	<i>Orobanche minor</i> Sm.	H		
Oxalidaceae	<i>Oxalis anthelmintica</i> A.Rich.	H		
Oxalidaceae	<i>Oxalis corniculata</i> L.	H		
Passifloraceae	<i>Passiflora edulis</i> Sims	C		√
Peraceae	<i>Clusia abyssinica</i> Jaub. & Spach	S	LC	
Phyllanthaceae	<i>Phyllanthus boehmii</i> Pax var. <i>boehmii</i>	H		
Phyllanthaceae	<i>Phyllanthus fischeri</i> Pax	H		
Phyllanthaceae	<i>Phyllanthus sepialis</i> Müll.Arg.	S		
Phytolaccaceae	<i>Phytolacca dioica</i> L.	S	LC	
Phytolaccaceae	<i>Phytolacca dodecandra</i> L'Hér.	S		
Pinaceae	<i>Pinus patula</i> Schiede ex Schltdl. & Cham.	T	LC	√
Piperaceae	<i>Peperomia abyssinica</i> Miq.	H		
Pittosporaceae	<i>Pittosporum viridiflorum</i> Sims	T		
Plantaginaceae	<i>Plantago lanceolata</i> L.	H		
Plantaginaceae	<i>Plantago major</i> L.	H	LC	
Plantaginaceae	<i>Plantago palmata</i> Hook.f.	H		
Plantaginaceae	<i>Veronica abyssinica</i> Fresen.	H		
Plantaginaceae	<i>Veronica anagallis-aquatica</i> L.	H		

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Poaceae	<i>Andropogon abyssinicus</i> R.Br. ex Fresen.	H		
Poaceae	<i>Andropogon amethystinus</i> Steud.	H		
Poaceae	<i>Aristida adoensis</i> Hochst. ex A.Rich.	H	LC	
Poaceae	<i>Aristida adscensionis</i> L.	H		
Poaceae	<i>Brachypodium flexum</i> Nees	H		
Poaceae	<i>Bromus catharticus</i> Vahl.	H		
Poaceae	<i>Bromus leptoclados</i> Nees	H		
Poaceae	<i>Cenchrus clandestinus</i> (Hochst. ex Chiov.) Morrone	H	LC	
Poaceae	<i>Cenchrus geniculatus</i> Thunb.	H	LC	
Poaceae	<i>Cenchrus hohenackeri</i> (Hochst. ex Steud.) Morrone	H	LC	
Poaceae	<i>Cenchrus riparius</i> (Hochst. ex A.Rich.) Morrone	H		
Poaceae	<i>Cenchrus sphacelatus</i> (Nees) Morrone	H	LC	
Poaceae	<i>Chloris gayana</i> Kunth	H		
Poaceae	<i>Chloris pycnothrix</i> Trin.	H		
Poaceae	<i>Chloris virgata</i> Sw.	H		
Poaceae	<i>Cynodon dactylon</i> (L.) Pers.	H		
Poaceae	<i>Digitaria abyssinica</i> (Hochst. ex A.Rich.) Stapf	H		
Poaceae	<i>Digitaria longiflora</i> (Retz.) Pers.	H		
Poaceae	<i>Digitaria sanguinalis</i> (L.) Scop.	H		
Poaceae	<i>Digitaria ternata</i> (A.Rich.) Stapf	H		
Poaceae	<i>Echinochloa colonum</i> (L.) Link	H	LC	
Poaceae	<i>Eleusine africana</i> Kenn.-O'Byrne	H	LC	
Poaceae	<i>Eleusine jaegeri</i> Pilg.	H	LC	
Poaceae	<i>Eleusine multiflora</i> Hochst. ex A.Rich.	H	LC	
Poaceae	<i>Eragrostis exasperata</i> Peter	H		
Poaceae	<i>Eragrostis heteromera</i> Stapf	H		
Poaceae	<i>Eragrostis olivacea</i> K.Schum.	H		
Poaceae	<i>Eragrostis paniciformis</i> (A.Braun) Steud	H		
Poaceae	<i>Eragrostis pilosa</i> (L.) P.Beauv.	H		
Poaceae	<i>Eragrostis schweinfurthii</i> Chiov.	H		
Poaceae	<i>Festuca abyssinica</i> A.Rich.	H		
Poaceae	<i>Harpachne schimperii</i> Hochst. ex A.Rich.	H		
Poaceae	<i>Hyparrhenia ?anamesa</i> Clayton	H		
Poaceae	<i>Hyparrhenia collina</i> (Pilg.) Stapf	H		
Poaceae	<i>Hyparrhenia dregeana</i> (Nees) Stapf ex Stent	H		
Poaceae	<i>Hyparrhenia filipendula</i> (Hochst.) Stapf	H		
Poaceae	<i>Leersia hexandra</i> Sw.	H	LC	
Poaceae	<i>Lolium multiflorum</i> Lam.	H		
Poaceae	<i>Lolium perenne</i> L.	H		
Poaceae	<i>Loudetia kagerensis</i> (K.Schum.) Hutch.	H		
Poaceae	<i>Melinis minutiflora</i> P.Beauv.	H		
Poaceae	<i>Microchloa kunthii</i> Desv.	H		

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Poaceae	<i>Panicum coloratum</i> L.	H		
Poaceae	<i>Panicum hochstetteri</i> Steud.	H		
Poaceae	<i>Panicum hygrocharis</i> Steud.	H		
Poaceae	<i>Phalaris arundinacea</i> L.	H	LC	
Poaceae	<i>Poa annua</i> L.	H	LC	
Poaceae	<i>Setaria pumila</i> (Poir.) Roem. & Schult.	H		
Poaceae	<i>Setaria sphacelata</i> (Schumach.) Stapf & C.E.Hubb. ex Moss	H	LC	
Poaceae	<i>Sporobolus discosporus</i> Nees	H	LC	
Poaceae	<i>Sporobolus pyramidalis</i> P.Beauv.	H		
Poaceae	<i>Themeda triandra</i> Forssk. H			
Podocarpaceae	<i>Afrocarpus falcatus</i> (Thunb.) C.N.Page	T	LC	
Podocarpaceae	<i>Podocarpus latifolius</i> (Thunb.) Mirb.	T	LC	
Polygalaceae	<i>Polygala sphenoptera</i> Fresen.	H		
Polygonaceae	<i>Persicaria ?pulchra</i> Soják	H	LC	
Polygonaceae	<i>Persicaria decipiens</i> (R. Br.) K.L.Wilson	H		
Polygonaceae	<i>Persicaria senegalensis</i> (Meisn.) Soják	H	LC	
Polygonaceae	<i>Persicaria setosula</i> (A. Rich.) K.L.Wilson	H		
Polygonaceae	<i>Polygonum aviculare</i> L.	H		
Polygonaceae	<i>Rumex abyssinicus</i> Jacq.	H		
Polygonaceae	<i>Rumex acetosella</i> L.	H		
Polygonaceae	<i>Rumex nepalensis</i> Spreng.	H		
Polypodiaceae	<i>Pleopeltis macrocarpa</i> (Willd.) Kaulf.	H		
Portulacaceae	<i>Portulaca quadrifida</i> L.	H		
Potamogetonaceae	<i>Potamogeton</i> sp.	H		
Primulaceae	<i>Lysimachia arvensis</i> (L.) U.Manns & Anderb.	H		
Primulaceae	<i>Lysimachia serpens</i> (Hochst. ex Duby) U.Manns & Anderb.	H	LC	
Primulaceae	<i>Maesa lanceolata</i> Forssk.	S	LC	
Primulaceae	<i>Myrsine africana</i> L.	S		
Proteaceae	<i>Grevillea robusta</i> A.Cunn. ex R.Br.	T	LC	√
Pteridaceae	<i>Hemionitis farinosa</i> (Forssk.) Christenh.	H		
Pteridaceae	<i>Hemionitis viridis</i> (Forssk.) Christenh.	H		
Ranunculaceae	<i>Clematis brachiata</i> Thunb.	C		
Ranunculaceae	<i>Clematis</i> sp.	C		
Ranunculaceae	<i>Ranunculus multifidus</i> Forssk.	H	LC	
Ranunculaceae	<i>Ranunculus sceleratus</i> L.	H	LC	
Resedaceae	<i>Caylusea abyssinica</i> (Fresen.) Fisch. & C.A. Mey.	H		
Rhamnaceae	<i>Rhamnus staddo</i> A.Rich.	S	LC	
Rhamnaceae	<i>Scutia myrtina</i> (Burm.f.) Kurz	C	LC	
Rhizophoraceae	<i>Cassipourea malosana</i> (Baker) Alston	T	LC	
Rosaceae	<i>Alchemilla cryptantha</i> Steud. ex A.Rich.	H		

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Rosaceae	<i>Alchemilla pedata</i> Hochst. ex A.Rich.	H		
Rosaceae	<i>Prunus africana</i> (Hook.f.) Kalkman	T	VU	
Rosaceae	<i>Rubus apetalus</i> Poir.	C		
Rosaceae	<i>Rubus niveus</i> Thunb.	C		√
Rubiaceae	<i>Anthospermum herbaceum</i> L.f.	H		
Rubiaceae	<i>Galium aparinoides</i> Forssk.	H		
Rubiaceae	<i>Galium ossirwaense</i> K.Krause	H		
Rubiaceae	<i>Galium scioanum</i> Chiov.	H		
Rubiaceae	<i>Galium spurium</i> L. subsp. africanum Verdc.	H		
Rubiaceae	<i>Gardenia volkensii</i> K.Schum. subsp. volkensii	S	LC	
Rubiaceae	<i>Oldenlandia corymbosa</i> L.	H		
Rubiaceae	<i>Oldenlandia monanthos</i> (Hochst. ex A.Rich.) Hiern	H		
Rubiaceae	<i>Pentas lanceolata</i> (Forssk.) Deflers	H		
Rubiaceae	<i>Pentas zanzibarica</i> (Klotzsch) Vatke var. intermedia	H		
Rubiaceae	<i>Rubia cordifolia</i> L.	C		
Rubiaceae	<i>Spermacoce arvensis</i> (Hiern) R.D.Good	H		
Rubiaceae	<i>Vangueria</i> sp.	S		
Rubiaceae	<i>Vangueria volkensii</i> K.Schum.	S		
Rutaceae	<i>Vepris simplicifolia</i> (Engl.) Mziray	T	LC	
Rutaceae	<i>Zanthoxylum asiaticum</i> (L.) Appelhans, Groppo & J.Wen	C		
Salicaceae	<i>Dovyalis abyssinica</i> (A.Rich.) Warb.	S	LC	
Salicaceae	<i>Dovyalis caffra</i> (Hook.f. & Harv.) Warb.	S	LC	√
Salicaceae	<i>Oncoba routledgei</i> Sprague	S		
Salicaceae	<i>Salix mucronata</i> Thunb.	S	LC	
Salicaceae	<i>Trimeria grandifolia</i> (Hochst.) Warb	S	LC	
Salviniaceae	<i>Azolla pinnata</i> R.Br.	H	LC	
Salviniaceae	<i>Salvinia molesta</i> D.Mitch.	H		√
Santalaceae	<i>Osyris lanceolata</i> Hochst. & Steud.	S	LC	
Santalaceae	<i>Thesium radicans</i> A.Rich.	H		
Sapindaceae	<i>Dodonaea viscosa</i> Jacq. subsp. <i>angustifolia</i> (L.f.) J.G.West	T		
Scrophulariaceae	<i>Buddleja polystachya</i> Fresen.	S		
Scrophulariaceae	<i>Verbascum sinaiticum</i> Benth.	H		
Solanaceae	<i>Cestrum aurantiacum</i> Lindl. S	LC		√
Solanaceae	<i>Datura stramonium</i> L.	H		√
Solanaceae	<i>Nicandra physalodes</i> (L.) Gaertn.	H		
Solanaceae	<i>Physalis peruviana</i> L.	H	LC	√
Solanaceae	<i>Solanum aculeastrum</i> Dunal	S	LC	
Solanaceae	<i>Solanum aculeatissimum</i> Jacq.	H		
Solanaceae	<i>Solanum campylacanthum</i> Hochst. ex A. Rich.	S	LC	√
Solanaceae	<i>Solanum mauense</i> Bitter	S	LC	
Solanaceae	<i>Solanum mauritianum</i> Scop.	S		

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Solanaceae	<i>Solanum nigrum</i> L.	H		
Solanaceae	<i>Withania somnifera</i> (L.) Dunal	H		
Stilbaceae	<i>Nuxia congesta</i> R.Br. ex Fresen.	T	LC	
Typhaceae	<i>Typha domingensis</i> Pers.	H	LC	
Urticaceae	<i>Scepcarpus hypselodendron</i> (Hochst. ex A.Rich.) T.Wells & A.K.Monro	H		
Urticaceae	<i>Urtica massaica</i> Mildbr.	H		
Verbenaceae	<i>Lantana trifolia</i> L.	S		
Verbenaceae	<i>Phyla nodiflora</i> (L.) Greene	H	LC	
Verbenaceae	<i>Verbena bonariensis</i> L.	H		
Verbenaceae	<i>Verbena officinalis</i> L.	H		
Viburnaceae	<i>Sambucus africana</i> Standl.	H		
Violaceae	<i>Viola abyssinica</i> Oliv.	H		
Vitaceae	<i>Cyphostemma kilimandscharicum</i> (Gilg) Desc. ex Wild & R.B.Drumm.	C		
Vitaceae	<i>Cyphostemma maranguense</i> (Gilg) Desc.	C		
Xyridaceae	<i>Xyris capensis</i> Thunb.	H	LC	

Appendix 2: Checklist of macrofungi documented in Lake Ol Bolossat in November 2023

Coverage Wards include Central (Cent), Gatimu (Gat), Kir (Kiriita), Rurii (Rur), Weru (Wer) and Shamata (Sham). Land use includes Eucalyptus plantation (Euc), Farmland (Farm), Grassland (Grass) and Wetland (Wet) near the lake.

Family	Genus	Species	Cent	Gat	Kir	Rur	Sham	Wer	Euc	Farm	Grass	Wet	For
Agaricaceae	<i>Agaricus</i>	<i>arvensis</i>	9			6	6	4		2	23		
	<i>Agaricus</i>	<i>augustus</i>										2	
	<i>Agaricus</i>	<i>campestris</i>	63	38	16	7		90	9	78	121	6	
	<i>Agaricus</i>	<i>deardorffensis</i>	21						21				1
	<i>Agaricus</i>	<i>endoxanthus</i>		5		12		5	12			2	
	<i>Agaricus</i>	<i>osecanus</i>			2			2					
	<i>Agaricus</i>	<i>silvaticus</i>										26	
	<i>Agaricus</i>	<i>sp1-10</i>	55	73	50	11			70		71	48	23
	<i>Agaricus</i>	<i>subsaharianus</i>	4							4			
	<i>Agaricus</i>	<i>urinascens</i>	5								5		
	<i>Agaricus</i>	<i>xanthodermus</i>	1								1		
	<i>Arachnion</i>	<i>album</i>	11					17	2	6	20		
	<i>Bovista</i>	<i>nigrescens</i>					86		11	75			
	<i>Bovista</i>	<i>paludosa</i>									1		
	<i>Bovista</i>	<i>plumbea</i>			1				1				
	<i>Bovista</i>	<i>sp1</i>	3		5					8			
	<i>Bovista</i>	<i>umbrinum</i>			1			1					
	<i>Calvatia</i>	<i>Cyathiformis</i>	13	1				151	79	70	16		
	<i>Chlorophyllum</i>	<i>hortense</i>	10			7			10		7		
	<i>Chlorophyllum</i>	<i>sp1-9</i>	16		10	4		2	7	13	11		1
	<i>Hymenogagaricus</i>	<i>sp1</i>											4

Family	Genus	Species	Cent	Gat	Kir	Rur	Sham	Wer	Euc	Farm	Grass	Wet	For
Agaricaceae	<i>Lepiota</i>	<i>castanea</i>											1
	<i>Lepiota</i>	<i>cristata</i>											4
	<i>Lepiota</i>	<i>erminea</i>											18
	<i>Lepiota</i>	<i>ignivolvata</i>											1
	<i>Lepiota</i>	<i>rubrotinctoides</i>											1
	<i>Lepiota</i>	<i>sp1-8</i>											86
	<i>Leucoagaricus</i>	<i>leucothites</i>	3				7		1		6	3	
	<i>Leucoagaricus</i>	<i>rubrotinctus</i>											14
	<i>Leucoagaricus</i>	<i>sp1</i>						8			8		0
	<i>Leucocoprinus</i>	<i>cepistipes</i>	30	2			15		30	15	2		7
	<i>Leucocoprinus</i>	<i>sp</i>											48
	<i>Lycoperdon</i>	<i>echinatum-white</i>	1								1		
	<i>Lycoperdon</i>	<i>pratense</i>	32	28	225	21	62	6	61	11	234	68	
	<i>Lycoperdon</i>	<i>sp1-2</i>			75	4					79		
	<i>Lycoperdon</i>	<i>utriforme</i>	28	30				4	7	2	53		
	<i>Macrolepiota</i>	<i>dolichaula</i>	23	1	45	4	4	9	54	8	24		
	<i>Macrolepiota</i>	<i>exoriata</i>			4				3	1			
	<i>Macrolepiota</i>	<i>sp1-5</i>	3	1	4	1			1	3	1	4	
Agaricales	<i>Agaricales</i>	<i>sp1-4</i>				4				4			2
Amanitaceae	<i>Saproamanita</i>	<i>cf. codinae</i>	23	14		2		8	4		43		
Bolbitiaceae	<i>Bolbitius sp</i>					1					1		
	<i>Conocybe</i>	<i>sp</i>											9
	<i>Conocybe</i>	<i>tenera</i>	3	1		11	30		30		15		6
	<i>Galeropsis</i>	<i>sp-slender</i>				1						1	

Family	Genus	Species	Cent	Gat	Kir	Rur	Sham	Wer	Euc	Farm	Grass	Wet	For
	<i>Panaeolus</i>	<i>acuminatus</i>			1					1			
	<i>Panaeolus</i>	<i>antillarum</i>	1		2	1		1		3			
	<i>Panaeolus</i>	<i>castaneifolius</i>	54			2	2			35	16	7	
	<i>Panaeolus</i>	<i>cinctulus</i>				2		2					
	<i>Panaeolus</i>	<i>foeniseicii</i>	5		11					16			
	<i>Panaeolus</i>	<i>sp1-2</i>		3				3					
	<i>Setchelliogaster</i>	<i>tenuipes</i>		1			1						
Entolomataceae	<i>Entoloma</i>	<i>lucidum</i>		8		1		1	8				
	<i>Entoloma</i>	<i>sepium</i>	4								4		
	<i>Entoloma</i>	<i>sp1-2</i>				51					51		
Hydnangiaceae	<i>Laccaria</i>	<i>bicolor</i>		1		55	321		371	6			
	<i>Laccaria</i>	<i>fraterna</i>	150	120	50	1		2	323				
	<i>Laccaria</i>	<i>laccata</i>	20	170			140	50					
	<i>Laccaria</i>	<i>ochropurpurea</i>			18				18				
	<i>Laccaria</i>	<i>sp1</i>				150				150			
Hygrophoraceae	<i>Hygrocybe</i>	<i>sp1-2</i>	1				3				4		
Hymenogastreae	<i>Gymnopilus</i>	<i>junonius</i>	86	8	8		10		104	8			
	<i>Psilocybe</i>	<i>cubensis</i>				3			3		30		
	<i>Psilocybe</i>	<i>subaeruginosa</i>	31	1					8	1	23		
Incertae sedis	<i>Melanoleuca</i>	<i>cognata</i>									2		
	<i>Melanoleuca</i>	<i>sp1-3</i>					1				1		6
Inocybaceae	<i>Inocybe</i>	<i>sp</i>				3			3				
Lyophyllaceae	<i>Termitomyces</i>	<i>umkwaan</i>			1				1				
Marasmiaceae	<i>Marasmius</i>	<i>aurantioferrugineus</i>		75							75		

Family	Genus	Species	Cent	Gat	Kir	Rur	Sham	Wer	Euc	Farm	Grass	Wet	For
	<i>Marasmius</i>	<i>bulliardii</i>									4		
	<i>Marasmius</i>	<i>rotula</i>									15		
	<i>Marasmius</i>	<i>sp-brown</i>										20	
	<i>Marasmius</i>	<i>vagus</i>	75								75		
	<i>Marasmius</i>	<i>cf. oreades</i>	10					10					
Mycenaceae	<i>Favolaschia</i>	<i>claudopus</i>										35	
	<i>Mycena</i>	<i>ascendens</i>										1	
	<i>Mycena</i>	<i>flos-nivium</i>			15			15					
	<i>Mycena</i>	<i>inclinata</i>									1		
	<i>Mycena</i>	<i>sp1-4</i>	2	2	4		2	4			6		
	<i>Mycena</i>	<i>stylobates</i>										22	
Nidulariaceae	<i>Cyathus</i>	<i>stercoreus</i>	20	21		30			50		1	20	
	<i>Cyathus</i>	<i>striatus</i>									25		
Omphalotaceae	<i>Gymnopus</i>	<i>dryophilus</i>		45	3			8	3		53		20
	<i>Gymnopus</i>	<i>luxurians</i>			2	6			2		6		
	<i>Gymnopus</i>	<i>ocior</i>				1					1		
	<i>Gymnopus</i>	<i>sp</i>				3					3		
	<i>Marasmiellus</i>	<i>candidus</i>											15
	<i>Marasmiellus</i>	<i>sp</i>											10
	<i>Marasmiellus</i>	<i>tricolor</i>	5								5		
Porothelaceae	<i>Clitocybula</i>	<i>sp</i>											15
	<i>Gerronema</i>	<i>atrialbum</i>											11
Psathyrellaceae	<i>Candolleomyces</i>	<i>candolleanus</i>					0	4		4			
	<i>Coprinellus</i>	<i>micaceus</i>	2		3		5		3	5		2	6

Family	Genus	Species	Cent	Gat	Kir	Rur	Sham	Wer	Euc	Farm	Grass	Wet	For
	<i>Coprinopsis</i>	<i>sp</i>	8									8	
	<i>Psathyrella</i>	<i>longipes</i>					120			120			
	<i>Psathyrella</i>	<i>piluliformis</i>					2			2			3
	<i>Psathyrella</i>	<i>sp</i>								0			3
Schizophyllaceae	<i>Schizophyllum</i>	<i>commune</i>										15	
Strophariaceae	<i>Agrocybe</i>	<i>sp1-3</i>				3	150				152	1	
	<i>Deconica</i>	<i>coprophila</i>		36		5	2				38	5	
	<i>Deconica</i>	<i>sp</i>		1		1							
	<i>Hypholoma</i>	<i>fasciculare</i>					60						
	<i>Protostropharia</i>	<i>semiglobata</i>		2	2						4		
	<i>Stropharia</i>	<i>coronilla</i>				2						2	
	<i>Stropharia</i>	<i>melanosperma</i>				8				8			2
Tricholomataceae	<i>Ampulloclitocybe</i>	<i>sp1-2</i>											22
	<i>Clitocybe</i>	<i>sp1-2</i>											29
	<i>Dermoloma</i>	<i>sp</i>				2			2				
	<i>Lepista</i>	<i>nuda</i>									2		
	<i>Tricholoma</i>	<i>dryophilum</i>					63		63				
	<i>Tricholoma</i>	<i>sp1</i>					2		2				
	<i>Tricholoma</i>	<i>terreum</i>				3					3		
	<i>Tricholomataceae</i>	<i>sp</i>				2			2				
Auriculariaceae	<i>Auricularia</i>	<i>mesenterica</i>										10	
Boletinellaceae	<i>Boletinus</i>	<i>sp</i>				2		2					
Sclerodermataceae	<i>Pisolithus</i>	<i>microcarpus</i>		200		12		35	245	2			
	<i>Scloderma</i>	<i>bovista</i>			1				1				

Family	Genus	Species	Cent	Gat	Kir	Rur	Sham	Wer	Euc	Farm	Grass	Wet	For
	<i>Scleroderma</i>	<i>citrinum</i>	1				11		12				
Geastraceae	<i>Myriostoma</i>	<i>coliforme</i>									4		
Hymenochaetales	<i>Fuscoporia</i>	<i>gilva</i>		3		21	5		26	3			
	<i>Fuscoporia</i>	<i>sp</i>	10							10			
	<i>Phellinus</i>	<i>pomaceus</i>		1						1			
	<i>Trichaptum</i>	<i>sp</i>		1					1				
Phallaceae	<i>Clathrus</i>	<i>columnatus</i>				2					2		
Phanerochaetales	<i>Byssomerulius</i>	<i>sp</i>				0							4
Polyporaceae	<i>Lenzite</i>	<i>elegans</i>				5			5				
	<i>Picipes</i>	<i>badius</i>											1
	<i>Trametes</i>	<i>versicolor</i>					6		6				2
Stereaceae	<i>Stereum</i>	<i>complicatum</i>								10			
	<i>Stereum</i>	<i>hirsutum</i>	150	151	25	22	29	100	476	1			
	<i>Stereum</i>	<i>versicolor</i>											22
Dacrymycetaceae	<i>Calocera</i>	<i>cornea</i>					50		50				

Appendix 3: Checklist of fungi species in (Literature) Lake Ol Bolossat

(A-Animal dung; AD-Animal dung; C-Compost; D-Dust environment; ECM-Ectomycorrhizae fungi; L-Litter decomposers; M-Mycorrhiza (arbuscular mycorrhiza); P-Parasite; S-Soil (soil organic matter); T-Termite cultivated; W- Woodrotters)

Phylum	Family	Genus	Species	Substrate	Literature
Ascomycota	Conioscyphaceae	<i>Conioscypha</i>	<i>Sp</i>	A	Kiama <i>et al.</i> , 2022
	Onygenaceae	<i>Amauroascus</i>	<i>Sp.</i>	S, D	Kiama <i>et al.</i> , 2022
	Onygenaceae	<i>Spiromastix</i>	<i>Sp</i>	S, D	Kiama <i>et al.</i> , 2022
	Orbiliaceae	<i>Hyalorbilia</i>	<i>Sp</i>	A	Kiama <i>et al.</i> , 2022
	Saccharomyce-taceae	<i>Kazachstania</i>	<i>Sp</i>	W	Kiama <i>et al.</i> , 2022
	Saccharomyce-taceae	<i>Saccharomyces</i>	<i>Sp</i>	W	Kiama <i>et al.</i> , 2022
	Xylariaceae	<i>Daldinia</i>	<i>concentrica</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Xylariaceae	<i>Daldinia</i>	<i>sp</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Xylariaceae	<i>Kretzschmaria</i>	<i>sp</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Xylariaceae	<i>Xylaria</i>	<i>polymorpha</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
Basidiomycota	Agaricaceae	<i>Agaricus</i>	<i>arvensis</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>augustus</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>campestris</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>deardorffensis</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>endoxanthus</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>osecanus</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>silvaticus</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>sp1-10</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>subsaharianus</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>urinascens</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Agaricus</i>	<i>xanthodermus</i>	S	Muchane and Kelvin, 2024

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Agaricaceae	<i>Arachnion</i>	<i>album</i>		Muchane and Kelvin, 2024
	Agaricaceae	<i>Bovista</i>	<i>nigrescens</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Bovista</i>	<i>paludosa</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Bovista</i>	<i>plumbea</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Bovista</i>	<i>Sp1-2</i>	S	Kiama <i>et al.</i> , 2022, Muchane and Kelvin, 2024
	Agaricaceae	<i>Bovista</i>	<i>umbrinum</i>	P	Muchane and Kelvin, 2024
	Agaricaceae	<i>Calvatia</i>	<i>Cyathiformis</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Chlorophyllum</i>	<i>hortense</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Chlorophyllum</i>	<i>Sp</i>	S	Kiama <i>et al.</i> , 2022 Muchane and Kelvin, 2024
	Agaricaceae	<i>Chlorophyllum</i>	<i>sp1-9</i>	P	Muchane and Kelvin, 2024
	Agaricaceae	<i>Hymenoagaricus</i>	<i>sp</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Lepiota</i>	<i>castanea</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Lepiota</i>	<i>cristata</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Lepiota</i>	<i>erminea</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Lepiota</i>	<i>ignivolvata</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Lepiota</i>	<i>rubrotinctoides</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Lepiota</i>	<i>sp1-8</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Leucoagaricus</i>	<i>leucothites</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Leucoagaricus</i>	<i>rubrotinctus</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Leucoagaricus</i>	<i>sp1</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Leucocoprinus</i>	<i>cepistipes</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Leucocoprinus</i>	<i>sp1</i>	S	Muchane and Kelvin, 2024

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Agaricaceae	<i>Lycoperdon</i>	<i>echinatum</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Lycoperdon</i>	<i>pratense</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Lycoperdon</i>	<i>sp1-3</i>	S	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Agaricaceae	<i>Lycoperdon</i>	<i>utriforme</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Macrolepiota</i>	<i>dolichaula</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Macrolepiota</i>	<i>excoriata</i>	S	Muchane and Kelvin, 2024
	Agaricaceae	<i>Macrolepiota</i>	<i>sp1-6</i>	S	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Agaricaceae	<i>Tulostoma</i>	<i>Sp</i>	S	Kiama <i>et al.</i> , 2022
	Agaricales	<i>Agaricales</i>	<i>sp1-4</i>	P	Muchane and Kelvin, 2024
	Amanitaceae	<i>Saproamanita</i>	<i>codinae</i>	S	Muchane and Kelvin, 2024
	Auriculariaceae	<i>Auricularia</i>	<i>mesenterica</i>	S	Muchane and Kelvin, 2024
	Auriculariaceae	<i>Exidia</i>	<i>Sp</i>	W	Kiama <i>et al.</i> , 2022
	Bolbitiaceae	<i>Bolbitius</i>	<i>sp1</i>	W	Muchane and Kelvin, 2024
	Bolbitiaceae	<i>Conocybe</i>	<i>sp1-2</i>	L	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Bolbitiaceae	<i>Conocybe</i>	<i>tenera</i>	C	Muchane and Kelvin, 2024
	Bolbitiaceae	<i>Galeropsis</i>	<i>sp1</i>	L	Muchane and Kelvin, 2024
	Bolbitiaceae	<i>Panaeolus</i>	<i>antillarum</i>	L	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Bolbitiaceae	<i>Panaeolus</i>	<i>sp.</i>	C	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Bolbitiaceae	<i>Panaeolus</i>	<i>acuminatus</i>	C	Muchane and Kelvin, 2024
	Bolbitiaceae	<i>Panaeolus</i>	<i>castaneifolius</i>	L	Muchane and Kelvin, 2024

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Bolbitiaceae	<i>Panaeolus</i>	<i>cinctulus</i>	L	Muchane and Kelvin, 2024
	Bolbitiaceae	<i>Panaeolus</i>	<i>foenisecii</i>	L	Muchane and Kelvin, 2024
	Bolbitiaceae	<i>Panaeolus</i>	<i>sp1-3</i>	L	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Bolbitiaceae	<i>Setchelliogaster</i>	<i>tenuipes</i>	L	Muchane and Kelvin, 2024
	Boletinellaceae	<i>Boletinellus</i>	<i>sp1</i>	L	Muchane and Kelvin, 2024
	Ceratobasidiaceae	<i>Thanatephorus</i>	<i>Sp</i>	S	Kiama <i>et al.</i> , 2022
	Chionosphaeraceae	<i>Kurtzmanomyces</i>	<i>Sp</i>	S	Kiama <i>et al.</i> , 2022
	Clavariaceae	<i>Clavaria</i>	<i>sp</i>	A	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Kiama <i>et al.</i> , 2022, Kiama <i>et al.</i> , 2022
	Corticiaceae	<i>Limonomyces</i>	<i>Sp</i>	L	Kiama <i>et al.</i> , 2022
	Cryptococcaceae	<i>Cryptococcus</i>	<i>Sp</i>	P	Kiama <i>et al.</i> , 2022
	Cystofilobasidiaceae	<i>Cystofilobasidium</i>	<i>Sp1-2</i>	W, P	Kiama <i>et al.</i> , 2022 Muchane and Kelvin, 2024
	Dacrymycetaceae	<i>Calocera</i>	<i>cornea</i>	A	Muchane and Kelvin, 2024
	Entolomataceae	<i>Entoloma</i>	<i>sepium</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Entolomataceae	<i>Entoloma</i>	<i>Sp1-3</i>	L	Muchane and Kelvin, 2024
	Entolomataceae	<i>Entoloma</i>	<i>lucidum</i>	M	Kiama <i>et al.</i> , 2022
	Entylomataceae	<i>Entyloma</i>	<i>Sp</i>	L	Kiama <i>et al.</i> , 2022
	Erythrobasidiaceae	<i>Erythrobasidium</i>	<i>Sp</i>	P	Kiama <i>et al.</i> , 2022
	Filobasidiaceae	<i>Filobasidium</i>	<i>Sp 1-2</i>	S	Kiama <i>et al.</i> , 2022
	Filobasidiaceae	<i>Naganishia</i>	<i>Sp</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Geastraceae	<i>Geastrum</i>	<i>triplex</i>	S, W	Muchane and Kelvin, 2024
	Geastraceae	<i>Myriostoma</i>	<i>coliforme</i>	S	Muchane and Kelvin, 2024

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Hydnangiaceae	<i>Laccaria</i>	<i>bicolor</i>	L	Muchane and Kelvin 2024, Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Hydnangiaceae	<i>Laccaria</i>	<i>fraterna</i>	ECM	Muchane and Kelvin, 2024
	Hydnangiaceae	<i>Laccaria</i>	<i>laccata</i>	ECM	Muchane and Kelvin, 2024
	Hydnangiaceae	<i>Laccaria</i>	<i>ochropurpurea</i>	ECM	Muchane and Kelvin, 2024
	Hydnangiaceae	<i>Laccaria</i>	<i>sp1</i>	ECM	Muchane and Kelvin, 2024
	Hydnangiaceae	<i>Laccaria</i>	<i>sp1</i>	ECM	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Hygrophoraceae	<i>Hygrocybe</i>	<i>sp1-2</i>	ECM	Muchane and Kelvin, 2024
	Hymenochaeta-ceae	<i>Fuscoporia</i>	<i>gilva</i>	L	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane & Kelvin 2024
	Hymenochaeta-ceae	<i>Fuscoporia</i>	<i>sp1-2</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane & Kelvin, 2024
	Hymenochaeta-ceae	<i>Inocutis</i>	<i>Sp</i>	W	Kiama <i>et al.</i> , 2022
	Hymenochaeta-ceae	<i>Phellinus</i>	<i>pomaceus</i>	W	Muchane and Kelvin, 2024
	Hymenochaeta-ceae	<i>Phylloporia</i>	<i>Sp</i>	W	Kiama <i>et al.</i> , 2022
	Hymenochaeta-ceae	<i>Trichaptum</i>	<i>sp1</i>	W	Muchane and Kelvin, 2024
	Hymenogastrea-ceae	<i>Gymnopilus</i>	<i>junonius</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Kiama <i>et al.</i> , 2022, Muchane & Kelvin, 2024
	Hymenogastrea-ceae	<i>Psilocybe</i>	<i>cubensis</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane & Kelvin, 2024
	Hymenogastrea-ceae	<i>Psilocybe</i>	<i>subaeruginosa</i>	L	Muchane and Kelvin, 2024
	Incertae sedis	<i>Melanoleuca</i>	<i>cognata</i>	L	Muchane and Kelvin, 2024
	Incertae sedis	<i>Melanoleuca</i>	<i>sp1-3</i>	S	Muchane and Kelvin, 2024
	Inocybaceae	<i>Inocybe</i>	<i>sp1</i>	S	Muchane and Kelvin, 2024

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Lyophyllaceae	<i>Termitomyces</i>	<i>microcarpus</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Lyophyllaceae	<i>Termitomyces</i>	<i>sp1-3</i>	T	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Lyophyllaceae	<i>Termitomyces</i>	<i>umkowaan</i>	T	Muchane and Kelvin, 2024
	Marasmiaceae	<i>Marasmius</i>	<i>aurantioferrugineus</i>	T	Muchane and Kelvin, 2024
	Marasmiaceae	<i>Marasmius</i>	<i>bulliardii</i>	L	Muchane and Kelvin, 2024
	Marasmiaceae	<i>Marasmius</i>	<i>rotula</i>	L	Muchane and Kelvin, 2024
	Marasmiaceae	<i>Marasmius</i>	<i>sp1</i>	L	Muchane and Kelvin, 2024
	Marasmiaceae	<i>Marasmius</i>	<i>sp1-2</i>	L	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Marasmiaceae	<i>Marasmius</i>	<i>vagus</i>	C	Muchane and Kelvin, 2024
	Marasmiaceae	<i>Marasmius</i>	<i>cf. oreades</i>	L	Muchane and Kelvin, 2024
	Meruliaceae	<i>Aurantiporus</i>	<i>sp</i>	L	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Microbotryaceae	<i>Microbotryum</i>	<i>Sp</i>	W	Kiama <i>et al.</i> , 2022
	Microstromataceae	<i>Microstroma</i>	<i>Sp</i>	P	Kiama <i>et al.</i> , 2022
	Mycenaceae	<i>Favolaschia</i>	<i>claudopus</i>	A	Muchane and Kelvin, 2024
	Mycenaceae	<i>Mycena</i>	<i>adscendens</i>	W	Muchane and Kelvin, 2024
	Mycenaceae	<i>Mycena</i>	<i>flos-nivium</i>	L	Muchane and Kelvin, 2024
	Mycenaceae	<i>Mycena</i>	<i>inclinata</i>	L	Muchane and Kelvin, 2024
	Mycenaceae	<i>Mycena</i>	<i>sp1-4</i>	L	Muchane and Kelvin, 2024
	Mycenaceae	<i>Mycena</i>	<i>stylobates</i>	L	Muchane and Kelvin, 2024
	Niaceae	<i>Flagelloscypha</i>	<i>sp1-2</i>	L	Kiama <i>et al.</i> , 2022
	Nidulariaceae	<i>Cyathus</i>	<i>stercoreus</i>	L	Muchane and Kelvin, 2024
	Nidulariaceae	<i>Cyathus</i>	<i>striatus</i>	AD	Muchane and Kelvin, 2024
	Nidulariaceae	<i>Cyathus</i>	<i>sp.</i>	W	Kiama <i>et al.</i> , 2022
	Omphalotaceae	<i>Gymnopus</i>	<i>dryophilus</i>	W	Muchane and Kelvin, 2024

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Omphalotaceae	<i>Gymnopus</i>	<i>luxurians</i>	L	Muchane and Kelvin, 2024
	Omphalotaceae	<i>Gymnopus</i>	<i>ocior</i>	L	Muchane and Kelvin, 2024
	Omphalotaceae	<i>Gymnopus</i>	<i>sp1</i>	L	Muchane and Kelvin, 2024
	Omphalotaceae	<i>Marasmiellus</i>	<i>candidus</i>	L	Muchane and Kelvin, 2024
	Omphalotaceae	<i>Marasmiellus</i>	<i>sp1</i>	W	Muchane and Kelvin, 2024
	Omphalotaceae	<i>Marasmiellus</i>	<i>tricolor</i>	W	Muchane and Kelvin, 2024
	Phallaceae	<i>Clathrus</i>	<i>columnatus</i>	L	Muchane and Kelvin, 2024
	Phanerochaeta-ceae	<i>Byssomerulius</i>	<i>sp1</i>	S	Muchane and Kelvin, 2024
	Polyporaceae	<i>Datronia</i>	<i>mollis</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Polyporaceae	<i>Lentinus</i>	<i>sp</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Polyporaceae	<i>Lenzite</i>	<i>elegans</i>	W	Muchane and Kelvin, 2024
	Polyporaceae	<i>Picipes</i>	<i>badius</i>	W	Muchane and Kelvin, 2024
	Polyporaceae	<i>Polyporus</i>	<i>arcularius</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Polyporaceae	<i>Trametes</i>	<i>versicolor</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Porotheleaceae	<i>Clitocybula</i>	<i>sp1</i>	W	Muchane and Kelvin, 2024
	Porotheleaceae	<i>Gerronema</i>	<i>atrialbum</i>	L	Muchane and Kelvin, 2024
	Psathyrellaceae	<i>Candolleomyces</i>	<i>candolleanus</i>	L	Muchane and Kelvin, 2024
	Psathyrellaceae	<i>Coprinellus</i>	<i>micaceus</i>	L	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Kiama <i>et al.</i> , 2022, Muchane & Maina 2024
	Psathyrellaceae	<i>Coprinopsis</i>	<i>sp1</i>	W	Muchane and Kelvin, 2024
	Psathyrellaceae	<i>Psathyrella</i>	<i>longipes</i>	L	Muchane and Kelvin, 2024
	Psathyrellaceae	<i>Psathyrella</i>	<i>sp1</i>	L	Muchane and Kelvin, 2024

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Psathyrellaceae	<i>Psathyrella</i>	<i>piluliformis</i>	L	Muchane and Kelvin, 2024
	Rhizopogonaceae	<i>Rhizopogon</i>	<i>sp</i>	L	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Schizophyllaceae	<i>Schizophyllum</i>	<i>commune</i>	ECM	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Kiama <i>et al.</i> , 2022, Muchane & Maina, 2024
	Sclerodermataceae	<i>Pisolithus</i>	<i>microcarpus</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane & Maina 2024
	Sclerodermataceae	<i>Scleroderma</i>	<i>bovista</i>	M	Muchane and Kelvin, 2024
	Sclerodermataceae	<i>Scleroderma</i>	<i>citrinum</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Maina 2024
	Septobasidiaceae	<i>Septobasidium</i>	<i>Sp 1-2</i>	ECM	Kiama <i>et al.</i> , 2022
	Stephanosporaceae	<i>Lindtneria</i>	<i>Sp</i>	P	Kiama <i>et al.</i> , 2022
	Stereaceae	<i>Stereum</i>	<i>complicatum</i>	W	Muchane and Kelvin, 2024
	Stereaceae	<i>Stereum</i>	<i>hirsutum</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Maina 2024
	Stereaceae	<i>stereum</i>	<i>sp</i>	W	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Stereaceae	<i>Stereum</i>	<i>versicolor</i>	W	Muchane and Kelvin, 2024
	Strophariaceae	<i>Agrocybe</i>	<i>sp1-2</i>	W	Muchane and Kelvin, 2024
	Strophariaceae	<i>Deconica</i>	<i>coprophila</i>	S	Muchane and Kelvin, 2024
	Strophariaceae	<i>Deconica</i>	<i>sp1</i>	D	Muchane and Kelvin, 2024
	Strophariaceae	<i>Hypholoma</i>	<i>fasciculare</i>	D	Muchane and Kelvin, 2024
	Strophariaceae	<i>Protostropharia</i>	<i>semiglobata</i>	W	Muchane and Kelvin, 2024
	Strophariaceae	<i>Stropharia</i>	<i>coronilla</i>	S	Muchane and Kelvin, 2024
	Strophariaceae	<i>Stropharia</i>	<i>melanosperma</i>	S	Muchane and Kelvin, 2024
	Suillaceae	<i>Suillus</i>	<i>granulatus</i>	S	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Tricholomataceae	<i>Ampulloclitocybe</i>	<i>sp1-2</i>	ECM	Muchane and Kelvin, 2024
	Tricholomataceae	<i>Clitocybe</i>	<i>sp1-2</i>	S	Muchane and Kelvin, 2024
	Tricholomataceae	<i>Dermoloma</i>	<i>sp1</i>	L	Muchane and Kelvin, 2024
	Tricholomataceae	<i>Lepista</i>	<i>nuda</i>	L	Muchane and Kelvin, 2024
	Tricholomataceae	<i>Tricholoma</i>	<i>dryophilum</i>	S	Muchane and Kelvin, 2024
	Tricholomataceae	<i>Tricholoma</i>	<i>sp1</i>	M	Muchane and Kelvin, 2024
	Tricholomataceae	<i>Tricholoma</i>	<i>terreum</i>	S	Muchane and Kelvin, 2024
	Tricholomataceae	<i>Tricholomataceae</i>	<i>sp1</i>	E	Muchane and Kelvin, 2024
	Halomycetaceae	<i>Paranamyces</i>	<i>Sp</i>	S	Kiama <i>et al.</i> , 2022
	Halomycetaceae	<i>Halomyces</i>	<i>Sp</i>	S	Kiama <i>et al.</i> , 2022
	Lobulomycetaceae	<i>Clydaea</i>	<i>Sp</i>	S, A	Kiama <i>et al.</i> , 2022
	Powellomycetaceae	<i>Powellomyces</i>	<i>Sp</i>	S, A	Kiama <i>et al.</i> , 2022
	Rhizophlyctidaceae	<i>Rhizophlyctis</i>	<i>Sp</i>	S	Kiama <i>et al.</i> , 2022
	Spizellomycetaceae	<i>Kochiomyces</i>	<i>Sp</i>	S	Kiama <i>et al.</i> , 2022
	Spizellomycetaceae	<i>Spizellomyces</i>	<i>Sp</i>	S, P	Kiama <i>et al.</i> , 2022
	Acaulosporaceae	<i>Acaulospora</i>	<i>bireticulata</i>	S, P	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Acaulosporaceae	<i>Acaulospora</i>	<i>delicata</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Acaulosporaceae	<i>Acaulospora</i>	<i>denticulata</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Acaulosporaceae	<i>Acaulospora</i>	<i>excavata</i>	M	Muchane and Kelvin, 2024
	Acaulosporaceae	<i>Acaulospora</i>	<i>herrerae</i>	M	Muchane and Kelvin, 2024
	Acaulosporaceae	<i>Acaulospora</i>	<i>mellea</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Acaulosporaceae	<i>Acaulospora</i>	<i>morrowiae</i>	M	Muchane and Kelvin, 2024

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Acaulosporaceae	<i>Acaulospora</i>	<i>rehmii</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Acaulosporaceae	<i>Acaulospora</i>	<i>scrobiculata</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Acaulosporaceae	<i>Acaulospora</i>	<i>sp1-7</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Claroideo-glomeraceae	<i>Claroideoglomerus</i>	<i>etunicatum</i>	M	Muchane and Kelvin, 2024
	Claroideo-glomeraceae	<i>Claroideoglomerus</i>	<i>luteum</i>	M	Muchane and Kelvin, 2024
	Claroideo-glomeraceae	<i>Claroideoglomerus</i>	<i>Sp</i>	M	Kiama <i>et al.</i> , 2022
	Diversisporaceae	<i>Diversispora</i>	<i>spurca</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Diversisporaceae	<i>Diversispora</i>	<i>sp1-2</i>	M	Muchane and Kelvin, 2024
	Gigasporaceae	<i>Centrospora</i>	<i>pellucida</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Gigasporaceae	<i>Dentiscutata</i>	<i>nigra</i>	M	Muchane and Kelvin, 2024
	Gigasporaceae	<i>Gigaspora</i>	<i>albida</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Gigasporaceae	<i>Gigaspora</i>	<i>decipiens</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Gigasporaceae	<i>Gigaspora</i>	<i>gigantea</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Gigasporaceae	<i>Gigaspora</i>	<i>margarita</i>	M	Muchane and Kelvin, 2024
	Gigasporaceae	<i>Racocetra</i>	<i>fulgida</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021
	Gigasporaceae	<i>Racocetra</i>	<i>persica</i>	M	Muchane and Kelvin, 2024
	Gigasporaceae	<i>Scutellospora</i>	<i>calospora</i>	M	Muchane and Kelvin, 2024
	Gigasporaceae	<i>Scutellospora</i>	<i>scutata</i>	M	Muchane and Kelvin, 2024
	Gigasporaceae	<i>Scutellospora</i>	<i>sp1-3</i>	M	Muchane and Kelvin, 2024

Phylum	Family	Genus	Species	Substrate	Literature
Basidiomycota	Glomaraceae	<i>Funneliformis</i>	<i>geosporum</i>	M	Muchane and Kelvin, 2024
	Glomaraceae	<i>Funneliformis</i>	<i>sp1-2</i>	M	Muchane and Kelvin, 2024
	Glomaraceae	<i>Glomus</i>	<i>hoi</i>	M	Muchane and Kelvin, 2024
	Glomaraceae	<i>Glomus</i>	<i>sp1-4</i>	M	Terer <i>et al.</i> , 2019, Muchane <i>et al.</i> , 2021, Muchane and Kelvin, 2024
	Glomaraceae	<i>Glomus</i>	<i>tetrastratosum</i>	M	Muchane and Kelvin, 2024
	Glomaraceae	<i>Rhizophagus</i>	<i>sp1-2</i>	M	Muchane and Kelvin, 2024
	Glomaraceae	<i>Sclerocystis</i>	<i>sp1</i>	M	Muchane and Kelvin, 2024
	Glomaraceae	<i>Septoglomus</i>	<i>sp1-2</i>	M	Muchane and Kelvin, 2024
	Olpidiaceae	<i>Olpidium</i>	<i>Sp</i>	P	Kiama <i>et al.</i> , 2022
	Endogonaceae	<i>Endogone</i>	<i>Sp</i>	S, P	Kiama <i>et al.</i> , 2022
	Mortierellaceae	<i>Mortierella</i>	<i>Sp</i>	S, P	Kiama <i>et al.</i> , 2022

Appendix 4: Herpetofauna Species found in Lake Ol Bolossat

Species name	Common name	Type	Conservation status	Confirmed
<i>Adolfus kibonotensis</i>	Mt. Kilimanjaro Forest Lizard	Lizard	Least concern	No
<i>Agama caudospinosa</i>	Spiny-tailed rock agama	Lizard	Kenyan Endemic, Least concern	No
<i>Agama lionotus</i>	Red-headed rock agama	Lizard	Least concern	Yes
<i>Amietia nutti</i>	Nutt's river frog	Frog	Least concern	Yes
<i>Amietia wittei</i>	De Witte's river frog	Frog	Least concern	No
<i>Bitis worthingtoni</i>	Kenyan horned viper	Snake	Kenyan Endemic, Vulnerable	No
<i>Boaedon fuliginosus</i>	Common house snake	snake	Least concern	Yes
<i>Cacosternum kinangopensis</i>	Kinangop dainty frog	Snake	Kenyan Endemic, Least concern	Yes
<i>Crotaphopeltis hotamboeia</i>	Herald snake	Snake	Least concern	No
<i>Duberria lutrix</i>	Common slug eater	Snake	Least concern	No
<i>Hyperolius glandicolor</i>	Peter's reed frog	Frog	Least concern	Yes
<i>Hyperolius montanus</i>	Kenyan montane reed frog	Frog	Kenyan Endemic, Least concern	No
<i>Hyperolius viridiflavus</i>	Common reed frog	Frog	Least concern	No
<i>Kassina senegalensis</i>	Bubbling kassina	Frog	Least concern	Yes
<i>Lycophidion capense</i>	Cape wolf snake	Snake	Least concern	Yes
<i>Mertensophryne lonnbergi</i>	Lönberg's earless dwarf toad	Frog	Kenyan Endemic, Vulnerable	Yes
<i>Philothamnus battersbyi</i>	Battersby's Green Snake	Snake	Least concern	Yes
<i>Phrynobatrachus keniensis</i>	Kenyan puddle frog	Frog	Kenyan Endemic, Least concern	No
<i>Phrynobatrachus kinangopensis</i>	Kinangop puddle frog	Frog	Kenyan Endemic, Vulnerable	Yes
<i>Psammophylax multisquamis</i>	Kenyan striped skaapskater	Snake	Least concern	Yes
<i>Ptychadena mahnerti</i>	Mahnert's ridged frog	Frog	Kenyan Endemic, Least concern	Yes
<i>Ptychadena nilotica</i>	Nile ridged frog	Frog	Least concern	No
<i>Sclerophrys kerinyagae</i>	Kirinyaga toad	Frog	Least concern	Yes
<i>Sclerophrys garmani</i>	Garman's toad	Frog	Least concern	No
<i>Trachylepis striata</i>	Striped kink	Lizard	Least concern	Yes
<i>Trachylepis varia</i>	Variable skink	Lizard	Least concern	Yes
<i>Triceros jacksoni</i>	Jackson's three horned chameleon	Lizard	Least concern	No
<i>Trioceros hoehneli</i>	Von Höhnel's chameleon	Lizard	Least concern	Yes
<i>Xenopus borealis</i>	Northern clawed frog	Frog	Least concern	Yes

Appendix 5: Reference material deposited at National Museums of Kenya (NMK) and their unique museum numbers.

Catalogue Number	Number of specimens	Species name	Locality	Collection Date
KNM793A	5	<i>Cacosternum kinangopensis</i>	Shamata ward, Kirima area	16.xi.2023
KNM794A	1	<i>Ptychadena mahnerti</i>	Shamata ward, Kirima area	16.xi.2023
KNM795A	2	<i>Ptychadena mahnerti</i>	Shamata ward, Kirima area	16.xi.2023
KNM796A	1	<i>Mertensophryne lonnbergi</i>	Shamata ward, Kirima area	16.xi.2023
KNM797A	1	<i>Sclerophrys kirinyagae</i>	Shamata ward, Kirima area	16.xi.2023
KNM798A	3	<i>Hyperolius glandicolor</i>	Shamata ward, Kirima area	16.xi.2023
KNM799A	1	<i>Xenopus borealis</i>	Shamata ward, Kirima area	16.xi.2023
KNM800A	2	<i>Phrynobatrachus kinangopensis</i>	Shamata ward, Kirima area	16.xi.2023
KNM801L	2	<i>Trachylepis striata</i>	Central ward.	18.xi.2023
KNM802A	1	<i>Ptychadena mahnerti</i>	Rurii ward.	17.xi.2023
KNM803L	1	<i>Trachylepis varia</i>	Rurii ward.	17.xi.2024
KNM804A	1	<i>Cacosternum kinangopensis</i>	Rurii ward.	17.xi.2025
KNM805A	1	<i>Trachylepis striata</i>	Shamata ward, Kirima area	16.xi.2023
KNM806A	1	<i>Kassina senegalensis</i>	Shamata ward, Kirima area	16.xi.2023
KNM807A	2	<i>Phrynobatrachus kinangopensis</i>	Kiriita ward	21.xi.2023
KNM808A	1	<i>Amietia nutti</i>	Kiriita ward	19.xi.2023
KNM809S	1	<i>Lycophidion capense</i>	Kiriita ward	19.xi.2023
KNM810A	1	<i>Xenopus borealis</i>	Kiriita ward	21.xi.2023
KNM811A	1	<i>Xenopus borealis</i>	Kiriita ward	18.xi.2023
KNM812A	2	<i>Sclerophrys kirinyagae</i>	Kiriita ward	16.xi.2023

Appendix 6: Checklist of aquatic-invertebrates of Lake Ol Bolossat from past surveys

(LC – Least concern; NE -Not evaluated; NT-Near threatened)

Order	Family	Genus/species	IUCN category	Rurii	Weru	Gatimu	Kiriita	Central	Shamata
Araneae	Araneidae	<i>Argiope trifasciata</i>	NE		X				
Araneae	Araneidae	<i>Neoscona sp</i>			X				X
Araneae	Lycosidae	<i>Pardosa sp</i>			X				
Araneae	Lycosidae	<i>sp2</i>			X			X	X
Araneae	Lycosidae	<i>sp3</i>			X				
Araneae	Lycosidae	<i>sp4</i>			X				
Araneae	Salticidae	<i>sp1</i>					X		
Araneae	Salticidae	<i>sp2</i>						X	
Araneae	Thomisidae	<i>Thomisus sp</i>		X					X
Basommatophora	Planorbidae	<i>Biomphalaria sp</i>	LC				X		
Basommatophora	Planorbidae	<i>Bullinus sp</i>		X			X		X
Blattodea	Blattellidae	<i>Blattella sp</i>	NE				X		
Coleoptera	Bruchidae	<i>Spermophagus gossypii</i>	NE				X		
Coleoptera	Cantharidae	<i>Silidius gestroi</i>	NE		X	X			
Coleoptera	Cerambycidae	<i>Closteromerus laevipes</i>	NE						
Coleoptera	Chrysomelidae	<i>Aspidomorpha infinis</i>	NE						X
Coleoptera	Chrysomelidae	<i>Candezea haematura</i>	NE		X				
Coleoptera	Chrysomelidae	<i>Cryptocephalus callias</i>	NE			X	X		X
Coleoptera	Chrysomelidae	<i>Cryptocephalus semimetallicus</i>	NE		X				
Coleoptera	Chrysomelidae	<i>Cryptocephalus sp</i>							X
Coleoptera	Chrysomelidae	<i>Epitrix sp</i>			X				

Order	Family	Genus/species	IUCN category	Administrative Wards						
				Rurii	Weru	Gatimu	Kiriita	Central	Shamata	
Coleoptera	Chrysomelidae	<i>Hydrogaleruca funesta</i>	NE			x				
Coleoptera	Chrysomelidae	<i>Lema sp</i>			x					
Coleoptera	Chrysomelidae	<i>Monolepta lacta</i>	NE			x				
Coleoptera	Chrysomelidae	<i>Monolepta leuce</i>	NE	x	x	x	x			
Coleoptera	Chrysomelidae	<i>Myrcina fulva</i>	NE			x	x	x		
Coleoptera	Chrysomelidae	<i>Phaedonia areata</i>	NE		x	x				
Coleoptera	Chrysomelidae	<i>Podagrica nigriventris</i>	NE		x			x		
Coleoptera	Cleridae	<i>sp1</i>			x					
Coleoptera	Coccinellidae	<i>Cheilomenes lunata</i>	NE		x					
Coleoptera	Coccinellidae	<i>Hippodamia variegata</i>	NE	x		x	x			
Coleoptera	Coccinellidae	<i>Lidalia intermedia</i>	NE		x	x	x			
Coleoptera	Coccinellidae	<i>Lidalia sexareata</i>	NE			x				
Coleoptera	Curculionidae	<i>Brachyceropsis tuberculosa</i>	NE							
Coleoptera	Curculionidae	<i>Nematocerus lindblomi</i>	NE				x		x	
Coleoptera	Curculionidae	<i>Nematocerus striolatus</i>	NE							
Coleoptera	Curculionidae	<i>Neocleonus sannio</i>	NE			x	x			
Coleoptera	Curculionidae	<i>sp1</i>							x	
Coleoptera	Curculionidae	<i>sp2</i>							x	
Coleoptera	Dytiscidae	<i>Bidessus geminus</i>	NE	x	x					
Coleoptera	Dytiscidae	<i>Bidessus sp2</i>			x	x	x			
Coleoptera	Dytiscidae	<i>Bidessus sp3</i>					x	x		
Coleoptera	Dytiscidae	<i>Copelatus erichsoni</i>	NE		x				x	
Coleoptera	Dytiscidae	<i>Copelatus parallelipipedus</i>	NE				x	x	x	

Order	Family	Genus/species	IUCN category	Administrative Wards						
				Rurii	Weru	Gatimu	Kiriita	Central	Shamata	
Coleoptera	Dytiscidae	<i>Copelatus parumstriatus</i>	NE							
Coleoptera	Dytiscidae	<i>Herophydrus variabilis</i>	NE	X		X	X	X		X
Coleoptera	Dytiscidae	<i>Hydaticus capicola</i>	NE				X			
Coleoptera	Dytiscidae	<i>Hydrocanthus ferruginicollis</i>	NE			X				
Coleoptera	Dytiscidae	<i>Hydrovatus sp</i>					X			X
Coleoptera	Dytiscidae	<i>Laccophilus flavoscriptus</i>	NE			X	X			
Coleoptera	Dytiscidae	<i>larval stage</i>			X			X		X
Coleoptera	Dytiscidae	<i>Rhantus capensis</i>	NE				X			X
Coleoptera	Hydrophilidae	<i>Berosus furcatus</i>	NE	X	X	X	X	X		X
Coleoptera	Hydrophilidae	<i>Coelostoma conradsi</i>	NE				X			
Coleoptera	Hydrophilidae	<i>Coelostoma sp</i>					X			X
Coleoptera	Hydrophilidae	<i>Enochrus alluaudi</i>	NE			X				
Coleoptera	Hydrophilidae	<i>Enochrus anticus</i>	NE		X			X		
Coleoptera	Hydrophilidae	<i>Helochares dilutus</i>	NE		X	X	X	X		
Coleoptera	Hydrophilidae	<i>Helochares sp2</i>				X	X			X
Coleoptera	Hydrophilidae	<i>Helochares sp2</i>								
Coleoptera	Hydrophilidae	<i>Neohydrophilus deplanatus</i>	NE			X				X
Coleoptera	Tenebrionidae	<i>Lagria purpurascens</i>	NE	X	X	X	X			X
Coleoptera	Melyridae	<i>Melyris masaiensis</i>	NE				X			
Coleoptera	Scarabaeidae	<i>Aphodius maculicollis</i>	NE	X	X	X		X		X
Coleoptera	Scarabaeidae	<i>Aphodius urostigma</i>	NE			X	X			X
Coleoptera	Scarabaeidae	<i>Copris amyntor</i>	NE			X				
Coleoptera	Scarabaeidae	<i>Heteronychus lica</i>	NE			X				X

Order	Family	Genus/species	IUCN category	Administrative Wards						
				Rurii	Weru	Gatimu	Kiriita	Central	Shamata	
Coleoptera	Scarabaeidae	<i>Onitis intermedius</i>		x	x	x		x		
Coleoptera	Scarabaeidae	<i>Onitis viridulus</i>	NE	x						
Coleoptera	Scarabaeidae	<i>Onthophagus carbonarius</i>	NE	x	x			x		
Coleoptera	Scarabaeidae	<i>Onthophagus nigriventris</i>	LC	x	x	x			x	
Coleoptera	Scarabaeidae	<i>Onthophagus omostigma</i>	NE		x					
Coleoptera	Spercheidae	<i>Spercheus sp</i>			x		x	x		
Coleoptera	Staphylinidae	<i>Paederus sabaeus</i>	NE			x		x		
Coleoptera	Staphylinidae	<i>Philonthus natalensis</i>	NE	x			x		x	
Coleoptera	Staphylinidae	<i>Philonthus peregrinus</i>	NE							
Coleoptera	Tenebrionidae	<i>Gonocephalum simplex</i>	NE			x		x		
Decapoda	Cambaridae	<i>Procambarus clarkii</i>	LC							
Decapoda	Potamonautidae	<i>Potamonautes sp</i>						x		
Dermoptera	Forficulidae	<i>Forficula sp</i>								
Diptera	Asilidae	<i>Rhabdogaster sp</i>				x		x		
Diptera	Calliphoridae	<i>Pericallimya sp</i>					x	x		
Diptera	Conopidae	<i>sp1</i>							x	
Diptera	Culicidae	<i>Aedes duttoni</i>								
Diptera	Culicidae	<i>Anopheles christyi</i>								
Diptera	Muscidae	<i>Helina sp</i>		x	x	x	x	x	x	
Diptera	Muscidae	<i>Musca domestica</i>	NE				x			
Diptera	Muscidae	<i>Orthellia albigena</i>	NE	x		x	x		x	
Diptera	Muscidae	<i>Stomoxys niger</i>	NE				x			
Diptera	Neriidae	<i>sp1</i>					x			

Order	Family	Genus/species	IUCN category	Administrative Wards						
				Rurii	Weru	Gatimu	Kiriita	Central	Shamata	
Diptera	Sarcophagidae	<i>Poecilometopa sp</i>		x		x			x	
Diptera	Sarcophagidae	<i>Sarcophaga hirtipes</i>	NE				x			
Diptera	Syrphidae	<i>Asarkina hirsuticeps</i>	NE				x	x		
Diptera	Syrphidae	<i>Betasyrphus nandoni</i>	NE	x				x		
Diptera	Syrphidae	<i>Eristalis tenax</i>	LC		x				x	
Diptera	Syrphidae	<i>Melanostoma sp</i>		x						
Diptera	Syrphidae	<i>Phytomia incisa</i>	NE	x	x					
Diptera	Tabanidae	<i>sp1</i>				x				
Diptera	Tabanidae	<i>sp2</i>								
Diptera	Tachinidae	<i>Billaea minor</i>	NE	x						
Diptera	Tachinidae	<i>Compsilura sp</i>							x	
Diptera	Tachinidae	<i>Zygobothris sp</i>							x	
Diptera	Tipulidae	<i>Nephrotoma sp</i>					x			
Diptera	Tipulidae	<i>Tipula sp</i>					x			
Entomobryomorpha	Isotomidae	<i>Isotoma sp</i>					x			
Hemiptera	Belastomatidae	<i>Appasus nephoides</i>	NE				x			
Hemiptera	Cercopidae	<i>Locris ochroptera</i>	NE				x			
Hemiptera	Cicadellidae	<i>Platyretus sp</i>		x	x	x	x		x	
Hemiptera	Cicadellidae	<i>Tettigella sp</i>				x				
Hemiptera	Coreidae	<i>Anoplocnemis dallasiana</i>	NE	x	x	x				
Hemiptera	Coreidae	<i>Leptoglossus membranaceus</i>	NE	x						
Hemiptera	Coreidae	<i>Plectronemis bicolor</i>	NE		x					
Hemiptera	Gerridae	<i>Gerris sp</i>	NE				x			

Order	Family	Genus/species	IUCN category	Administrative Wards						
				Rurii	Weru	Gatimu	Kiriita	Central	Shamata	
Hemiptera	Gerridae	<i>Gerris swakopensis</i>	NE			X	X		X	
Hemiptera	Lygaeidae	<i>Lygaeus pandurus</i>	NE	X	X	X			X	
Hemiptera	Nepidae	<i>Laccotrephes ater</i>	NE	X	X		X			
Hemiptera	Notonectidae	<i>Anisops amaryllis</i>	NE				X		X	
Hemiptera	Notonectidae	<i>Anisops sardea</i>	NE	X	X	X	X			
Hemiptera	Notonectidae	<i>Anisops ares</i>		X	X	X	X		X	
Hemiptera	Micronectidae	<i>Micronecta scutellaris</i>	NE	X		X	X		X	
Hemiptera	Notonectidae	<i>Sigara sjostedti</i>	NE	X	X	X	X		X	
Hemiptera	Pentatomidae	<i>Aspavia armigera</i>	NE		X					
Hemiptera	Pentatomidae	<i>Dorycoris pavoninus</i>	NE				X			
Hemiptera	Pentatomidae	<i>Dryodocoris sp</i>			X			X		
Hemiptera	Pentatomidae	<i>Durmia luteola</i>	NE	X				X		
Hemiptera	Pentatomidae	<i>Halydicoris corticinus</i>	NE				X			
Hemiptera	Pentatomidae	<i>Metonymia modesta</i>	NE					X	X	
Hemiptera	Pentatomidae	<i>Nezara viridula</i>	NE						X	
Hemiptera	Pyrrhocoridae	<i>Dysdercus nigrofasciatus</i>	NE		X	X				
Hemiptera	Reduviidae	<i>Rhinocoris sp</i>							X	
Hemiptera	Velidae	<i>sp1</i>								
Hymenoptera	Apidae	<i>Apis mellifera</i>	NE		X	X	X		X	
Hymenoptera	Apidae	<i>Thyreus meripes</i>	NE			X	X			
Hymenoptera	Apidae	<i>Xylocopa flavorufa</i>	NE			X			X	
Hymenoptera	Chrysididae	<i>Chrysis modica</i>	NE	X						
Hymenoptera	Eumenidae	<i>Eumenes maxillosus</i>	NE				X			

Order	Family	Genus/species	IUCN category	Administrative Wards						
				Rurii	Weru	Gatimu	Kiriita	Central	Shamata	
Hymenoptera	Eumenidae	<i>Eumenes xanthaspsis</i>	NE		x			x	x	
Hymenoptera	Eumenidae	<i>Odynerus sp</i>			x			x		
Hymenoptera	Eumenidae	<i>Polistes marginalis</i>	NE	x		x				
Hymenoptera	Formicidae	<i>Camponotus rufoglaucus</i>	NE			x				
Hymenoptera	Formicidae	<i>Dorylus nigricans</i>	NE							
Hymenoptera	Formicidae	<i>Messor barburus</i>	NE	x	x					
Hymenoptera	Formicidae	<i>Pheidole sculpturata</i>	NE		x			x		
Hymenoptera	Halictidae	<i>Halictus sp1</i>							x	
Hymenoptera	Halictidae	<i>Halictus sp2</i>							x	
Hymenoptera	Halictidae	<i>Lasioglossum sp1</i>		x		x			x	
Hymenoptera	Halictidae	<i>Lasioglossum sp2</i>		x	x	x		x	x	
Hymenoptera	Halictidae	<i>Nomia sp1</i>		x					x	
Hymenoptera	Halictidae	<i>Nomia sp2</i>		x						
Hymenoptera	Halictidae	<i>Seladonia sp</i>								
Hymenoptera	Ichneumonidae	<i>sp1</i>		x						
Hymenoptera	Ichneumonidae	<i>sp2</i>		x	x			x		
Hymenoptera	Ichneumonidae	<i>sp3</i>				x				
Hymenoptera	Ichneumonidae	<i>sp4</i>			x					
Hymenoptera	Megachilidae	<i>Megachile sp2</i>		x						
Hymenoptera	Megachilidae	<i>Megachile venustus</i>	NE		x			x		
Hymenoptera	Pompilidae	<i>Betonzonellus fuliginosus</i>	NE		x					
Hymenoptera	Pompilidae	<i>Pompilius plumbeus</i>	NE							
Hymenoptera	Pompilidae	<i>sp1</i>					x			

Order	Family	Genus/species	IUCN category	Administrative Wards						
				Rurii	Weru	Gatimu	Kiriita	Central	Shamata	
Hymenoptera	Sphecidae	<i>Ammophila bonaespei</i>	NE	x						
Hymenoptera	Sphecidae	<i>Dasyproctus jucundus</i>	NE	x					x	
Hymenoptera	Sphecidae	<i>Dasyproctus sp</i>							x	
Hymenoptera	Sphecidae	<i>Liris intermedia</i>	NE	x						
Hymenoptera	Sphecidae	<i>Philanthus triangulum</i>	NE	x				x		
Hymenoptera	Sphecidae	<i>Podalonia canescens</i>	NE	x	x					
Hymenoptera	Sphecidae	<i>Tachysphex fugax</i>	NE							
Hymenoptera	Vespidae	<i>sp1</i>			x					
Hymenoptera	Vespidae	<i>sp2</i>		x						
Isoptera	Termitidae	<i>Macrotermes sp</i>		x				x		
Ixodida	Ixodidae	<i>Ixodes sp</i>					x			
Lepidoptera	Hesperiidae	<i>Borbo genella</i>	LC						x	
Lepidoptera	Hesperiidae	<i>Eretis lugens</i>	NE		x					
Lepidoptera	Lycaenidae	<i>Actizera stellata</i>	LC	x	x	x	x	x	x	
Lepidoptera	Lycaenidae	<i>Lycaena phlaeas</i>	LC	x				x		
Lepidoptera	Lycaenidae	<i>Zizula hylax</i>	LC			x				
Lepidoptera	Nymphalidae	<i>Hypolimnas misippus</i>	LC	x			x			
Lepidoptera	Nymphalidae	<i>Vanessa cardui</i>	LC	x	x		x			
Lepidoptera	Pieridae	<i>Catopsilia florella</i>	LC		x				x	
Lepidoptera	Pieridae	<i>Colias electo</i>	LC	x	x		x	x	x	
Lymnaeida	Lymnaeidae	<i>Radix natalensis</i>			x	x	x			
Odonata	Aeshnidae	<i>Anax imperator</i>	LC	x						
Odonata	Coenagrionidae	<i>Africallagma elongatum</i>	LC	x	x	x	x	x	x	

Order	Family	Genus/species	IUCN category	Administrative Wards					
				Rurii	Weru	Gatimu	Kiriita	Central	Shamata
Odonata	Coenagrionidae	<i>Africallagma glaucum</i>	LC					x	
Odonata	Libellulidae	<i>Crocothemis erythraea</i>	LC					x	
Odonata	Libellulidae	<i>Orthethrum cafrum</i>	LC	x	x	x	x		x
Odonata	Libellulidae	<i>Sympetrum fonscolombii</i>	LC	x	x				
Orthoptera	Acrididae	<i>Acrida sulphuripennis</i>	NE		x			x	
Orthoptera	Acrididae	<i>Acrotylus elgonensis</i>	NE		x			x	
Orthoptera	Acrididae	<i>Aiolopus acutus</i>	NE		x	x	x		x
Orthoptera	Acrididae	<i>Cyrtacanthacris tatarica</i>	NE	x	x	x		x	
Orthoptera	Acrididae	<i>Morphacris fasciata</i>	LC	x	x			x	
Orthoptera	Acrididae	<i>Oedalus flavus</i>	NE			x			
Orthoptera	Acrididae	<i>Orthoctha dasyncnemis</i>	NE	x	x	x	x	x	x
Orthoptera	Acrididae	<i>Paracrinema tricolor</i>	NT(Europe)	x				x	x
Orthoptera	Acrididae	<i>Pezocatantops kinangopi</i>	NE			x			
Orthoptera	Acrididae	<i>Trilophidia conturbata</i>	NE	x					
Orthoptera	Gryllidae	<i>Gymnogryllus sp</i>				x			
Orthoptera	Gryllidae	<i>Trigonidium sp</i>					x	x	
Orthoptera	Pyrgomorphidae	<i>Parasphena kinangopa</i>							
Orthoptera	Tetrigidae	<i>Dasyleutotetrix sp</i>		x			x		
Orthoptera	Tetrigidae	<i>Paratetrix humilis</i>	NE		x	x	x		
Phasmatodea	Phasmodae	<i>nymphal stage</i>			x				

Appendix 7: Checklist of bird species

(FF -Forest Specialist; F-Forest generalist; f –Forest visitors; PM-Palaearctic migrant)

Species No.	Common Name	Scientific Name	Family	IUCN Status	Forest category
2736	Abyssinian Thrush	<i>Turdus abyssinicus</i>	Turdidae	Least Concern	
95	African Black Duck	<i>Anas sparsa</i>	Anatidae	Least Concern	
380	African Black Swift	<i>Apus barbatus</i>	Apodidae	Least Concern	
973	African Citril	<i>Crithagra citrinelloides</i>	Fringillidae	Least Concern	
655	African Dusky Flycatcher	<i>Muscicapa adusta</i>	Muscicapidae	Least Concern	F
350	African Emerald Cuckoo	<i>Chrysococcyx cupreus</i>	Cuculidae	Least Concern	F
833	African Firefinch	<i>Lagonosticta rubricata</i>	Estrildidae	Least Concern	
149	African Fish Eagle	<i>Haliaeetus vocifer</i>	Accipitridae	Least Concern	
171	African Harrier Hawk	<i>Polyboroides typus</i>	Accipitridae	Least Concern	f
228	African Jacana	<i>Actophilornis africanus</i>	Jacanidae	Least Concern	
167	African Marsh Harrier	<i>Circus ranivorus</i>	Accipitridae	Least Concern	
74	African Openbill	<i>Anastomus lamelligerus</i>	Ciconiidae	Least Concern	
682	African Paradise-flycatcher	<i>Terpsiphone viridis</i>	Monarchidae	Least Concern	f
685	African Pied Wagtail	<i>Motacilla aguimp</i>	Motacillidae	Least Concern	
692	African Pipit	<i>Anthus cinnamomeus</i>	Motacillidae	Least Concern	f
250	African Snipe	<i>Gallinago nigripennis</i>	Scolopacidae	Least Concern	
85	African Spoonbill	<i>Platalea alba</i>	Threskiornithidae	Least Concern	
576	African Stonechat	<i>Saxicola torquatus</i>	Muscicapidae	Least Concern	
10874	African Yellow White-eye	<i>Zosterops senegalensis</i>	Zosteropidae	Least Concern	f
772	Amethyst Sunbird	<i>Chalcomitra amethystina</i>	Nectariniidae	Least Concern	f
153	Augur Buzzard	<i>Buteo augur</i>	Accipitridae	Least Concern	
476	Baglafecht Weaver	<i>Ploceus baglafecht</i>	Ploceidae	Least Concern	f
493	Barn Swallow	<i>Hirundo rustica</i>	Hirundinidae	Least Concern(PM)	
128	Black Kite (Resident)	<i>Milvus migrans</i>	Accipitridae	Least Concern	
2914	Black Saw-wing	<i>Psolidoprocne pristoptera</i>	Hirundinidae	Least Concern	f
159	Black Sparrowhawk	<i>Accipiter melanoleucus</i>	Accipitridae	Least Concern	f
55	Black-headed Heron	<i>Ardea melanocephala</i>	Ardeidae	Least Concern	

Species No.	Common Name	Scientific Name	Family	IUCN Status	Forest category
55	Black-headed Heron	<i>Ardea melanocephala</i>	Ardeidae	Least Concern	
245	Blacksmith Lapwing	<i>Vanellus armatus</i>	Charadriidae	Least Concern	
270	Black-winged Stilt	<i>Himantopus himantopus</i>	Recurvirostridae	Least Concern	
99	Blue-billed Teal	<i>Spatula hottentota</i>	Anatidae	Least Concern	
863	Brimstone Canary	<i>Crithagra sulphurata</i>	Fringillidae	Least Concern	
823	Bronze Mannikin	<i>Spermestes cucullatus</i>	Estrildidae	Least Concern	
752	Bronze Sunbird	<i>Nectarinia kilimensis</i>	Nectariniidae	Least Concern	
443	Brown-backed Honeybird	<i>Prodotiscus regulus</i>	Indicatoridae	Least Concern	
581	Cape Robin-Chat	<i>Cossypha caffra</i>	Muscicapidae	Least Concern	f
523	Cape Rook	<i>Corvus capensis</i>	Corvidae	Least Concern	
686	Cape Wagtail	<i>Motacilla capensis</i>	Motacillidae	Least Concern	
61	Cattle Egret	<i>Bubulcus ibis</i>	Ardeidae	Least Concern	
3082	Chestnut-throated Apalis	<i>Apalis porphyrolaema</i>	Cisticolidae	Least Concern	F
673	Chinspot Batis	<i>Batis molitor</i>	Platysteiridae	Least Concern	
1107	Cinnamon Bracken Warbler	<i>Bradypterus cinnamomeus</i>	Locustellidae	Least Concern	F
1578	Cinnamon-chested Bee-eater	<i>Merops oreobates</i>	Meropidae	Least Concern	F
11491	Common Bulbul	<i>Pycnonotus barbatus</i>	Pycnonotidae	Least Concern	
154	Common Buzzard	<i>Buteo buteo</i>	Accipitridae	Least Concern (PM)	
517	Common Drongo	<i>Dicrurus adsimilis</i>	Dicruridae	Least Concern	
7887	Common Fiscal	<i>Lanius collaris</i>	Laniidae	Least Concern	
507	Common House Martin	<i>Delichon urbicum</i>	Hirundinidae	Least Concern (PM)	
189	Common Quail	<i>Coturnix coturnix</i>	Phasianidae	Least Concern	
258	Common Sandpiper	<i>Actitis hypoleucos</i>	Scolopacidae	Least Concern	
957	Common Snipe	<i>Gallinago gallinago</i>	Scolopacidae	Least Concern (PM)	f
843	Common Waxbill	<i>Estrilda astrild</i>	Estrildidae	Least Concern	
427	Crowned Hornbill	<i>Tockus alboterminatus</i>	Bucerotidae	Least Concern	f
242	Crowned Lapwing	<i>Vanellus coronatus</i>	Charadriidae	Least Concern	
1874	Dusky Turtle Dove	<i>Streptopelia lugens</i>	Columbidae	Least Concern	
89	Egyptian Goose	<i>Alopochen aegyptiaca</i>	Anatidae	Least Concern	

Species No.	Common Name	Scientific Name	Family	IUCN Status	Forest category
115	Eurasian Hobby	<i>Falco subbuteo</i>	Falconidae	Least Concern (PM)	
412	European Roller	<i>Coracias garrulus</i>	Coraciidae	Least Concern (PM)	
395	Giant Kingfisher	<i>Megaceryle maxima</i>	Alcedinidae	Least Concern	
83	Glossy Ibis	<i>Plegadis falcinellus</i>	Threskiornithidae	Least Concern	
1118	Golden-winged Sunbird	<i>Drepanorhynchus</i>	Nectariniidae	Least Concern	f
56	Goliath Heron	<i>reichenowi</i>	Ardeidae	Least Concern	
58	Great White Egret	<i>Ardea goliath</i>	Ardeidae	Least Concern	
86	Greater Flamingo	<i>Ardea alba</i>	Phoenicopteridae	Least Concern	
259	Green Sandpiper	<i>Phoenicopus roseus</i>	Scolopacidae	Least Concern (PM)	
214	Grey Crowned Crane	<i>Tringa ochropus</i>	Gruidae	Endangered	
54	Grey Heron	<i>Balearica regulorum</i>	Ardeidae	Least Concern	f
628	Grey-backed Camaroptera	<i>Ardea cinerea</i>	Cisticolidae	Least Concern	f
3170	Grey-capped Warbler	<i>Camaroptera brevicaudata</i>	Cisticolidae	Least Concern	f
401	Grey-headed Kingfisher	<i>Eminia lepida</i>	Alcedinidae	Least Concern	f
804	Grosbeak Weaver	<i>Halcyon leucocephala</i>	Ploceidae	Least Concern	f
84	Hadada Ibis	<i>Amblyospiza albifrons</i>	Threskiornithidae	Least Concern	
72	Hammerkop	<i>Bostrychia hagedash</i>	Scopidae	Least Concern	F
1718	Hartlaub's Turaco	<i>Scopus umbretta</i>	Musophagidae	Least Concern	
784	House Sparrow	<i>Tauraco hartlaubi</i>	Passeridae	Least Concern (non-native)	
632	Hunter's Cisticola	<i>Passer domesticus</i>	Cisticolidae	Least Concern	
3752	Jackson's Widowbird	<i>Cisticola hunteri</i>	Ploceidae	Least Concern	
3840	Kenya Rufous Sparrow	<i>Euplectes jacksoni</i>	Passeridae	Least Concern	
351	Klass's Cuckoo	<i>Passer rufocinctus</i>	Cuculidae	Least Concern	
125	Lesser Kestrel	<i>Cuculus klaas</i>	Falconidae	Least Concern (PM)	
646	Levaillant's Cisticola	<i>Falco naumanni</i>	Cisticolidae	Least Concern	
59	Little Egret	<i>Cisticola tinniens</i>	Ardeidae	Least Concern	
6	Little Grebe	<i>Egretta garzetta</i>	Podicipedidae	Least Concern	

Species No.	Common Name	Scientific Name	Family	IUCN Status	Forest category
955	Little Ringed Plover	<i>TCharadrius dubius</i>	Charadriidae	Least Concern (PM)	
158	Little Sparrowhawk	<i>Accipiter minullus</i>	Accipitridae	Least Concern	
385	Little Swift	<i>Apus affinis</i>	Apodidae	Least Concern	
818	Long-tailed Widowbird	<i>Euplectes progne</i>	Ploceidae	Least Concern	
751	Malachite Sunbird	<i>Nectarinia famosa</i>	Nectariniidae	Least Concern	F
361	Marsh Owl	<i>Asio capensis</i>	Tytonidae	Least Concern	
262	Marsh Sandpiper	<i>Tringa stagnatilis</i>	Scolopacidae	Least Concern	
327	Meyer's Parrot	<i>Poicephalus meyeri</i>	Psittacidae	Least Concern	
357	Montane Nightjar	<i>Caprimulgus poliocephalus</i>	Caprimulgidae	Least Concern	
382	Mottled Swift	<i>Apus aequatorialis</i>	Apodidae	Least Concern	
688	Mountain Wagtail	<i>Motacilla clara</i>	Motacillidae	Least Concern	
3852	Northern Grey-headed Sparrow	<i>Passer griseus</i>	Passeridae	Least Concern	
563	Northern Wheatear	<i>Oenanthe oenanthe</i>	Muscicapidae	Least Concern (PM)	
168	Pallid Harrier	<i>Circus macrourus</i>	Accipitridae	Near Threatened (PM)	
522	Pied Crow	<i>Corvus albus</i>	Corvidae	Least Concern	
394	Pied Kingfisher	<i>Ceryle rudis</i>	Alcedinidae	Least Concern	
846	Pin-tailed Whydah	<i>Vidua macroura</i>	Viduidae	Least Concern	
509	Plain Martin	<i>Riparia paludicola</i>	Hirundinidae	Least Concern	
3978	Purple Grenadier	<i>Uraeginthus i anthinogaster</i>	Estrildidae	Least Concern	
57	Purple Heron	<i>Ardea purpurea</i>	Ardeidae	Least Concern	
708	Red-backed Shrike	<i>Lanius collurio</i>	Laniidae	Least Concern (PM)	
837	Red-billed Firefinch	<i>Lagonosticta senegala</i>	Estrildidae	Least Concern	
97	Red-billed Teal	<i>Anas erythrorhyncha</i>	Anatidae	Least Concern	
488	Red-capped Lark	<i>Calandrella cinerea</i>	Alaudidae	Least Concern	
3974	Red-cheeked Cordon-bleu	<i>Uraeginthus bengalus</i>	Estrildidae	Least Concern	
314	Red-eyed Dove	<i>Streptopelia semitorquata</i>	Columbidae	Least Concern	
212	Red-knobbed Coot	<i>Fulica cristata</i>	Rallidae	Least Concern	
962	Red-rumped Swallow	<i>Cecropis daurica</i>	Hirundinidae	Least Concern	

Species No.	Common Name	Scientific Name	Family	IUCN Status	Forest category
745	Red-winged Starling	<i>Onychognathus morio</i>	Sturnidae	Least Concern	f
50	Reed Cormorant	<i>Microcarbo africanus</i>	Phalacrocoracidae	Least Concern	
316	Ring-necked Dove	<i>Streptopelia capicola</i>	Columbidae	Least Concern	
506	Rock Martin	<i>Ptyonoprogne fulgula</i>	Hirundinidae	Least Concern	
256	Ruff	<i>Calidris pugnax</i>	Scolopacidae	Least Concern (PM)	
458	Rufous-naped Lark	<i>Mirafra africana</i>	Alaudidae	Least Concern	
2576	Ruppell's Robin-chat	<i>Cossypha semirufa</i>	Muscicapidae	Least Concern	F
81	Sacred Ibis	<i>Threskiornis aethiopicus</i>	Threskiornithidae	Least Concern	
904	Scarce Swift	<i>Schoutedenapus myoptilus</i>	Apodidae	Least Concern	
119	Sharpe's Longclaw	<i>Macronyx sharpei</i>	Motacillidae	Endangered/Endemic	
423	Silvery-cheeked Hornbill	<i>Bycanistes brevis</i>	Bucerotidae	Least Concern	F
390	Speckled Mousebird	<i>Colius striatus</i>	Coliidae	Least Concern	f
311	Speckled Pigeon	<i>Columba guinea</i>	Columbidae	Least Concern	
3934	Speke's Weaver	<i>Ploceus spekei</i>	Ploceidae	Least Concern	
88	Spur-winged Goose	<i>Plectropterus gambensis</i>	Anatidae	Least Concern	
1031	Spur-winged Lapwing	<i>Vanellus spinosus</i>	Charadriidae	Least Concern	
62	Squacco Heron	<i>Ardeola ralloides</i>	Ardeidae	Least Concern	
135	Steppe Eagle	<i>Aquila nipalensis</i>	Accipitridae	Endangered (PM)	
778	Streaky Seedeater	<i>Crithagra striolata</i>	Fringillidae	Least Concern	
2800	Superb Starling	<i>Lamprotornis superbus</i>	Sturnidae	Least Concern	
134	Tawny Eagle	<i>Aquila rapax</i>	Accipitridae	Vulnerable	
238	Three-banded Plover	<i>Charadrius tricollaris</i>	Charadriidae	Least Concern	
7866	Tropical Boubou	<i>Laniarius aethiopicus</i>	Malaconotidae	Least Concern	
762	Variable Sunbird	<i>Cinnyris venustus</i>	Nectariniidae	Least Concern	
851	Village Indigobird	<i>Vidua chalybeata</i>	Viduidae	Least Concern	
137	Wahlberg's Eagle	<i>Hieraaetus wahlbergi</i>	Accipitridae	Least Concern (intra-africa)	
274	Water Thick-knee	<i>Burhinus vermiculatus</i>	Burhinidae	Least Concern	

Species No.	Common Name	Scientific Name	Family	IUCN Status	Forest category
166	Western Marsh Harrier	<i>Circus aeruginosus</i>	Accipitridae	Least concern (PM)	
172	Western Osprey	<i>Pandion haliaetus</i>	Pandionidae	Least concern (PM)	
577	Whinchat	<i>Saxicola rubetra</i>	Muscicapidae	Least concern (PM)	
780	White-browed Sparrow-weaver	<i>Plocepasser mahali</i>	Ploceidae	Least Concern	
2600	White-eyed Slaty Flycatcher	<i>Melaenornis fischeri</i>	Muscicapidae	Least Concern	F
100	White-faced Whistling Duck	<i>Dendrocygna viduata</i>	Anatidae	Least Concern	
3142	Winding Cisticola	<i>Cisticola galactotes</i>	Cisticolidae	Least Concern	
634	Wing-snapping Cisticola	<i>Cisticola ayresii</i>	Cisticolidae	Least Concern	
496	Wire-tailed Swallow	<i>Hirundo smithii</i>	Hirundinidae	Least Concern	
77	Wolly-necked Stork	<i>Ciconia episcopus</i>	Ciconiidae	Vulnerable (intra-africa)	
264	Wood Sandpiper	<i>Tringa glareola</i>	Scolopacidae	Least Concern (PM)	
689	Yellow Wagtail	<i>Motacilla flava</i>	Motacilidae	Least Concern	
826	Yellow-bellied Waxbill	<i>Coccothraustes quartinia</i>	Estrildidae	Least Concern	f
96	Yellow-billed Duck	<i>Anas undulata</i>	Anatidae	Least Concern	
151	Yellow-billed Egret	<i>Ardea brachyrhyncha</i>	Ardeidae	Least Concern	
625	Yellow-breasted Apalis	<i>Apalis flavida</i>	Cisticolidae	Least Concern	f
4098	Yellow-fronted Canary	<i>Serinus flavivertex</i>	Fringillidae	Least Concern	

Appendix 8: Water quality parameters at various sites

(ppm-parts per million; PSU- practical salinity unit;)

Ward/Habitat	Transect	pH	Temperature (°C)	Conductivity (mS/cm)	TDS (ppm)	Salinity (PSU)	Nitrates (ppm)	Phosphates (ppm)	Longitude	Latitude
Shamata	Stream 1	7.21	19.7	284	142	0.14	0.62	0.41	36.4553	-0.1771
	Lake	7.19	20.8	454	228	0.22	1.96	0.44	36.4502	-0.1803
	Stream 2	7.23	21.98	226	113	0.11	0.4	0.21	36.4604	-0.1859
Rurii	Rurii stream	7.23	16.86	224	112	0.11	0.52	0.37	36.447	-0.1874
Central	Lake	7.16	21.37	1244	620	0.62	0.64	0.96	36.4454	-0.1812
	Canal	7.23	15.73	627	316	0.31	0.8	0.48	36.4319	-0.1106
Weru	Ground Zero	7.45	18.43	3532	1765	1.85	0.55	0.24	36.4287	-0.1419
Gatimu	Njunu Springs	7.97	21.77	175	88	0.08	2.66	0.16	36.3907	-0.0267
	Mashimoni (hippo pool)	8.02	26.34	152	76	0.07	0.6	0.21	36.4034	-0.0174
	Lake	7.92	20.7	180	90	0.08	2.16	0.66	36.3898	0.02737
Associated rivers	Ewaso Narok (Manguo bridge)	7.26	18.59	135	67	0.06	0.52	0.19	36.3723	0.0428
	Chamuka River	7.63	16.18	104	52	0.05	0.48	0.25	36.3702	0.02582
	Nyandarua National Polytechnic stream	7.49	15.15	53	27	0.02	1.34	0.27	36.3617	-0.0295
	Nyakariong'a Stream	7.88	19.06	131	65	0.06	0.72	0.3	36.3616	-0.0424
	Oloro Orok (Simba) stream	7.44	16.26	74	37	0.03	3.26	0.25	36.3664	-0.0791
Average		7.487		506.33	253.2	0.254	1.1486	0.36		
Average lake		7.461		768.67	355	0.359	1.091	0.414		
Average rivers		7.54		99.4	49.6	0.044	1.264	0.252		

Appendix 9: Ground Truthed Land Use Land Cover along 2 km transect

Ward/Area	Land use	Land cover	Latitude	Longitude	DCIM No.
Shamata	Farmland	Maize	0.181375	36.33828167	281
Shamata	Farmland	Maize	0.179756667	36.47604667	282
Shamata	Shrubland	Thickets	0.179371667	36.47642667	283
Shamata	Shrubland	Thickets	0.176787778	36.475445	284
Shamata	Farmland	Cabbage	0.177338333	36.473395	285
Shamata	Farmland	Oat	0.176001667	36.472825	286
Rurii	Lake	Water	0.181861667	36.43901667	DCIM 287
Rurii	Lake	Grass	0.181883333	36.445545	288
Rurii	Lake	Grass	0.167405	36.44611667	289/290/291
Rurii	Grassland	Tussocks	0.199763333	36.44448	292/3
Rurii	Grassland	Grass	0.179765	36.44263333	294
Rurii	Lake	Grass	0.1791	36.44253667	295
Rurii	Grassland	Grass	0.179948333	36.44068167	296
Rurii	Lake	Water	0.179151667	36.44052944	297
Rurii	Lake	Invasive species	0.180061667	36.438345	298
Rurii	Grassland	Grass	0.181635	36.43854167	299
Rurii	Grassland	Tussocks	0.182685	36.43847333	300
Rurii	Woodlot	Eucalyptus	0.182008333	36.440865	301
Rurii	Woodlot	Eucalyptus	0.181976667	36.44342333	302
Rurii	Woodlot	Eucalyptus	0.193800556	36.420185	303
Rurii	Woodlot	Eucalyptus	0.193836667	36.42071833	304
Rurii	Farmland	Maize	0.19367	36.42137667	305
Rurii	Farmland	Oat	0.193483333	36.42277611	306
Rurii	Farmland	Maize	0.193483333	36.42277611	307
Rurii	Farmland	Oat	0.193461667	36.42274	308
Rurii	Woodlot	Eucalyptus	0.193128333	36.42394833	309
Rurii	Farmland	Maize	0.192906667	36.42510667	310
Rurii	Grassland	Tussocks	0.192866667	36.42573833	311
Rurii	Grassland	Tussocks	0.192796667	36.42624333	312
Rurii	Woodlot	Eucalyptus	0.192625	36.42817	314
Rurii	Grassland	Grass	0.192530556	36.42879389	315
Rurii	Grassland	Grass	0.19243	36.42952667	316
Rurii	Farmland	Potato	0.192378333	36.429935	317
Rurii	Farmland		0.19231	36.43036667	318
Rurii	Farmland	Tussocks	0.192108333	36.430975	319
Rurii	Grassland	Tussocks	0.191305	36.43144833	320
Rurii	Farmland	Maize	0.18986	36.43210667	322
Rurii	Woodlot	Eucalyptus	0.18965	36.43204028	323/4
Rurii	Farmland	Maize	0.188688889	36.43248167	325

Appendix 9: Ground Truthed Land Use Land Cover along 2 km transect

Ward/Area	Land use	Land cover	Latitude	Longitude	DCIM No.
Rurii	Woodlot	Eucalyptus	0.188133333	36.43270167	326
Rurii	Farmland	oat	0.188285	36.43295833	327
Rurii	Grassland	Tussocks	0.188125	36.43316167	328
Rurii	Farmland		0.188098333	36.43350667	329
Rurii	Farmland		0.187956667	36.433875	330
Rurii	Grassland	Tussocks	0.18744	36.436055	331
Rurii	Grassland	Tussocks	0.187408333	36.43742833	Not taken
Rurii	Woodlot	Eucalyptus	0.187451667	36.43752	Not taken
Rurii	Grassland	Tussocks	0.187463889	36.43854667	Not taken
Rurii	Woodlot	Eucalyptus	0.186266111	36.43932167	Not taken
Rurii	Farmland	Beans	0.184766667	36.441085	Not taken
Central Ward	Lake	Grass	0.139151667	36.437515	332/3
Central Ward	Grassland	Grass	0.139308333	36.43850833	333
Central Ward	Lake	Grass	0.140793333	36.43801667	334
Central Ward	Grassland	Invasive species	0.139641667	36.439495	335
Central Ward	Grassland	Tussocks	0.138671111	36.44111667	343
Central Ward	Grassland	Invasive species	0.138203333	36.44151667	344
Central Ward	Grassland	Tussocks	0.138127222	36.44148889	345
Central Ward	Grassland	Invasive species	0.138005 3	6.44481667	346
Central Ward	Grassland	Tussocks	0.136903333	36.44756667	347
Central Ward	Woodlot	Eucalyptus	0.135155	36.44730667	349
Central Ward	Farmland	Maize	0.135391667	36.44784556	351
Central Ward	Farmland	oat	0.140993333	36.44929056	352
Central Ward	Farmland	Potato	0.142865	36.45082	353
Central Ward	Grassland	Tussocks	0.143221667	36.45104333	354
Central Ward	Farmland	Beans	0.143813333	36.451305	355
Central Ward	Farmland	Carrots	0.145021667	36.451995	356
Central Ward	Farmland	Onion	0.146188333	36.45224333	360
Central Ward	Farmland	Cabbage	0.136195	36.456675	361
Central Ward	Forest	Tree	0.135442778	36.45900667	362/3
Central Ward	Farmland	Maize	0.13512	#VALUE!	365
Weru	Lake	Grass	0.141725	36.42857333	377
Weru	Grassland	Tussocks	0.143151667	36.428385	378
Weru	Grassland	Tussocks	0.145812778	36.42832667	379
Weru	Grassland	Tussocks	0.150976667	36.428805	380
Weru	Forest	Tree	0.152058333	36.42894833	381/2
Weru	Lake	Herbs	0.151559722	36.4315 383	
Weru	Grassland	Tussocks	0.150980833	36.43089667	384
Weru	Grassland	Grass	0.148658333	36.428235	385

Appendix 9: Ground Truthed Land Use Land Cover along 2 km transect

Ward/Area	Land use	Land cover	Latitude	Longitude	DCIM No.
Weru	Farmland	Potato	0.147816667	36.42787667	386
Weru	Farmland	oat	0.146711667	36.42744	387
Weru	Farmland	Grass	0.14533	36.42686667	388/9
Weru	Farmland	Maize	0.143918333	36.42657833	390
Weru	Farmland	Potato	0.138969444	36.42619333	392
Weru	Woodlot	Eucalyptus	0.138581111	36.42617333	393
Weru	Grassland	Tussocks	0.135536667	36.42614667	394
Weru	Grassland	Grass	0.135333333	36.42667667	395
Weru	Grassland	Grass	0.149833333	36.42783833	396
Weru	Grassland	Invasive species	0.128277778	36.42974333	397/8
Weru	Grassland	Grass	0.126503333	36.43051333	399
Weru	Grassland	Invasive species	0.126600278	36.42859833	400
Weru	Forest	Tree	0.126661667	36.42684361	401
Weru	Farmland	Maize	0.123953333	36.42580333	403
Weru	Forest	Tree	0.123971667	36.425415	404
Weru	Forest	Tree	0.124123333	36.42473333	405/6
Weru	Farmland	Maize	0.124176667	36.42458667	407
Weru	Grassland	Tussocks	0.124233333	36.42391833	408
Weru	Farmland	Beans	0.124414444	36.42324	409
Weru	Farmland	Potato	0.124503333	36.42141667	411
Weru	Farmland	Tussocks	0.125536667	36.42029	412
Weru	Farmland	Herbs	0.125589167	36.4204	413
Weru	Farmland	Wheat	0.126825	36.42033667	414
Weru	Grassland	Tussocks	0.127138889	36.42039667	415
Weru	Grassland	Tussocks	0.128102778	36.42047667	416
Weru	Forest	Tree	0.128455833	36.42042	417
Weru	Grassland	Tussocks	0.129538889	36.42951167	418
Weru	Farmland	Baresoil	0.131944444	36.42069167	420
Weru	Farmland	Wheat	0.134694444	36.42069	421
Weru	Farmland	Oat	0.135466667	36.420805	422
Weru	Farmland	Maize	0.136305833	36.42077167	423
Weru	Grassland	Tussocks	0.136766667	36.42083333	424
Weru	Farmland	Beans	0.139355556	36.42089167	425
Weru	Farmland	oat	0.139811667	36.42090833	426
Weru	Farmland	Maize	0.141103333	36.420925	427
Weru	Farmland	Maize	0.142616667	36.42098833	428/9
Weru	Farmland	Avocado	0.143676667	36.41862667	434
Gatimu	Shrubland	Thickets	0.026195	36.38904	437
Gatimu	Farmland	Maize	0.025461667	36.38920833	438

Appendix 9: Ground Truthed Land Use Land Cover along 2 km transect

Ward/Area	Land use	Land cover	Latitude	Longitude	DCIM No.
Gatimu	Farmland	Maize	0.024885	36.38963167	439
Gatimu	Grassland	Woodlot	0.025196667	36.38929333	442
Gatimu	Grassland	Forest	0.026628333	36.390305	443
Gatimu	Grassland	Mixed Sedges	0.026708333	36.39070167	446
Gatimu	Woodlot	Eucalyptus	0.028913333	36.39107833	447
Gatimu	Grassland	Tussocks	0.028071667	36.39147333	448
Gatimu	Grassland	Tussocks	0.028708333	36.39339667	449
Gatimu	Grassland	Tussocks	0.028771667	36.39503667	450
Gatimu	Farmland	Maize	0.0276475	36.39512333	451
Gatimu	Woodlot	Eucalyptus	0.026726667	36.39696333	452
Gatimu	Farmland	Sunflower	0.026593889	36.39598833	453
Gatimu	Farmland	Maize	0.023898333	36.397865	456
Gatimu	Grassland	Grass	0.026438889	36.40179833	457/8
Gatimu	Grassland	Grass	0.026746667	36.40297667	459
Gatimu	Grassland	Tussocks	0.02325	36.40678667	460
Gatimu	Grassland	Herbs	0.022233333	36.406585	462
Gatimu	Grassland	Mixed Sedges	0.020396667	36.406055	463
Gatimu	Grassland	Grass	0.020265	36.40670833	464
Gatimu	Grassland	Mixed Sedges	0.016794444	36.40548167	470
Gatimu	Grassland	Invasive species	0.0165	36.40594667	471
Gatimu	Grassland	Mixed Sedges	0.018005	36.40221833	472
Gatimu	Woodlot	Eucalyptus	0.016086667	36.39642333	473
Gatimu	Grassland	Grass	0.016366667	36.39658333	474
Gatimu	Farmland	Beans	0.013038333	36.39641	475/6
Gatimu	Farmland	Maize	0.013195	36.39601333	477
Gatimu	Farmland	Potato	0.013445556	36.39556333	478
Gatimu	Forest	Tree	0.013645	36.39421833	479
Gatimu	Farmland	Maize	0.014522222	36.392235	480
Gatimu	Farmland	Wheat	0.014744444	36.391695	481
Gatimu	Farmland	Kales	0.01533 3	6.38979667	483
Gatimu	Farmland	Wheat	0.017551667	36.38729833	484
Gatimu	Farmland	Baresoil	0.019478333	36.38781833	485
Gatimu	Forest	Woodlot	0.019356667	36.3885	486
Gatimu	Grassland	Tussocks	0.018701667	36.38953167	487
Gatimu	Grassland	Tussocks	0.019607778	36.390895	488
Gatimu	Grassland	Tussocks	0.020008889	36.39707278	489
Kiriita Ward	Farmland	Kales	0.006918333	36.40317667	490
Kiriita Ward	Forest	Woodlot	0.00842	36.40216	491
Kiriita Ward	Lake	Mixed Sedges	0.00791	36.40117667	492

Appendix 9: Ground Truthed Land Use Land Cover along 2 km transect

Ward/Area	Land use	Land cover	Latitude	Longitude	DCIM No.
Kiriita Ward	Forest	Woodlot	0.006965	36.40159833	493
Kiriita Ward	Lake	Mixed Sedges	0.010686667	36.40008	494
Kiriita Ward	Grassland	Grass	0.013305	36.40047833	495
Kiriita Ward	Lake	Mixed Sedges	0.015558333	36.39968667	496
Kiriita Ward	Woodlot	Eucalyptus	0.019293333	36.40279167	497
Kiriita Ward	Lake	Mixed Sedges	0.020668333	36.40201167	499
Kiriita Ward	Lake	Mixed Sedges	0.023533333	36.39799167	500
Kiriita Ward	Forest	Woodlot	0.023956667	36.39830778	501
Kiriita Ward	Forest	Woodlot	0.025191667	36.39922833	502
Kiriita Ward	Forest	Woodlot	0.026645	36.40078333	503
Kiriita Ward	Grassland	Tussocks	0.024726667	36.40109667	504
Igwamiti (Manguo)	Grassland	Eucalyptus	0.042047222	36.37288 505	
Igwamiti (Manguo)	Grassland	Tussocks	0.041861667	36.37336167	506
Igwamiti (Manguo)	Forest	Tree	0.042089444	36.37497833	507/8
Igwamiti (Manguo)	Grassland	Tussocks	0.040122778	36.37542333	509
Igwamiti (Manguo)	Swamp	Mixed Sedges	0.039471667	36.37578333	510
Igwamiti (Manguo)	Farmland	Cabbage	0.037218333	36.37519833	511
Igwamiti (Manguo)	Grassland	Tussocks	0.038188333	36.374385	512
Igwamiti (Manguo)	Swamp	Mixed Sedges	0.040235	36.37450833	513
Igwamiti (Manguo)	=Woodlot	Eucalyptus	0.040261667	36.37474833	514
Kiriita (Chaparungu)	Farmland	Maize	0.040225	36.428665	515
Kiriita (Chaparungu)	Grassland	Invasive species	0.041657778	36.42622667	516/7
Kiriita (Chaparungu)	Woodlot	Eucalyptus	0.040735	36.42475833	518
Kiriita (Chaparungu)	Lake	Mixed Sedges	0.041413333	36.42030167	519
Kiriita (Chaparungu)	Grassland	Tussocks	0.039683333	36.42083167	520
Kiriita (Chaparungu)	Grassland	Mixed Sedges	0.041375	36.43080667	522
Kiriita (Chaparungu)	Forest	Tree	0.041278333	36.430985	521
Kiriita (Chaparungu)	Farmland	Potato	0.040111667	36.42796833	524
Kiriita (Chaparungu)	Farmland	Potato	0.038793333	36.42758667	525
Kiriita (Chaparungu)	Grassland	Tussocks	0.037946667	36.42733667	526
Kiriita (Chaparungu)	Farmland	Maize	0.03783	36.42731333	527
Kiriita (Chaparungu)	Woodlot	Eucalyptus	0.037023333	36.42708333	528
Kiriita (Chaparungu)	Farmland	Cabbage	0.036591667	36.42698333	529
Kiriita (Chaparungu)	Farmland	Baresoil	0.037375	36.42715	530
Kiriita (Ziwani)	Grassland	Tussocks	0.05666	36.36201833	531
Kiriita (Ziwani)	Forest	Tree	0.045781667	36.36983333	536
Kiriita (Ziwani)	Forest	Tree	0.045466667	36.37008278	537/8

Appendix 10: Distribution of Land Use Land Cover types (in Ha)

Year 1973	Gatimu	Kaimbaga	Kanyagia	Kiriita	Leshau	Maina	Mutitu	Nyahururu	OI Joro Orok	Rurii	Shamata	Wanjohi	Weru
Built-up area	0	0	0	4	0	11	0	43	0	0	0	0	0
Farmland/Ranch	1765	701	202	110	0	84	0	25	29	2631	2066	118	3572
Forest/Thickets	0	0	401	142	23	128	2	0	0	0	513	0	0
Grassland: Tussocks	4268	372	583	885	1	449	0	266	17	1605	1009	25	1360
Wetland: Sedges	326	0	159	65	0	39	0	0	0	73	47	0	499
Wetland: Water area	16	8	441	52	1	0	0	0	0	286	647	0	1437
Year 1986													
Built-up area	1	0	0	24	0	60	0	87	0	0	0	0	0
Eucalyptus Plantation	16	3	0	0	0	0	0	0	0	14	93	16	33
Farmland: Cropped Land	1437	416	266	204	5	120	0	47	32	2792	557	23	2842
Forest/Thickets	0	0	142	2	13	103	0	0	0	0	505	0	0
Grassland: Short Grasses	82	38	334	21	0	3	0	2	0	360	204	1	284
Grassland: Tussocks	4111	557	875	861	4	309	2	147	13	1210	2112	79	2435
Wetland: Muddy Soil	0	38	4	0	0	0	0	0	0	99	157	0	530
Wetland: Sedges	746	32	166	156	4	119	0	57	1	128	664	23	745
Year 2019													
Built-up area	42	0	0	69	0	78	0	103	0	0	0	0	0
Eucalyptus Plantation	497	76	45	103	12	20	1	7	2	349	371	23	402
Farmland/Cropped	1539	317	237	223	6	39	1	21	16	1130	867	45	1341
Forest/Thickets	0	0	135	2	1	87	0	0	0	0	241	0	0
Grassland: Short Grasses	2428	456	435	409	3	245	1	150	16	1874	1184	59	2020
Grassland: Tussocks	1490	221	278	283	2	188	0	58	11	957	864	15	1243
Wetland: Sedges	389	0	400	175	1	43	0	0	0	111	220	0	556
Wetland: Water area	1	0	256	0	0	13	0	0	0	161	535	0	1267

Appendix 11: Land Use Land Cover Change (LULC) Matrix (in Ha)

LULC 1973	LULC 1986	LULC 2019	Area
Unclassified	Built-up area	Built-up area	0.42
		Eucalyptus Plantation	0.02
		Farmland/Cropped	0.06
		Grassland: Short Grasses	1.06
		Grassland: Tussocks	0.19
	Eucalyptus Plantation	Farmland/Cropped	0.01
		Grassland: Short Grasses	0.00
		Grassland: Tussocks	0.00
	Farmland: Cropped Land	Built-up area	0.17
		Eucalyptus Plantation	0.22
		Farmland/Cropped	3.52
		Grassland: Short Grasses	5.58
		Grassland: Tussocks	2.92
	Forest/Thickets	Eucalyptus Plantation	0.37
		Farmland/Cropped	0.61
		Forest/Thickets	2.54
		Grassland: Short Grasses	0.16
		Grassland: Tussocks	0.04
	Grassland: Short Grasses	Eucalyptus Plantation	0.01
		Farmland/Cropped	0.53
		Grassland: Short Grasses	0.79
		Grassland: Tussocks	0.17
		Wetland: Sedges	0.32
	Grassland: Tussocks	Built-up area	1.70
		Eucalyptus Plantation	3.43
		Farmland/Cropped	8.65
		Grassland: Short Grasses	12.24
		Grassland: Tussocks	7.55
		Wetland: Sedges	0.21
	Wetland: Sedges	Built-up area	0.11
		Eucalyptus Plantation	0.31
		Farmland/Cropped	1.19
		Grassland: Short Grasses	1.20
		Grassland: Tussocks	0.61
		Wetland: Sedges	0.46
Built-up area	Built-up area	Built-up area	9.63
		Eucalyptus Plantation	0.09
		Farmland/Cropped	1.21
		Grassland: Short Grasses	15.51
		Grassland: Tussocks	2.88

Appendix 11: Land Use Land Cover Change (LULC) Matrix (in Ha)

LULC 1973	LULC 1986	LULC 2019	Area
	Farmland: Cropped Land	Built-up area	1.92
		Eucalyptus Plantation	0.01
		Farmland/Cropped	0.13
		Grassland: Short Grasses	2.36
		Grassland: Tussocks	0.77
	Grassland: Short Grasses	Built-up area	0.39
		Farmland/Cropped	0.03
		Grassland: Short Grasses	0.59
	Grassland: Tussocks	Grassland: Tussocks	0.20
		Built-up area	5.60
		Eucalyptus Plantation	0.20
		Farmland/Cropped	1.02
		Grassland: Short Grasses	7.57
		Grassland: Tussocks	2.01
	Wetland: Sedges	Built-up area	2.41
		Eucalyptus Plantation	0.17
		Farmland/Cropped	0.24
		Grassland: Short Grasses	2.12
		Grassland: Tussocks	0.77
Farmland/Ranch	Built-up area	Built-up area	5.74
		Eucalyptus Plantation	0.94
		Farmland/Cropped	0.75
		Grassland: Short Grasses	5.43
		Grassland: Tussocks	2.02
		Wetland: Water area	0.97
	Eucalyptus Plantation	<i>Unclassified</i>	0.13
		Eucalyptus Plantation	44.95
		Farmland/Cropped	26.14
		Grassland: Short Grasses	34.70
		Grassland: Tussocks	15.03
	Farmland: Cropped Land	<i>Unclassified</i>	27.47
		Built-up area	9.11
		Eucalyptus Plantation	383.43
		Farmland/Cropped	1215.46
		Grassland: Short Grasses	1975.26
		Grassland: Tussocks	1190.24
		Wetland: Sedges	20.48
		Wetland: Water area	2.24

Appendix 11: Land Use Land Cover Change (LULC) Matrix (in Ha)

LULC 1973	LULC 1986	LULC 2019	Area
	Forest/Thicket	Built-up area Eucalyptus Plantation Farmland/Cropped Forest/Thickets Grassland: Short Grasses Grassland: Tussocks Wetland: Sedges 0.04	0.13 4.42 19.74 2.22 6.30 5.62
	Grassland: Short Grasses	<i>Unclassified</i> Built-up area Eucalyptus Plantation Farmland/Cropped Grassland: Short Grasses Grassland: Tussocks Wetland: Sedges Wetland: Water area	1.05 0.59 24.88 160.32 232.66 128.31 26.20 3.73
	Grassland: Tussocks	<i>Unclassified</i> Built-up area Eucalyptus Plantation Farmland/Cropped Grassland: Short Grasses Grassland: Tussocks Wetland: Sedges Wetland: Water area	28.00 33.02 372.52 1192.68 2118.21 1389.22 46.81 8.04
	Wetland: Muddy Soil	Eucalyptus Plantation Farmland/Cropped Grassland: Short Grasses Grassland: Tussocks	1.60 4.61 16.22 5.82
	Wetland: Sedges	<i>Unclassified</i> Built-up area Eucalyptus Plantation Farmland/Cropped Grassland: Short Grasses Grassland: Tussocks Wetland: Sedges Wetland: Water area	0.17 6.19 72.85 164.87 137.36 108.82 19.34 0.55
Forest/Thickets	Built-up area	Built-up area Eucalyptus Plantation Farmland/Cropped Grassland: Short Grasses Grassland: Tussocks	4.33 1.58 0.83 5.37 2.20

Appendix 11: Land Use Land Cover Change (LULC) Matrix (in Ha)

LULC 1973	LULC 1986	LULC 2019	Area
	Farmland: Cropped Land	Built-up area Eucalyptus Plantation Farmland/Cropped Grassland: Short Grasses Grassland: Tussocks Wetland: Sedges	1.83 12.63 23.10 17.89 11.26 0.25
	Forest/Thickets	Built-up area Eucalyptus Plantation Farmland/Cropped Forest/Thickets Grassland: Short Grasses Grassland: Tussocks Wetland: Sedges	3.99 65.83 106.05 386.06 48.63 19.54 0.54
	Grassland: Short Grasses	Built-up area Eucalyptus Plantation Farmland/Cropped Grassland: Short Grasses Grassland: Tussocks	0.14 0.94 2.31 2.36 1.55
	Grassland: Tussocks	Built-up area Eucalyptus Plantation Farmland/Cropped Forest/Thickets Grassland: Short Grasses Grassland: Tussocks Wetland: Sedges	6.02 33.80 119.98 29.17 126.44 63.21 0.57
	Wetland: Sedges	Built-up area Eucalyptus Plantation Farmland/Cropped Forest/Thickets Grassland: Short Grasses Grassland: Tussocks Wetland: Sedges	2.52 14.29 44.05 13.17 23.34 13.02 0.19
Grassland: Tussocks	Built-up area	Built-up area Eucalyptus Plantation Farmland/Cropped Grassland: Short Grasses Grassland: Tussocks Wetland: Sedges Wetland: Water area	32.03 2.03 6.61 50.09 15.12 0.06 3.12

Appendix 11: Land Use Land Cover Change (LULC) Matrix (in Ha)

LULC 1973	LULC 1986	LULC 2019	Area
	Eucalyptus Plantation	<i>Unclassified</i>	0.06
		Eucalyptus Plantation	6.60
		Farmland/Cropped	12.25
		Grassland: Short Grasses	29.94
		Grassland: Tussocks	6.48
	Farmland: Cropped Land	<i>Unclassified</i>	18.27
		Built-up area	23.20
		Eucalyptus Plantation	260.21
		Farmland/Cropped	831.70
		Grassland: Short Grasses	1378.78
		Grassland: Tussocks	838.18
		Wetland: Sedges	55.15
		Wetland: Water area	4.86
	Forest/Thickets	<i>Unclassified</i>	0.05
		Built-up area	0.32
		Eucalyptus Plantation	7.96
		Farmland/Cropped	29.42
		Forest/Thickets	21.52
		Grassland: Short Grasses	12.16
		Grassland: Tussocks	8.35
		Wetland: Sedges	0.75
	Grassland: Short Grasses	<i>Unclassified</i>	0.10
		Built-up area	2.79
		Eucalyptus Plantation	9.01
		Farmland/Cropped	77.98
		Grassland: Short Grasses	108.11
		Grassland: Tussocks	74.41
		Wetland: Sedges	46.57
		Wetland: Water area	9.26
	Grassland: Tussocks	<i>Unclassified</i>	15.22
		Built-up area	107.68
		Eucalyptus Plantation	462.42
		Farmland/Cropped	1351.18
		Grassland: Short Grasses	2477.24
		Grassland: Tussocks	1379.81
		Wetland: Sedges	112.04
		Wetland: Water area	14.75

Appendix 11: Land Use Land Cover Change (LULC) Matrix (in Ha)

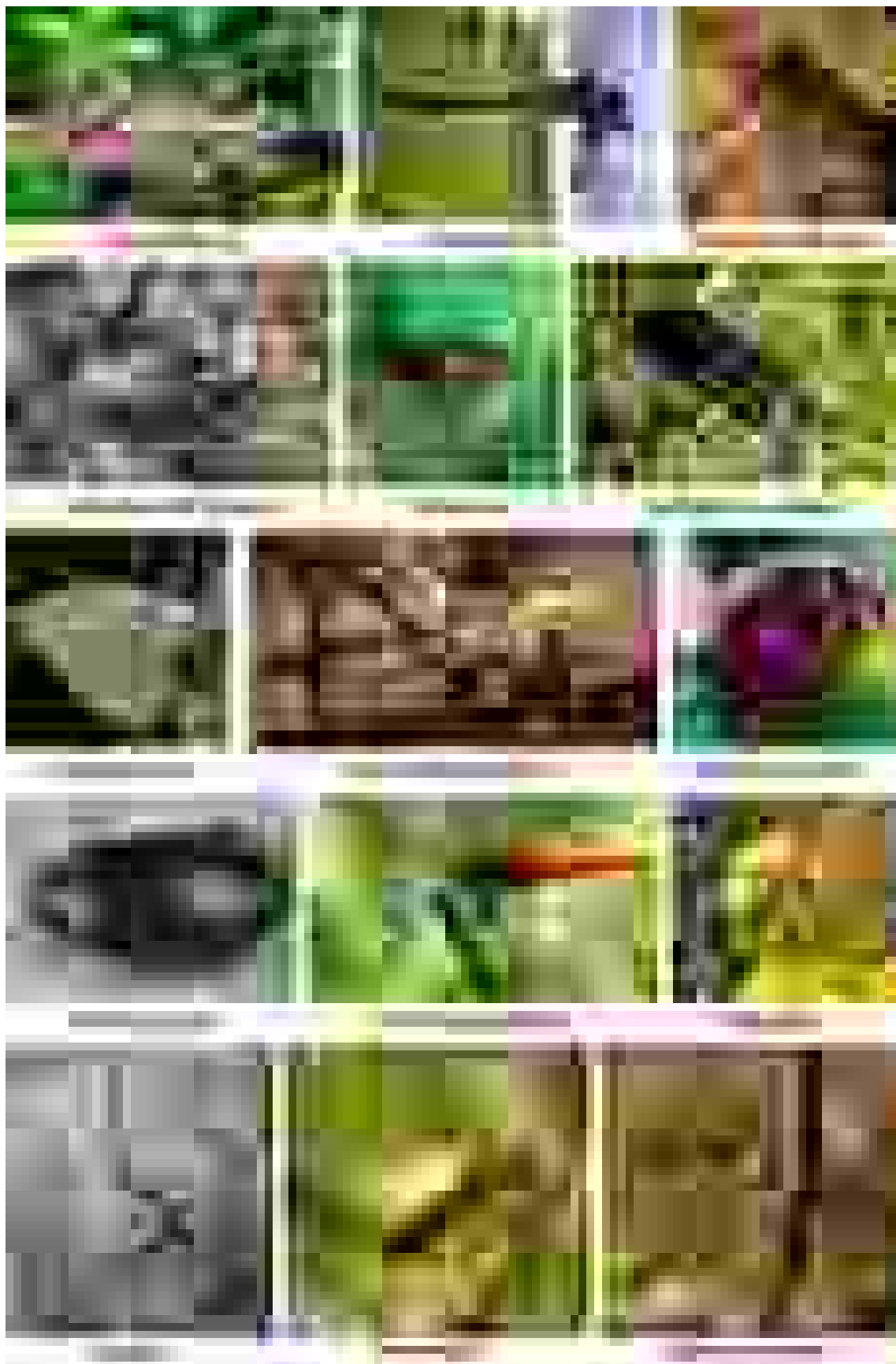
LULC 1973	LULC 1986	LULC 2019	Area
	Wetland: Muddy Soil	Eucalyptus Plantation	0.27
		Farmland/Cropped	2.21
		Grassland: Short Grasses	5.35
		Grassland: Tussocks	1.47
	Wetland: Sedges	<i>Unclassified</i>	0.79
		Built-up area	28.79
		Eucalyptus Plantation	113.86
		Farmland/Cropped	300.07
		Grassland: Short Grasses	214.12
		Grassland: Tussocks	170.31
		Wetland: Sedges	93.68
		Wetland: Water area	5.48
Wetland: Sedges	Farmland: Cropped Land	<i>Unclassified</i>	0.41
		Built-up area	0.12
		Eucalyptus Plantation	3.70
		Farmland/Cropped	12.38
		Grassland: Short Grasses	35.70
		Grassland: Tussocks	28.3
		Wetland: Sedges	76.43
		Wetland: Water area	5.33
	Grassland: Short Grasses	Unclassified	0.01
		Eucalyptus Plantation	0.38
		Farmland/Cropped	5.81
		Grassland: Short Grasses	16.57
		Grassland: Tussocks	8.77
		Wetland: Sedges	51.02
		Wetland: Water area	4.02
	Grassland: Tussocks	<i>Unclassified</i>	0.25
		Built-up area	0.13
		Eucalyptus Plantation	5.33
		Farmland/Cropped	18.75
		Grassland: Short Grasses	76.46
		Grassland: Tussocks	59.12
		Wetland: Sedges	221.20
		Wetland: Water area	41.19
	Wetland: Sedges	Unclassified	0.17
		Built-up area	1.33
		Eucalyptus Plantation	3.47
		Farmland/Cropped	6.84

Appendix 11: Land Use Land Cover Change (LULC) Matrix (in Ha)

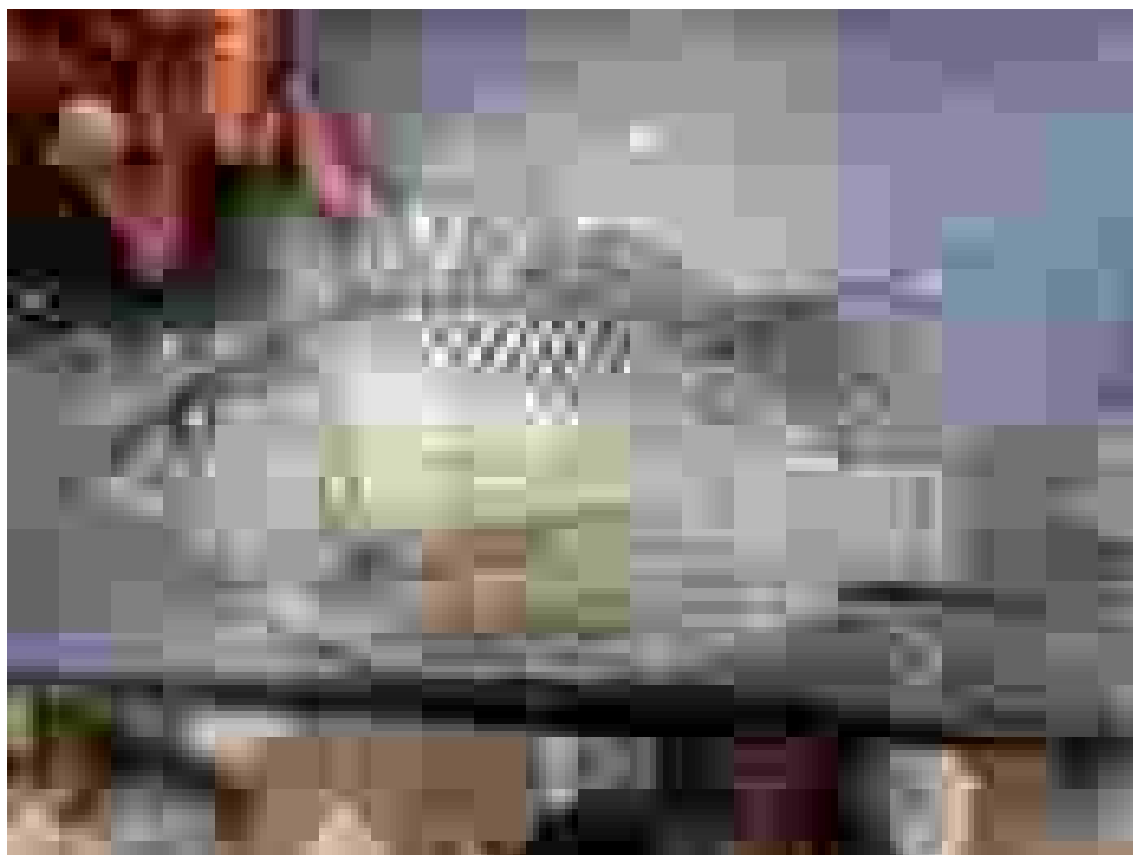
LULC 1973	LULC 1986	LULC 2019	Area
		Grassland: Short Grasses	11.32
		Grassland: Tussocks	11.58
		Wetland: Sedges	456.51
		Wetland: Water area	44.80
Wetland: Water area	Farmland: Cropped Land	Eucalyptus Plantation	0.31
		Farmland/Cropped	8.57
		Grassland: Short Grasses	13.59
		Grassland: Tussocks	8.32
		Wetland: Sedges	94.10
		Wetland: Water area	146.67
	Grassland: Short Grasses	Eucalyptus Plantation	0.09
		Farmland/Cropped	4.59
		Grassland: Short Grasses	13.77
		Grassland: Tussocks	5.46
		Wetland: Sedges	186.93
		Wetland: Water area	114.97
	Grassland: Tussocks	Eucalyptus Plantation	0.83
		Farmland/Cropped	15.20
		Grassland: Short Grasses	38.01
		Grassland: Tussocks	20.14
		Wetland: Sedges	222.33
		Wetland: Water area	457.81
	Wetland: Muddy Soil	Eucalyptus Plantation	0.01
		Farmland/Cropped	0.13
		Grassland: Short Grasses	0.07
		Grassland: Tussocks	0.00
		Wetland: Sedges	1.52
		Wetland: Water area	787.89
	Wetland: Sedges	<i>Unclassified</i>	0.15
		Eucalyptus Plantation	1.49
		Farmland/Cropped	1.70
		Grassland: Short Grasses	0.73
		Grassland: Tussocks	0.99
		Wetland: Sedges	162.59
		Wetland: Water area	577.45

Appendix B: Figures

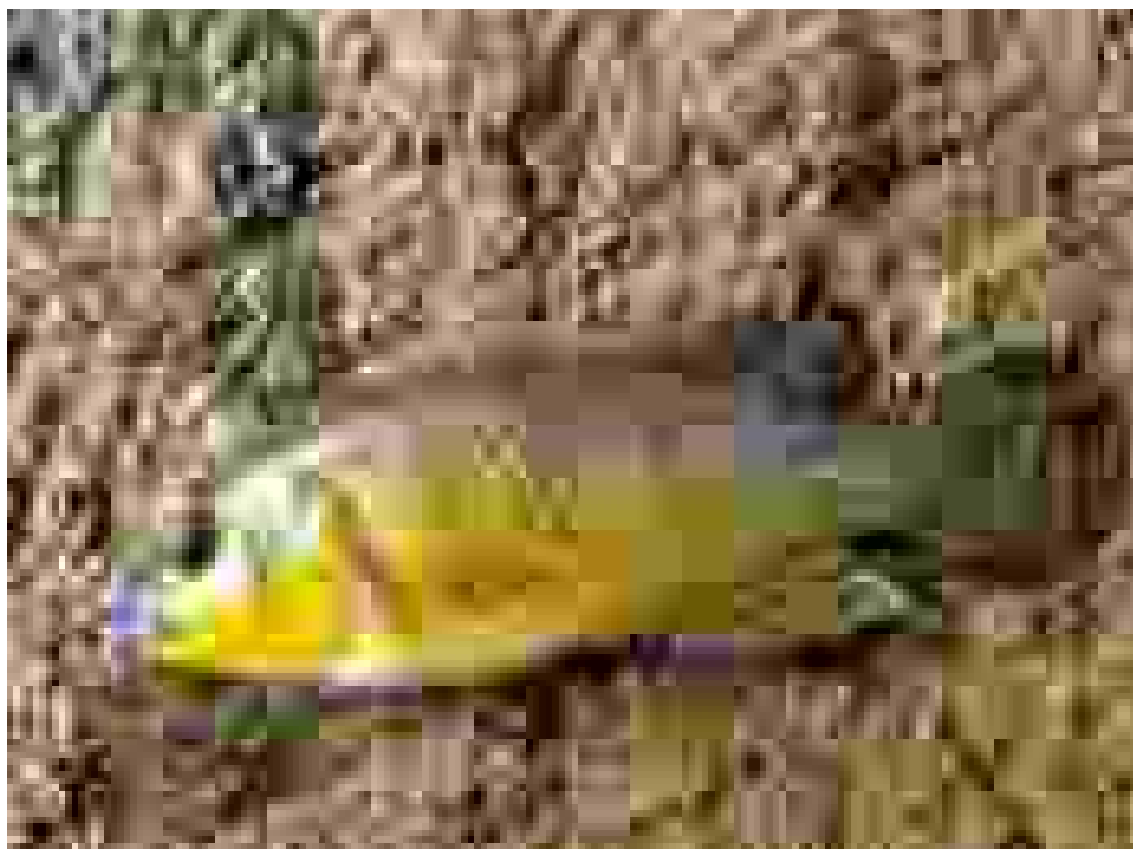
Appendix 12: A collection of different invertebrate species from Lake Ol Bolossat, November 2023



Appendix 13: Specimens of fish collected

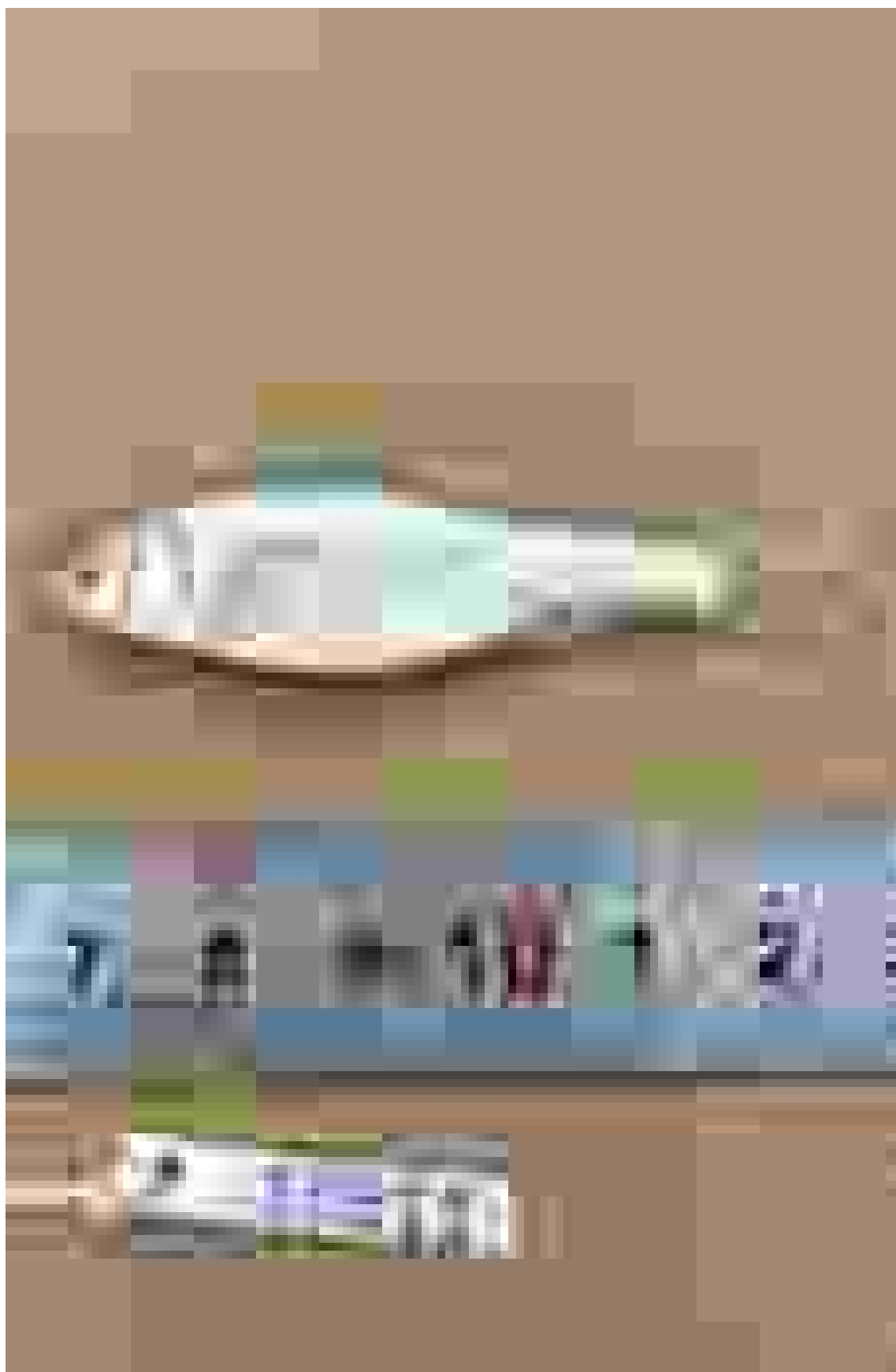


Sabaki tilapia (*Oreochromis spilurus*)



Dwarf Lake Victoria mouth brooder (*Pseudocrenilabrus multicolour victoriae*)

Appendix 13: Specimens of fish collected



Straight fin barb (*Enteromius paludinos*)



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